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# COMPASS

## BRIEFS IN EDUCATION

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## Female science and mathematics teachers: *Better than they think?*

### SUMMARY

Using IEA's Trends in International Mathematics and Science Study (TIMSS) 2015 data, this brief explores the relationship between teachers' gender and students' mathematics and science achievement, as well as gender differences in science and mathematics teachers' self-efficacy and its relation to job satisfaction. We find that there is no direct relationship between the gender of the teacher and students' performance in science and mathematics. Grade 4 and 8 students taught by female teachers perform just as well in science and mathematics as their peers taught by male teachers. Yet, results show that female science and mathematics teachers have less self-efficacy than their male counterparts. Additionally, the relationship between self-efficacy and job satisfaction is positive, and this relation is particularly strong for female science and mathematics teachers. The brief concludes with a discussion of the potential implications of these results, some suggested actions to build female science and mathematics teachers' self-efficacy, and areas for further research.

### IMPLICATIONS

- Lower self-efficacy of female science and mathematics teachers may affect girls' own self-efficacy in these subjects, and pursuit of science, technology, engineering, and mathematics (STEM) careers. There is a need for interventions—for example, leadership training and learning from a community of practice—aimed at raising awareness among female STEM teachers of their strengths and building their self-efficacy.
- Self-efficacy is positively correlated with job satisfaction and more so among female teachers. Professional training programs tailored to enhance male and female teachers' self-efficacy beliefs also need to address issues related to job satisfaction and overall teacher well-being such as working conditions and school climate.

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## INTRODUCTION

Time and time again, girls have been found to have lower levels of self-efficacy than boys in certain subjects, particularly in science, technology, engineering, and mathematics (STEM) (Fraillon et al. 2014; Pajares 2005). There is a strong relationship between girls' lower levels of self-efficacy and gender gaps in STEM fields of study, starting from advanced high school mathematics and science course enrolment (Mullis et al. 2016a), and growing into tertiary fields of study. In over two-thirds of education systems, less than 25% of students in engineering, manufacturing, construction, or ICT are female. Additionally, only 20% of new entrants to short-cycle tertiary programs and 30% of new entrants to bachelor's programs in STEM fields in 2017 were women in OECD countries (Encinas-Martin 2020; UNESCO 2020).

Female teachers have been associated with improved educational experiences and enhanced learning outcomes for girls in some contexts (Unterhalter et al. 2014). They have also been found to positively influence girls' perceptions, interest, and self-efficacy in STEM by dispelling myths about sex-based, innate abilities among boys, and by acting as role models for girls (Baker 2013; Blickenstaff 2005). Despite the positive influence on overall STEM performance, female STEM teachers may also demonstrate low self-efficacy in their teaching practice, thereby reinforcing

the commonly held stereotype that boys are good at science and mathematics, and girls at reading (Beilock et al. 2010). Although existing research has examined the interaction and influence of various factors on teacher self-efficacy including how it affects teacher motivation and job satisfaction, the gender dimensions have rarely been investigated (Klassen and Chiu 2010).

Using IEA's Trends in International Mathematics and Science Study (TIMSS) data, in this brief we examine how female science and mathematics teachers' self-efficacy affects their work and their overall job satisfaction. Specifically, this brief addresses the following questions:

- What is the relationship between students' achievement and self-efficacy in science and mathematics, and how does student achievement relate to teacher self-efficacy?
- What is the relationship between teachers' gender and students' mathematics and science achievement?
- Are there gender differences in teachers' self-efficacy and, if so, how is this related to their job satisfaction?
- What are the potential implications of lower female teacher self-efficacy in efforts to get more girls and women into teaching and studying STEM?

## DATA AND ANALYSIS

The International Association for the Evaluation of Educational Achievement's (IEA) TIMSS is a four-year cyclical survey that assesses students' mathematics and science achievements at grade 4 and 8.<sup>1</sup> Here, we examined students' assessment results in both grades as well as data resulting from the teachers' questionnaire. The 2015 cycle of TIMSS (Mullis et al. 2016b) assessed more than 580,000 students in

63 education systems<sup>2</sup> (56 participated in the grade 4 assessment and 45 for grade 8) and gathered background data from students, their mathematics and science teachers, school principals, and parents.<sup>3</sup> Not all participating education systems had data available for the purposes of our analyses. Consequently, we included data from 43 education systems at grade 8 and 52 education systems at grade 4.

1. See <https://www.iea.nl/timss>

2. TIMSS participants include countries and distinct educational systems within countries. In this brief, for ease of reading, we use the term "education systems" to describe both.

3. All questionnaires can be found at: <https://timssandpirls.bc.edu/timss2015/questionnaires/index.html>

The TIMSS 2015 teachers' questionnaires include a question on how prepared they feel in teaching various areas of mathematics and science that are part of the TIMSS assessment.<sup>4</sup> They are asked to choose responses of "not applicable," "very well prepared," "somewhat prepared," and "not well prepared." A self-efficacy score was calculated for teachers by counting the number of "very well prepared" in their responses. The maximum score was 17 for grade 4 mathematics teachers, 23 for grade 4 science teachers, 20 for grade 8 mathematics teachers, and 22 for grade 8 science teachers. Job satisfaction data were calculated by how

often teachers responded positively to the following seven statements: 1) I am content with my profession as a teacher; 2) I am satisfied with being a teacher at this school; 3) I find my work full of meaning and purpose; 4) I am enthusiastic about my job; 5) My work inspires me; 6) I am proud of the work I do; and 7) I am going to continue teaching for as long as I can. Respondents that answered "very often" to the above statements were classified as being very satisfied, those who answered "often" were classified as satisfied, while those answering "sometimes" or "never or almost never" were classified as less than satisfied.

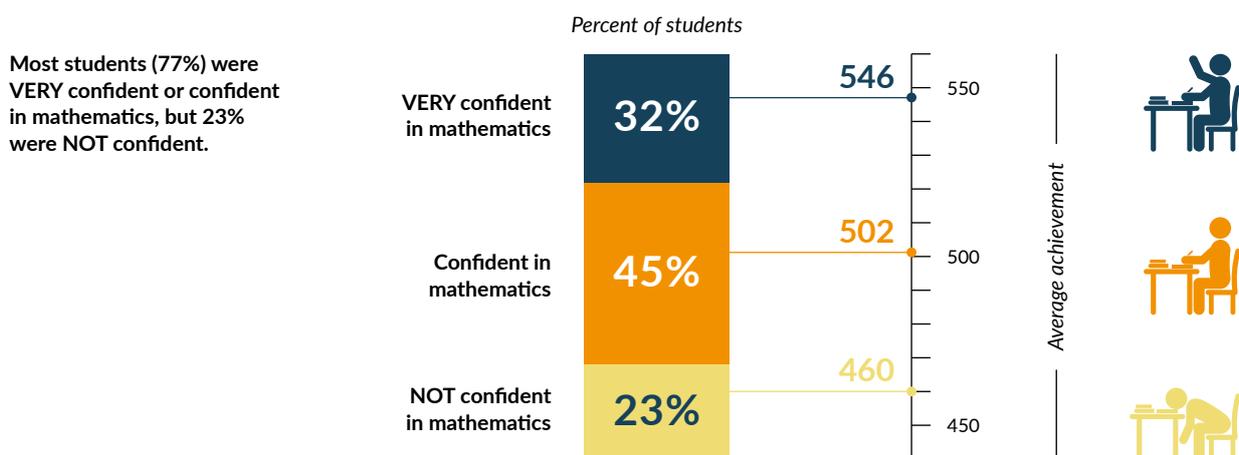
## RESULTS

### Student achievement and self-efficacy

Results show a strong relationship between students' self-efficacy and achievement. Those students who were very confident in mathematics scored much higher on average achievement (546 points) than those who were confident (502) or not confident in mathematics (460) in grade 4 (Figure 1). Likewise, in grade 8, those who were very confident in mathematics score highest (554),

compared to those who were confident (494) or not confident (449). A similar relationship exists for science for both grades. In grade 4, students who were very confident in science scored high (532) and lower when they were simply confident (501) or not confident (464). For grade 8 the averages scores were 538, 490, and 452 respectively.

Figure 1: Grade 4 students' self-efficacy in mathematics



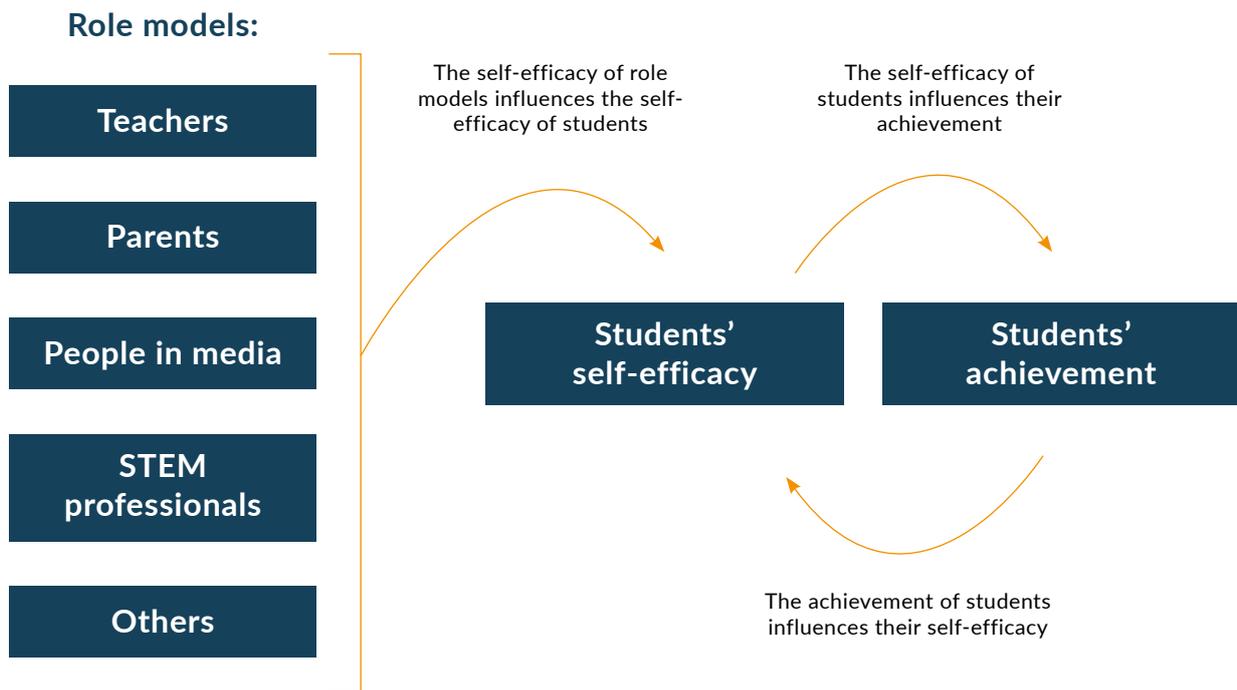
Source: This figure was adapted from the graphic "Students' Attitudes Toward Mathematics," from the TIMSS 2015 International Results in Mathematics report (Mullis et al. 2016b).

4. This question was not included in the TIMSS 2019 questionnaire. Therefore, this brief focuses on data from 2015.

Moreover, analysis of grade 8 data for science has shown an overall positive correlation between teachers' self-efficacy and student achievement.<sup>5</sup> The self-efficacy of

teachers (and other role models) could influence student self-efficacy and, in turn, achievement (Figure 2).

**Figure 2: A model of the relationship between role models and student achievement**



### Student achievement by teachers' gender

Our analysis of TIMSS 2015 data additionally looked at whether the gender of a teacher is related to students' achievement levels in science and mathematics. The data on student performance indicate that those taught by female teachers were performing just as well or, in most cases, better than their peers taught by male teachers (Figure 3). This was the case in both grades 4 and 8, and in both mathematics and science, and was more apparent at grade 8.

Boys in particular seem to benefit from a female science and mathematics teacher. For grade 4 mathematics, in 6 of the 52 education systems (12%), boys who were taught by female teachers outperformed those who were taught by male teachers while the opposite appeared to be the case in only three education systems. For grade 8, in 11 of the 43 education systems (26%), boys who were taught mathematics by female teachers were performing better

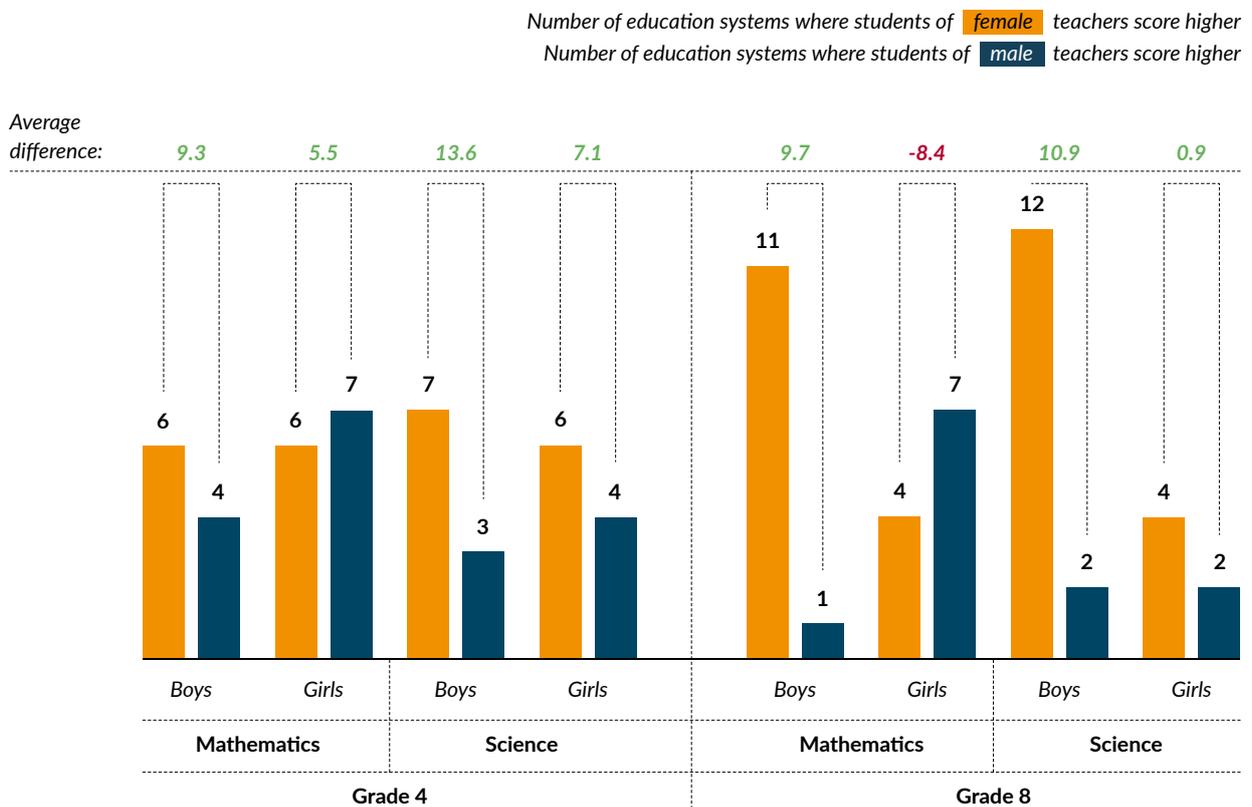
<sup>5</sup> We would expect here a bi-directional relationship. Higher self-efficacy in teaching a topic might very well be caused to some extent by better results of the students that the teacher is teaching.

than those taught by male teachers. Only in one education system, Saudi Arabia, did boys instructed by male teachers achieve better scores in mathematics than those taught by female teachers.<sup>6</sup> Similarly, for grade 8, in 12 of the 43 education systems (28%), the science scores of boys taught by female teachers were higher than those taught by male teachers while the contrary was found in only two education systems: England and Lebanon. Although this trend was less apparent for grade 8 girls, those who were taught by

female teachers were still doing better in science than those taught by male teachers.

This finding was consistent in terms of both the number of education systems and the average difference in scores. Overall, there were more education systems where students taught by female teachers were doing better than students taught by male teachers in mathematics and science, and this is confirmed in the latest TIMSS data from 2019.<sup>7</sup>

Figure 3: Achievement differences of students taught by male and female teachers in TIMSS 2015



**Note:** Average difference refers to students' scores. A positive value indicates students of female teachers scoring higher; colors are used to reflect statistically significant differences and numbers in black reflect no statistical significance. The above figure is based on data from 43 education systems at grade 8 and 52 education systems at grade 4.

6. Saudi Arabia uses single-sex education. The relationship between the gender of the teacher and student achievement in the context of single-sex education warrants further research.  
 7. See the TIMSS 2019 International Results in Mathematics and Science (Mullis et al. 2020): <http://timssandpirls.bc.edu/timss2019/international-results/>

## Gender differences in teacher self-efficacy

The self-efficacy scores of female and male teachers showed a more concerning picture, particularly for science subjects (Figure 4). At grade 4, 17 of the 52 education systems (33%) had statistically significant differences in reported levels of self-efficacy between male and female science teachers. At grade 8, this was found for 15 of the 43 education systems (35%). These differences were overwhelmingly linked to higher reported levels of self-efficacy among male teachers than their female peers. Female science teachers reported lower levels of self-efficacy than their male counterparts in 16 of the 17 education systems (94%) showing differences at grade 4, and in 13 of the 15 education systems (87%) showing differences at grade 8. The greatest differences were found in Bahrain, Canada, and Finland at grade 4 and in Canada, Malta, and the Republic of Korea at grade 8. Georgia was the only education system where female science teachers had statistically higher levels of reported self-efficacy than their male peers at grade 4, while this was the case only in Saudi Arabia and Slovenia at grade 8.

In mathematics, there were fewer education systems with statistically significant differences in self-efficacy by gender; however, when these differences did appear, they were overwhelmingly associated with higher reported levels among male teachers. At grade 4, 4 of the 52 education systems (8%) had statistically significant differences in reported levels of self-efficacy between male and female mathematics teachers. At grade 8, this was found for 7 of the 43 education systems (16%). Female mathematics teachers reported lower levels of self-efficacy than their male counterparts in 3 of the 4 education systems (75%) with differences at grade 4 and all education systems at grade 8. The greatest differences were found in Canada at grade 4 and in Malta at grade 8. Of the education systems participating in both grade 4 and grade 8 assessments, Dubai was the only education system in which female mathematics and science teachers reported statistically higher levels of self-efficacy. However, this was found only for grade 4.

## Teacher self-efficacy and job satisfaction

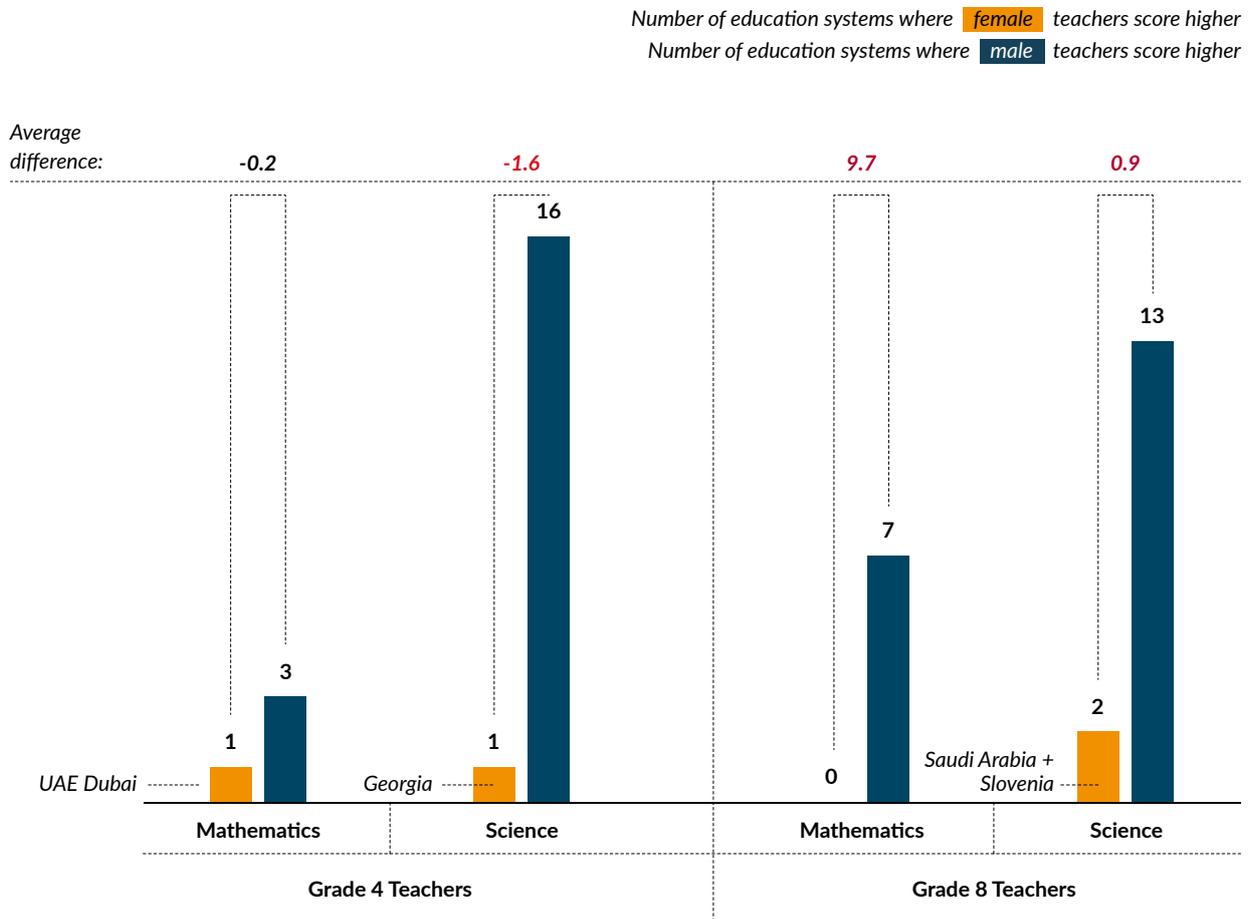
Using TIMSS 2015 data on teacher' job satisfaction, the correlation between teachers' self-efficacy and their level of job satisfaction was further analyzed. For grade 4 mathematics teachers, 10 of the 52 education systems (19%) had statistically significant correlations with the average correlation also being statistically significant. The highest correlations were in Lithuania (.39), Italy (.37), Japan (.37), Finland (.35), and France (.35). The same analysis was also done for grade 4 science teachers and a staggering number of 21 of the 52 education systems (40%) were found to have statistically significant correlations. This strongly suggests that teachers' self-efficacy correlates with their job satisfaction.

When the job satisfaction data of grade 4 teachers was disaggregated by sex, self-efficacy and job satisfaction

were found to be more closely related for female teachers than for male teachers. Statistically significant correlations between self-efficacy and job satisfaction were found in 17 of the 52 education systems (33%) for female teachers while the correlations were statistically significant for male teachers in only nine. This seems to indicate that self-efficacy has a greater influence on job satisfaction for female teachers than for male teachers.

Although the same analysis was done for grade 8 science teachers, the results were not as clear. This may be explained by the fact that the questions on self-efficacy in teaching were aggregated across all science subjects while teachers might only teach a certain topic in the sciences, such as biology or physics, instead of all the subjects in the grade 8 context.

Figure 4: Teachers' self-efficacy by male and female teachers in TIMSS 2015



**Note:** Average difference refers to teachers' scores. A positive value indicates female teachers scoring higher; colors are used to reflect statistically significant differences and numbers in black reflect no statistical significance. The above figure is based on data from 43 education systems at grade 8 and 52 education systems at grade 4.

## DISCUSSION

First, our analysis of the TIMSS 2015 data finds that female science and mathematics teachers reported lower levels of self-efficacy. Further, their students perform as well or better than students taught by their male peers. Female teachers may be underestimating their capacities in transmitting science and mathematics knowledge.

Interestingly, our results show that low levels of self-efficacy among female science and mathematics teachers are particularly apparent at secondary level, mirroring similar drops in self-efficacy of girls in these subjects at this level of education. The trend of male students reporting greater self-efficacy than female students in these subjects starts at lower secondary and grows as students become older (Pajares 2005).

Evidence suggests that teachers with a strong sense of self-efficacy contribute to increased self-efficacy and motivation among their students (Caprara et al. 2006). Female teachers are important role models for girls. Lower self-efficacy of female science and mathematics teachers may affect girls' own self-efficacy in these subjects. As self-efficacy in mathematics and

science has been associated with intentions to study these subjects further (Sheldrake 2016; Pajares 2005), the self-efficacy of female mathematics and science teachers may impact girls' intentions to further pursue science and mathematics fields. Significantly fewer girls than boys expect to work in science and engineering professions. These expectations are not related to performance: fewer girls who are top performers in science or mathematics expect working in science and engineering compared to boys who are top performers (OECD 2019).

Second, our analysis also found a positive correlation between teacher self-efficacy and job satisfaction but, more importantly, found that self-efficacy seems to play a bigger role in the level of job satisfaction among female teachers than male teachers. Low levels of self-efficacy could therefore negatively influence female mathematics and science teachers' decision to stay in their profession.

These two points suggest that addressing low self-efficacy of female mathematics and science teachers should be a concern for policymakers.

## CONCLUSION

Data shows that there are significantly fewer female teachers in STEM subjects (Watt 2006). As the likelihood of attrition significantly increases in teaching specialty areas including STEM (Nguyen and Springer 2019), our analysis has important implications on the recruitment, retention, and progression of female STEM teachers and the continued engagement of girls in these fields.

There is a need to raise awareness among female STEM teachers to help them understand their strengths and more accurately assess their performance. Likewise, there is a need for interventions aimed at building female STEM teachers' self-efficacy. These could include leadership training and learning from a community of practice.

Professional training programs tailored to enhance male and female teachers' self-efficacy beliefs also need to address issues related to job satisfaction and

overall teacher well-being such as working conditions and school climate. School administrators also play a role in the development of teachers' self-efficacy and their job satisfaction. Teachers must feel valued and their work recognized. Professional and administrative support have also shown to improve STEM teachers' self-efficacy.

This brief raises several leads for further research. The relationship between self-efficacy of female STEM teachers and girls' own self-efficacy in these subjects, as well as their career choice, has to be further researched. Likewise, the relationship between self-efficacy of female STEM teachers and their performance should be further looked into.

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# IEA COMPASS

## ABOUT THIS BRIEF

This special issue of IEA Compass: Briefs in Education has been created in partnership with UNESCO. In this special issue we aim to translate TIMSS study findings into the education field, both for policymakers as well as teachers, and other practitioners in the education sector.

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