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Early learning activities matter for girls' and boys' mathematics and science achievement

SUMMARY

Using IEA's TIMSS (Trends in International Mathematics and Science Study) 2019 data, this brief examines gender differences in parental involvement with their child's education measured through participation in early home learning activities. We find that engaging children in home learning activities before entering primary school is associated with increased students' fourth-grade mathematics and science achievement, with a significantly larger positive relationship for boys than girls for numeracy activities. Parents engage girls significantly more than boys in early learning activities such as *singing songs, drawing shapes, writing letters and words, saying counting rhymes or singing counting songs, and writing numbers*, and only one activity listed on the TIMSS questionnaire where parents engage boys significantly more which is *playing with building blocks and construction toys*. The brief concludes with a discussion of the potential policy implications.

IMPLICATIONS

- Parents of boys tend to focus more on numeracy activities compared to literacy activities. However, parental involvement in learning activities before primary school, in general, is higher with girls compared to boys.
- Early learning activities are important for student achievement in mathematics and science, regardless of gender, stressing the importance of promoting activities across all households.
- Parents should encourage spatial play with their daughters to increase their spatial skills. The ability to understand problems relating to forms, shapes, and physical spaces which builds spatial skills is important to predict competence in mathematics.

INTRODUCTION

STEM (science, technology, engineering, and mathematics) fields are essential for innovation and to address global challenges. Despite a global skills shortage, women remain underrepresented in STEM and only accounted for 28% of engineering graduates and 40% of computer science and informatics graduates in 2018 (UNESCO, 2021). This is despite girls outperforming boys in science in secondary school in many countries (Mullis et al., 2020). While boys tend to do better in mathematics at early grades, on average, they lose their advantage later in school (UNESCO, 2022). However, boys are more confident in mathematics than girls (Hencke et al., 2022).

Parents are essential to their child's early learning experiences. Parental engagement in early home learning activities—such as reading together or playing with counting toys—are important in developing literacy and numeracy skills (Meinck et al., 2018). Students entering primary school with these skills are often better prepared for learning. Research has demonstrated that engaging students in learning activities before primary school is positively associated with later student achievement (Mullis et al., 2017). Engaging parents in the mathematics education of young children aged three to eight has been found to positively affect learning (Van Voorhis et al., 2013). Such activities also have the potential to generate children's interest in learning (Balala et al., 2021). Parental involvement and continued engagement in their child's early learning experiences can have long-lasting impacts on the child's educational experiences.

Parents' beliefs about girls' and boys' stereotypical behaviors may influence the types of learning activities they participate in with their child. Past research shows that parents often hold the belief that boys are better than girls in mathematics and science which affects children more than their real achievement (Muntoni and Retelsdorf, 2019; Starr et al., 2021). This belief could lead to parents engaging less in certain early home learning activities with their children.

Girls' attitudes related to science and mathematics are strongly influenced by their close family environment. Starting from early childhood many girls receive subtle messages from parents, that science and mathematics are not for them (UNESCO, 2017). Differential treatment of girls and boys can entrench negative stereotypes about gender and ability in science and mathematics, deterring girls from developing their interest in these subjects and pursuing a career in STEM (Wang and Degol, 2013).

Using IEA's TIMSS 2019 data, we address three major questions:

- Are there gender differences in the frequency of early learning activities?
- Are there gender differences in the type of early learning activities?
- Are there gender differences in the relationship between early learning activities and children's achievement in mathematics and science?

DATA

Examining results from the fourth-grade TIMSS 2019 assessment and home questionnaire, we focus our analysis on responses from parents or guardians of the assessed students reporting on how often they or someone else in their home participated in several learning activities with their child before they entered primary education. [Appendix 1](#) presents a list of the activities that parents were asked about. The response

options included *often, sometimes, and never or almost never*. The single responses to the home-learning activities were combined to construct two continuous scales, one on early literacy activities (items 1-9) and one on early numeracy activities (items 10-18). More details on the analytical sample are included in the [Technical Appendix](#).

RESULTS

Frequency of early home learning activities by gender differences

We begin our exploration by calculating the percentage of students who were *often* engaged in each of the 18 early home learning activities listed in the TIMSS questionnaire. Results are separated by gender and type of activity. **Figure 1** presents the percentage of students with parents who report that they *often* engaged in the listed early home learning activities with their child before primary school.

More than 50% of parents reported that they *often* engaged with their child for many of the investigated home learning activities (highlighted in blue). **Figure 1** demonstrates that parents of girls reported, in general, more activities being done *often* with their children compared to parents with boys. Girls are engaged in nine activities, whereas boys are engaged in four activities *often*.

Independent of the gender of the child, 63% of parents of both girls and boys reported *talking about things one had done* as being the early literacy activity done most *often* with their child. In contrast, the early numeracy

activity that was most often reported for girls and boys is different. For girls it was *counting different things* with about 62% of parents reporting having done this *often*. For boys, the activity was *playing with building blocks or construction toys* with 67% of parents reporting having done this most *often*. *Measuring or weighing things* is the activity that was reported as being done least *often*, regardless of the child’s gender with 18% of parents reporting for girls and 15% of parents reporting for boys.

While, overall, the results appear to show that girls were more *often* engaged in early home learning activities with their parents before primary school than boys, an interesting picture can be found when examining this by gender. For girls, the activities for which over 50% of parents reported doing *often* with their child (highlighted in blue), were equally distributed across both literacy and numeracy activities. In contrast, the activities that were done more *often* with boys tended to fall within the numeracy activities category. This might indicate that girls tend to be engaged overall in a wider variety of learning activities with their parents from a young age, while boys tend to do more numeracy-skill based activities *often*.

Figure 1: Frequency of participation of boys and girls in home learning activities as reported as being often done by parents

		Percentage of parents reporting they “often” do a certain activity	
		Girls	Boys
Early Literacy Activities	Talk about things you had done	63.1%	62.7%
	Sing songs	57.4%	49.6%
	Write letters or words	53.3%	48.9%
	Read books	53.0%	48.0%
	Tell stories	52.3%	46.8%
	Read aloud signs and labels	47.5%	46.6%
	Play with alphabet toys	47.4%	45.8%
	Play word games	41.1%	38.6%
	Talk about what you had read	40.0%	37.7%
Early Numeracy Activities	Count different things	61.8%	66.7%
	Play games involving shapes	58.9%	61.5%
	Play with building blocks or construction toys	57.5%	57.5%
	Write numbers	54.7%	49.6%
	Draw shapes	54.3%	45.7%
	Say counting rhymes or sing counting songs	44.3%	44.0%
	Play with number toys	44.3%	43.1%
	Play board or card games	43.7%	39.0%
	Measure or weigh things	17.7%	15.3%

- Blue highlighted activities are those reported by more than 50% of parents as being done “often” with their child.
- Yellow highlighted activities are those reported by between 40 and 50% of parents as being done “often” with their child.
- Orange highlighted activities are those reported by less than 40% of parents as being done “often” with their child.

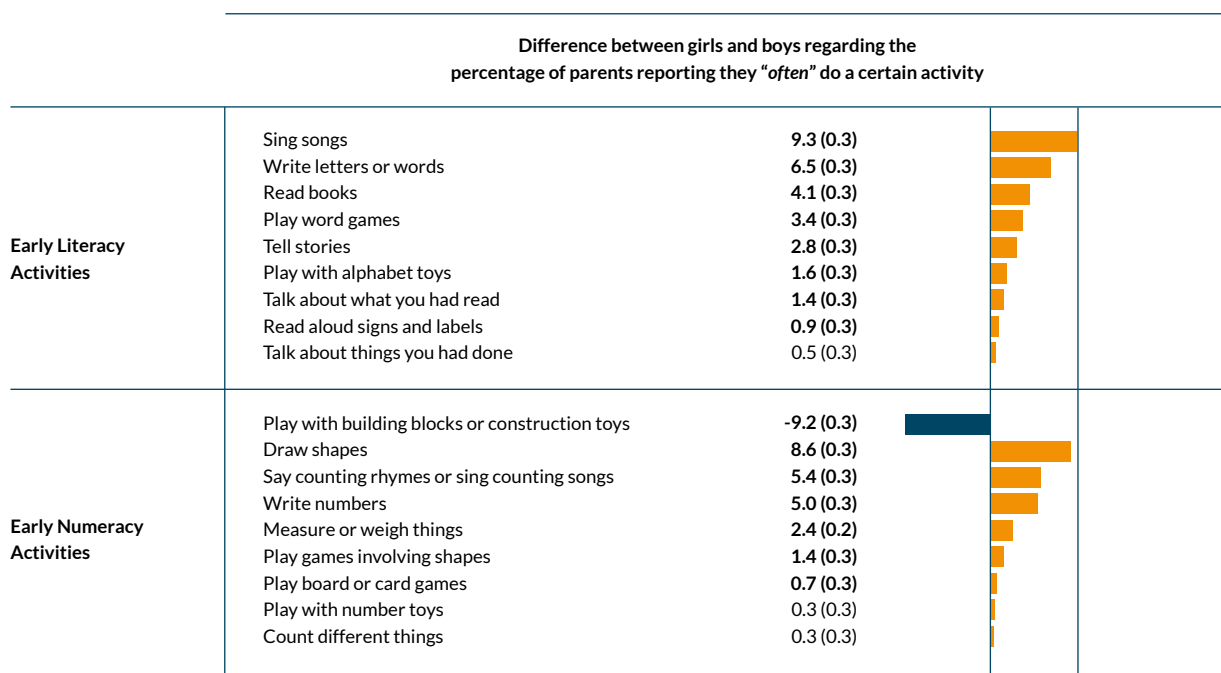
Source: TIMSS 2019.



Notes: The activities are sorted in decreasing order by the percentage of parents having reported that they have engaged “often” in the activity with their child prior to primary school.

We test whether there are significant differences between boys and girls who *often* participated in each activity to identify whether certain activities were more

likely to be used with boys or girls. **Figure 2** shows these differences in percentage points. Those in bold indicate statistically significant differences.

Figure 2: Differences between girls and boys with parents reporting that they often engaged in certain activities with their child before entering primary school



-  Differences represented by orange bars indicate that more parents reported to have done the specific activity "often" with girls compared to parents with boys.
-  Blue bars indicate more parents reported to have done the specific activity "often" with boys compared to parents with girls.
- Bold** differences indicate significant differences between girls and boys.

Source: TIMSS 2019.

Notes: Differences between girls and boys in the percentage of students with parents reporting that they "often" engaged in specific learning activities with their child before they entered primary school (girls minus boys) sorted by the absolute size of the differences.

As illustrated in prior results, girls tend to be engaged in early home learning activities more *often* than boys. This difference is significant in all activities except three: *talking about things you had done*, *playing with number toys*, and *counting different things*. These three activities tend to be done most *often* with children, regardless of their gender (see **Figure 3**).

The largest significant differences in favor of girls were found in *singing songs* and *writing letters and words* for early literacy activities and *drawing shapes* and *saying*

counting rhymes for early numeracy activities. The one activity parents reported having done significantly more *often* with boys is *playing with building blocks or construction toys*, which was nine percentage points higher for boys than girls. When focusing on significant differences among literacy activities, girls participate *often*, on average, four percentage points higher than boys. The gap, on average, is smaller for numeracy activities as girls *often* participate in these activities two percentage points more than boys.

Gender differences in the relationship between early home learning activities and student achievement

Having identified gender differences in early home learning activity engagement, we explore whether early home learning activities are differentially linked with achievement by gender. To test this, we use a regression model to calculate the relationship between the use of early home learning activities and mathematics and science achievement. For this analysis, we use the continuous early literacy and numeracy activities scale that was derived using responses to the items listed in [Appendix 1](#). The first nine items are used to construct a measure of “Early Home Literacy Activities” and the second nine items are used to construct a measure of “Early Home Numeracy Activities.” Both are already derived and included in the TIMSS 2019 international database. The regression coefficient can be interpreted as the achievement scale score improvement associated with an increase in the early literacy or numeracy activities scales. More details on the regression model and sample are included in the [Technical Appendix](#).

[Figure 3](#) shows the relationship between the use of early home learning activities and mathematics or science

achievement. The results are separated for girls and boys and significant relationships are in bold. The figure shows that early learning activities are positively and significantly related with mathematics and science achievement for both boys and girls. Children of parents that were engaged more *often* in early home learning activities achieve higher results in mathematics and science in TIMSS at the fourth grade. This is true for both literacy and numeracy activities.

Differences in bold indicate that the relationships are significantly different between boys and girls. There are no significant differences in the relationship between early literacy activities and mathematics or science achievement between boys and girls. Early literacy activities are shown to be positively associated with mathematics and science achievement for boys and girls at a similar magnitude. When examining early numeracy activities, we observe a significant difference in the relationship between mathematics and science achievement in favor of boys. While early numeracy activities are significantly associated with mathematics and science achievement for both boys and girls, the estimated return to an increase in such activities is significantly higher for boys compared to girls.

Figure 3: Relationship between early home learning activities and mathematics and science achievement for boys and girls

		Girls Coef.	Boys Coef.	Difference Girls - Boys	
Early Literacy Activities	Mathematics Achievement	2.6 (0.2)	2.8 (0.2)	-0.3 (0.2)	
	Science Achievement	3.4 (0.2)	3.8 (0.2)	-0.3 (0.2)	
Early Numeracy Activities	Mathematics Achievement	2.4 (0.2)	2.9 (0.2)	-0.5 (0.2)	
	Science Achievement	2.3 (0.2)	2.8 (0.2)	-0.5 (0.2)	

Differences represented by the blue bars indicate that the relationship is stronger for boys.
Numbers in bold indicate significant relationships or differences in relationships between girls and boys.

Source: TIMSS 2019.
 Notes: Numbers in brackets indicate standard errors.

DISCUSSION AND CONCLUSION

Our results show that, overall, parents tend to engage girls more *often* in early home learning activities than boys. There was one exception, *playing with building blocks or construction toys*. Girls tend to be engaged in a variety of different types of activities, whereas boys tend to be engaged in more activities that develop numeracy skills.

As noted, the one activity that parents engaged significantly more *often* in with boys is *playing with building blocks or construction toys*, pointing to a gender bias among parents. Research shows that male students outperform female students in spatial skills, but that play experiences with construction toys can close this gender gap (Gold et al., 2018). Research on the cognitive predictors of STEM learning in children suggests that written language and spatial skills can predict mathematics competence. Targeted interventions to increase spatial skills are needed during early childhood as these skills are flexible and can be significantly improved through early activities (Reilly et al., 2016; Zhang et al., 2014). Parents should therefore encourage spatial play with their daughters. This effort should extend to pedagogical staff in early childhood education and care programs. The early childhood education and care workforce needs to be sensitized through pre- and in-service training to do more spatial play with girls and their capacities must be built to encourage parents to equally do so.

Only comparing differences on the *Home Early Literacy and Numeracy Activities Before Primary School* scale can mask some subtle differences in the types of activities that parents engage in with their child in the home as seen in the item-level analysis. Parents can engage in a wide variety of activities to support their child's learning at an early age, not just those included in the TIMSS parent questionnaire. Therefore, gender differences in these activities found in this brief in favor of girls may be a result of real differences in parental involvement or could reflect an underrepresentation of typical activities that parents engage their boys in.

Our analysis does not reveal what parents believe about the mathematics and science abilities of their children. Even though parents engage more with girls in early home learning activities, they may transmit their beliefs that girls are less talented than boys in

mathematics onto their daughters, which adversely affects girls' confidence in STEM. This assumption could be supported by the finding that parents of boys tend to focus more on numeracy activities compared to literacy activities. Parental outreach programs can help to dismantle harmful gender stereotypes about women in STEM, thereby helping to develop the abilities and interest of girls in science and mathematics. Schools and universities are well placed to provide parents with information about STEM educational opportunities and careers (UNESCO, 2017). Supporting parent-child dialogue through the provision of materials on the usefulness of STEM has been shown to increase children's motivation and preparation for science and mathematics (Harackiewicz et al., 2012).

The relationship between early numeracy activities and achievement in science and mathematics was positive for both girls and boys, however, it was significantly larger for boys compared to girls. Parents of boys tend to focus more on numeracy activities compared to literacy activities which could increase boys' achievement and interest in numeracy. The relationship between early learning activities and achievement may not only be determined by the overall frequency of activities, but also by the type of activities prioritized by parents.

This brief raises leads for further research. Our analysis was limited to the learning activities included in the TIMSS questionnaire. What other typical activities not included in the questionnaire do parents engage their daughters and sons most in? What may be the effect of these activities on mathematics and science achievement? Our brief did not investigate the relationship between confidence and early learning activities. What is the effect of early learning activities on girls' and boys' confidence in science and mathematics? Last but not least, is there a link between engaging girls more in early learning activities than boys and boys' lower reading achievement?

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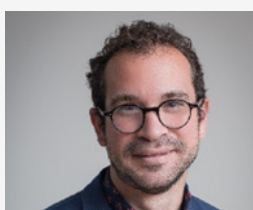
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IEA COMPASS

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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