

Gender Differences in Children's Extracurricular Activities: Japanese Parental Preference for Science, Technology, Engineering, and Mathematics (STEM) Activities for Sons

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Abstract

Using original survey data from parents of children in kindergarten through junior high school in Tokyo, Japan, we find that parents exhibit stronger preferences for sons over daughters to participate in extracurricular Science, Technology, Engineering, and Mathematics (STEM) activities, with the gender gap widening as children age. Parents aspiring for their children to pursue STEM degrees prioritize science classes more, a preference more often directed toward boys. These gendered differences affect children's early exposure to science. Since Japanese students choose between science and humanities tracks by eleventh grade, early disparities may limit girls' opportunities. Promoting equal STEM access is crucial to reducing these gender gaps.

Keywords: science learning, STEM, gender, Japan

JEL Classifications: A21, I24, J13, J16

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1 Introduction

Parents play a crucial role in shaping their children's future through decisions that significantly impact their development (Rozek et al., 2017; Doepke, Sorrenti, and Zilibotti 2019; Carlana and Corno, 2024). Extracurricular activities for elementary school children, often chosen and funded by parents, can influence their educational paths, including their likelihood of pursuing a degree in science, technology, engineering, and mathematics (a STEM degree) in college. If parents' decisions regarding STEM-related extracurricular activities are influenced by their child's gender, then gender disparities in STEM-degree attainment may have their roots in childhood—since early exposure to such activities is relevant for developing scientific aptitude (Microsoft, 2018; Thomas et al., 2020; Ennes et al., 2023). Understanding how and why parents choose specific extracurricular activities is crucial for addressing gender inequality and its intergenerational transmission.

Research shows that gender differences in mathematics test scores are smaller in early childhood but widen during middle to high school (Hyde et al., 2008; Penner and Paret, 2008; Fryer and Levitt, 2010; Lubienski et al., 2013; Ceci et al., 2014; Kahn and Ginther, 2017). This growing gap contributes to the underrepresentation of adult women in STEM fields. This problem is particularly pronounced in Japan, which has the lowest percentage of women with STEM degrees among OECD countries—only eighteen percent in 2021, compared to forty percent in the United States. Studies indicate that a key factor underlying this gender gap is the fact that parents' perceptions of their children's mathematical and scientific abilities shape their children's future interests and involvement in these subjects (Inoue, 2019; Jacobs and Bleeker, 2004; Wolter and Zollner, 2024). Another related factor is the extent to which parents in Japan encourage STEM activities for their sons more than for their daughters—an issue that has been understudied before this paper.

In this study, we investigate the types of extracurricular activities Japanese children participate in and how these activities differ between girls and boys, even within the same family. The data come from two surveys we conducted of parents with children from kindergarten to junior high school: one from the Tokyo metropolitan area and another focused on families with a child enrolled in extracurricular STEM activities. Our findings reveal that parents' emphasis on early exposure to science is gender-biased. Parents who aspire for their

children to pursue college majors in engineering or science or to obtain a graduate degree—goals which parents hold more often for boys than for girls—are more likely to enroll them in, or to prefer that they participate in, extracurricular STEM activities. Moreover, this gender preference for boys increases from early childhood through adolescence. Because participation in extracurricular STEM activities reflects parental decisions rather than random assignment, these patterns should be interpreted as descriptive associations rather than causal gender differences in take-up. A randomized intervention—for example, offering free STEM classes by lottery—would be better suited to identifying whether take-up differs causally by gender. With our data, however, selection into STEM activities cannot be ruled out.

Such parental behaviors can shape children’s aptitudes and performance in science, ultimately influencing their decision as to whether to pursue a STEM degree. In Japan, the majority of elementary school teachers are not science specialists (i.e., they did not major in science education, science, engineering, or agriculture), and 66 percent report that their knowledge and skills for conducting science observations and experiments are either somewhat insufficient or insufficient (Japan Science and Technology Agency, 2012). As a result, children’s exposure to hands-on science in school may be limited or otherwise inadequate. In such an environment, early skill formation may depend more heavily on parental input and beliefs. Parents who view STEM as valuable may therefore invest in extracurricular STEM activities to foster their children’s scientific skills; however, if such investments are shaped by gendered beliefs, they may also widen gender gaps in later STEM pathways.¹ According to the 2023 Trends in International Mathematics and Science Study (TIMSS), which assessed students in their fourth and eighth years of schooling, Japanese girls at both those ages were less likely than boys to express interest in studying science (National Institute for Educational Policy Research, 2024). This discrepancy may be influenced, at least in part, by differences in parental behaviors.

¹ Related evidence suggests that gender gaps in STEM pathways partly reflect differences in early STEM skill formation. Using German data, Hertweck and Lehner (2025) show that female teenagers are less likely to choose STEM careers unless they acquire strong ICT (Information and Communication Technology) skills during secondary school. Similarly, using Canadian data, Card and Payne (2021) find that most of the gender gap in STEM entry can be attributed to differences in STEM readiness at the high school level.

Encouraging girls to participate in STEM activities from an early age is therefore essential for reducing future gender disparities in STEM fields. As Schiefer et al. (2021) found, extracurricular science activities enhance students' epistemic beliefs and increase their intrinsic motivation and perceived value of science—effects that are especially pronounced among girls. These findings suggest that such interventions can have a lasting impact in promoting girls' engagement with science and encouraging them to pursue STEM careers.

The paper is structured as follows. Section 2 describes the surveys that we conducted. Section 3 presents key findings on gender differences in participation in STEM activities. Section 4 reports estimates from family fixed-effect models on the determinants of participation and preference rankings in STEM activities. Section 5 provides the conclusion.

2 Surveys on Children's Participation in Extracurricular Activities

2.1 Survey Design

We conducted an online survey in January 2024 using a commercial survey firm. Respondents were recruited from the firm's online panel and were eligible to participate if they were married parents residing in the Tokyo metropolitan area with at least one child ranging from pre-kindergarten through junior high school. Parents received modest incentives for completing the survey in the form of reward points redeemable for online shopping. A total of 3,114 respondents were collected; we refer to this sample as the Tokyo Sample. Details of the survey design and questionnaire are provided in the Data Appendix.

The questionnaire asked parents to report each child's participation in extracurricular activities, for up to three children in the household. This design yields multiple child-level observations per parent and allows us to estimate specifications with family fixed-effects, identified from within-family variation among siblings. For each child, parents selected the extracurricular activities the child was currently participating in or had previously participated in from a prespecified list (see the Data Appendix). This list is adapted from the Longitudinal Survey of Newborns in the 21st Century, conducted by Japan's Ministry of Labour and Welfare, which outlines common extracurricular activities among school-age children in Japan. We expanded the list to include two STEM-related activities central to this study: (i) science experiment classes and (ii) robotics and programming classes. The survey also collected

information on children’s grade levels and parental aspirations for each child, including desired educational attainment and preferred field of study. In addition, we collected parental background characteristics, including education, occupation, and household income.

Because participation in STEM extracurricular activities is relatively limited in the Tokyo Sample, it is difficult to characterize families who enroll their children in such activities using that sample alone. To complement the Tokyo Sample, we conducted an online survey in November 2023 of parents whose children were enrolled in structured, in-person, fee-based, year-long STEM extracurricular classes in a laboratory setting offered by one of the largest providers in the Tokyo metropolitan area. The provider offers (i) science-experiment classes and (ii) robotics and programming classes (hereafter, “robotics classes”) for children from kindergarten to junior high school across twelve sites and eight independent courses. Classes meet in person every two weeks for 1.5 hours per session, and monthly tuition averages about 10,000 yen (US\$65), depending on course track.² Approximately two thousand invitation emails were distributed to parents through the company, and 388 parents completed the survey via SurveyMonkey.com. We refer to this dataset as the STEM-class Sample.

As in the Tokyo Sample, parents in the STEM-class Sample reported information not only for the child enrolled in the STEM class but also for up to three children in the family. These parents are, on average, more educated, higher-income parents and report stronger aspirations for their children to pursue STEM degrees (as shown below). We therefore use the STEM-class Sample to complement the Tokyo Sample and to characterize families that opt for formal STEM instruction.

² For comparison, sports activities typically cost between 5,000 and 8,000 yen per month, while music lessons range from 10,000 to 15,000 yen per month. Tutoring in academic subjects is more expensive—typically 30,000 to 70,000 yen per month—reflecting longer instruction time. The STEM classes we discuss here are more expensive than sports and broadly comparable in monthly cost to music lessons. Because these STEM classes require a laboratory environment and are offered primarily in large metropolitan areas, they may also involve location constraints. At the same time, children can engage in STEM-related learning without laboratory environments through lower-cost alternatives, such as home kits and toys, online content, or one-off community events.

3 Key Facts

3.1 Family Background and Gender Differences in Parental Aspirations for Their Children

We begin by describing family characteristics and parental aspirations using the Tokyo Sample. As shown in Table 1, 62 percent of fathers are college graduates and 15 percent hold a graduate degree. Among mothers, 52 percent are college graduates but only 4 percent hold a graduate degree. Regarding family income, 39 percent of families earn more than 10 million yen (approximately US\$65,000), and only 6 percent earn more than 20 million yen. Children participate in extracurricular activities an average of 2.1 days per week for boys and 2.3 days per week for girls.

Parental aspirations in the Tokyo Sample exhibit clear gender differences. Parents are more likely to expect sons than daughters to obtain a graduate degree (9 percent versus 5 percent), while daughters are more likely to be expected to attend junior or technical colleges (4.2 percent versus 2.6 percent). Preferences over fields of study are also gendered: parents disproportionately favor engineering or science majors for sons (32 percent) relative to daughters (15 percent), while expressing stronger preferences for daughters to pursue medical or health-related fields (12 percent versus 7 percent), or humanities or social sciences (15 percent versus 10 percent). Parents are also more likely to report having no specific field preference for daughters (59 percent) than for sons (51 percent). Overall, parents in the Tokyo Sample hold aspirations for higher educational attainment and more specialized engineering- and science-oriented educational pathways for sons than for daughters.

We next present results from the STEM-class Sample for comparison. Parents in this sample are substantially more advantaged socioeconomically. While the share of college-educated fathers is similar to that in the Tokyo Sample, a much larger fraction holds graduate degrees (27 percent). Educational differences are also particularly pronounced among mothers: 65 percent are college graduates, and 13 percent hold graduate degrees. Family income is also considerably higher, with 75 percent of families earning more than 10 million yen and 23 percent earning more than 20 million yen. Children in this sample participate in extracurricular activities more intensively, averaging 3.8 days per week for boys and 3.7 days per week for

girls.

Parental aspirations in the STEM-class Sample are more gender-neutral with respect to degree attainment: aspirations for graduate education are similar for sons (21 percent) and daughters (22 percent). However, gender differences persist in preferred fields of study. Parents are more likely to prefer engineering or science majors for sons (42 percent) than for daughters (24 percent), while expressing stronger preferences for medical or health-related fields for daughters (20 percent versus 7 percent).

These comparisons highlight two key patterns. First, families in the STEM-class Sample represent a more educated, higher-income, and more STEM-oriented subset of parents. Second, although aspirations for degree attainment are more gender-balanced in the STEM-class Sample, preferences over specific fields of study remain gendered in both samples, with engineering or science more strongly associated with sons.

3.2 Gender Differences in STEM Activity Participation

We next examine children's participation in extracurricular STEM activities. In the Tokyo Sample, girls are less likely than boys to have ever participated in either a science class or a robotics class (or both), with the gender difference more pronounced in robotics: 1.6 percent of girls versus 2.0 percent of boys have ever taken a science class, and 2 percent of girls versus 6 percent of boys have ever taken a robotics class.

Table 2 shows family-level participation in children's extracurricular activities. In families with two or more children, enrollment in STEM activities is often concentrated on a single child. Among families with at least one child enrolled in a science class, only 9.8 percent have two or more children enrolled; for robotics classes, the corresponding share is 18 percent (Table 2, Column 3). In contrast, sibling co-enrollment is more common in non-STEM activities: among families with at least one child enrolled, 55 percent have two or more children taking tutoring classes, and 61 percent have two or more children in swimming. Overall, these patterns suggest that, even within the same household, parents often concentrate formal STEM extracurricular participation on only one child, potentially creating within-family differences in STEM

exposure.

4 Econometric Model and Estimation Results

We estimate a linear probability model to examine the determinants of parents' choices (or preference ranking) for children's extracurricular activities, with a focus on science and robotics classes. The model for each child is specified as follows:

$$y_i = \beta_1 \text{Girl}_i + \beta_2 X_i + \beta_3 Z_j + \theta_j + \varepsilon_i,$$

where i indexes child and j indexes families. The outcome variable y_i denotes the activity choice (or ranking) of interest, and Girl_i is an indicator for whether the child is a girl. The vector X_i contains child-level characteristics, including the child's grade and the total number of extracurricular activities in which the child has ever participated. The vector Z_j contains family-level characteristics, including the number of children in the family, the parents' education, family income, and the gender of the parent responding to the survey. The term ε_i is an idiosyncratic error, and θ_j captures unobserved family-level factors. The model is estimated using (i) ordinary least squares and (ii) a family fixed-effects specification that absorbs θ_j . The fixed-effect approach compares siblings within the same household, thereby controlling for unobserved family characteristics (e.g., household environment and family culture) that may influence children's STEM participation. Because families with only one child provide no within-family variation, the identification of β_1 in the fixed-effects model comes exclusively from families with two or more children; accordingly, we report fixed-effect estimates only for selected outcomes.³ Robust standard errors are clustered at the family level in all regressions.

4.1 Gender and Extracurricular STEM Activity Participation

We present estimation results only from the Tokyo Sample from now on because it is a

³ Family fixed effects have the potential to be biased if there are learning effects related to sibling order; for example, if parents adjust their decisions for younger children based on their experiences with older ones, the estimated fixed effects may capture these dynamic adaptations rather than stable family preferences or characteristics. Additionally, the model cannot account for time-varying family shocks, such as changes in income or household circumstances, which may influence children's participation in different ways over time. A randomized intervention—such as offering free STEM classes via a lottery—would be an ideal design to study whether take-up differs causally by gender. Our data, however, do not allow us to identify a causal gender difference in take-up; participation reflects parental decisions, and selection cannot be ruled out.

representative sample of Tokyo metropolitan area.⁴ Panel A of Table 3 and Table 4 (Column 1) reports linear probability model estimates using OLS, for indicators of whether the child has ever participated in a science class or a robotics class, respectively. Participation in STEM extracurricular activities is modest: 2.0 percent of boys have ever participated in a science class and 6.2 percent have ever participated in a robotics class. Girls are 0.4 percentage points less likely than boys to have ever participated in a science class—a small and statistically insignificant difference—whereas they are 4.3 percentage points less likely to have ever participated in a robotics class, which indicates a statistically significant gender gap. The estimate for science classes is small and statistically insignificant, reflecting the very low participation rate in science classes in the Tokyo Sample. In both kinds of classes, households with annual income of 20 million yen or more are significantly more likely to have ever enrolled their children in such classes, whereas families with multiple children are less likely to have ever enrolled any given child.

Panel B of Table 3 and Table 4 (Column 1) reports estimates from specifications with family fixed effects identified only from families with two or more children. The fixed-effects estimates indicate that girls are 0.6 percentage points less likely than boys to have ever participated in a science class and 2.6 percentage points less likely to have ever participated in a robotics class. The robotics estimate remains statistically significant, although smaller in magnitude than the corresponding OLS estimate. In the family-effects estimate, parents who prefer engineering or sciences for their children are 5.4 percentage points more likely to enroll them in robotics classes than parents who report no specific preference for a field of study for their children.

4.2 Within-Family Spillovers of STEM Extracurricular Activity

Existing research highlights the importance of accounting for sibling spillover effects when studying parental investments and aspirations for their children (Nicoletti and Rabe, 2019). We investigate within-family spillovers in STEM extracurricular participation using two

⁴ Estimation results from the STEM-class Sample are available from the authors upon request.

approaches. First, we examine whether STEM participation differs by sibling gender composition. Second, we examine whether an older sibling's STEM participation is associated with a younger sibling's participation, and whether this relationship differs by the younger child's gender. The estimation results for this subsection are presented in Table 5.

We begin by extending our baseline regression by replacing the female indicator with mutually exclusive indicators for: (i) only-child girls, (ii) girls with no brothers, (iii) girls with brothers, (iv) boys with no sisters, and (v) boys with sisters. The reference category is only-child boys, and we include the same set of controls as in the baseline specification. The estimates indicate that, relative to only-child boys, only-child girls are 5.6 percentage points less likely to have ever participated in a robotics class, girls with no brothers are 4.2 percentage points less likely, and girls with brothers are 5.0 percentage points less likely (Column 2, Panel A, Table 5). While the point estimates suggest that girls with brothers may be slightly less likely to have ever participated in a robotics class than girls without any brothers, the difference between these two coefficients is not statistically significant ($p = 0.312$).⁵

Next, we examine whether an older child's participation in STEM activities is related to a younger sibling's participation. We restrict the sample to younger siblings (i.e., second-born and later-born children) and estimate a model in which the dependent variable is the younger child's STEM participation, and the key regressors are (i) an indicator for whether the first-born participated in the STEM extracurricular activity, (ii) an indicator for the younger child being female, and (iii) their interaction, along with the same set of controls.

The evidence we found of within-family spillovers is shown in Panel B of Table 6. For science participation, having a first-born child who has ever participated in a science class is associated with an 18.7 percentage-point higher probability that a younger son has ever participated. The female indicator is -0.1 percentage points (not statistically significant), and the interaction term is -10.6 percentage points (not statistically significant). These estimates suggest that spillovers to younger siblings are larger for boys than for girls, although the difference is not statistically significant ($p = 0.198$).

⁵ For science participation, relative to only-child boys, only-child girls are 0.6 percentage points less likely to have ever participated in a science class, girls with no brothers are 1.5 percentage points less likely, and girls with brothers are 0.4 percentage points less likely (Column 1, Panel A, Table 5). These estimates are smaller than those for robotics, reflecting the much lower rate of participation in science classes in the Tokyo Sample.

We observe a similar but stronger pattern for robotics participation. Having a first-born child who has ever participated in a robotics class is associated with a 27.5 percentage-point higher probability that a younger son has ever participated. The female indicator is -1.7 percentage points, and the interaction term is -17.0 percentage points. These estimates indicate sizable within-family spillovers for boys, with significantly lower spillovers for girls. These patterns are consistent with the possibility that parents place a higher value on STEM experience for boys than for girls.

Furthermore, we explore whether the oldest sibling's gender matters. We find that having an oldest sister who has participated in extracurricular STEM activities is strongly associated with younger boys' participation in such activities: younger boys whose oldest sister has participated in STEM activities are 47.9 percentage points more likely to participate in science and 43.0 percentage points more likely to participate in robotics. The effects of having an oldest brother who has participated in extracurricular STEM activities are more modest: for younger boys, the effects are 7.5 percentage points for science and 24.0 percentage points for robotics, with only the latter being statistically significant. These findings suggest that sibling spillovers may partly reflect household-level preferences for investing in STEM activities. In STEM-oriented households, parents who provide such opportunities to oldest daughters may be at least as willing, and possibly more willing, to provide them to sons. Thus, the strong association between oldest sisters' participation and younger boys' participation may reflect a household environment that strongly encourages STEM involvement, though not necessarily in a gender-neutral way.

4.3 Gender Differences in Parents' Preference Rankings of STEM Extracurricular Activities

Bearing in mind the low participation rates in STEM classes in the Tokyo Sample, we next examine gender differences in parents' rankings of STEM activities for their children. To capture parental preferences independent of actual enrollment, parents were asked to rank extracurricular activities from first to fifth based on how strongly they would like their child to

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participate in them, regardless of whether the child had ever participated in them. The results are reported in Table 3 and Table 4 (Columns 2 to 6): Table 3 presents estimates for science classes and Table 4 for robotics classes. Panel A reports OLS estimates, while Panel B reports family fixed-effects estimates. The dependent variables are indicators for whether a given activity is ranked as a parent's first choice, second (or better), third (or better), fourth (or better), or fifth (or better). Although the family fixed-effects estimates are identified only from families with two or more children, we report results from the family-fixed effects estimates, which control for unobserved family characteristics.

For science classes, there are no significant gender differences in parents' first, second, or third preferences. This is due to the low share of parents who select science as a top-three extracurricular activity. Among boys in the Tokyo Sample, only 0.8 percent of their parents rank science as their first choice, 2.4 percent within the top two, and 5.6 percent within the top three. However, as the share increases to 10.4 percent for boys when considering the top four, parents are 2.8 percentage points less likely to include science among the top four choices for girls compared to boys, and this difference is statistically significant. Similarly, when considering the top five choices—where 14.3 percent of parents include science for boys—parents are 3.9 percentage points less likely to do so for girls, also statistically significant. Thus, a gender gap emerges when considering broader preference rankings beyond the very top.

Parents who aspire for their child to pursue a graduate degree (as opposed to only a college education) are 10.9 percentage points more likely to include science among their top four extracurricular choices. Likewise, parents who prefer that their child obtain an engineering or science degree in college are 4.5 percentage points more likely to include science among their top three choices and 7.3 percentage points more likely to include it in their top four choices, compared to parents who do not include science in their top five choices. These findings suggest that parents view science classes as a form of human capital investment aligned with aspirations for a future career in engineering or science.

Gender disparities are even more pronounced for robotics classes. Parents are consistently more likely to rank robotics higher for boys than for girls: robotics is the top choice for 3.3 percent of boys (1.4 percentage points higher than for girls) and is ranked among the top two choices for 8.8 percent of boys (4.0 percentage points higher than for girls). The gap widens

beyond the very top: robotics is ranked among the top three choices for 17.9 percent of boys (6.8 percentage points higher than for girls), among the top four for 27.6 percent (12.2 percentage points higher), and among the top five for 36.8 percent (14.9 percentage points higher). The regression results also show that parents who prefer an engineering or science major for their child tend to rank robotics higher, placing it among their top choices.⁶

4.4 Parental Preference Rankings for STEM Activity by Child's Grade Level

Lastly, we examine how parents' rankings of science and robotics classes vary with the child's grade level—kindergarten, lower elementary, upper elementary, and middle school; our findings appear in Table 7. This table reports the percentage of parents who include these classes in their top five preferences. For science classes, 7.4 percent of the parents of kindergarten girls and 10 percent of the parents of kindergarten boys list it among their top five choices—a 3 percentage point difference that is not statistically significant. However, as children advance in grade level, parental interest in science classes for their children increases for both girls and boys, and the gender gap becomes significant. The differences are 3.2 percentage points in lower elementary, 4.6 percentage points in upper elementary, and 4.6 percentage points in middle school. By middle school, 13 percent of parents of girls and 18 percent of parents of boys rank science among their top five choices.

For robotics, a clear gender gap emerges even in kindergarten: 17 percent of parents of kindergarten girls versus 29 percent of kindergarten boys include robotics in their top five, a 12 percentage point difference. This gap remains at 12 percentage points in lower elementary school, and expands in upper elementary school to 14 percentage points and in middle school to 18 percentage points. By middle school, 27 percent of parents of girls and 45 percent of parents of boys list robotics among their top five extracurricular preferences.

⁶ The survey asked parents how often their job uses science- and engineering-related knowledge (never, rarely, sometimes, often, or always). We use an indicator for the father's use of such knowledge often or always as a proxy for STEM-related occupational background. This proxy is strongly associated with stated preferences: such parents are more likely to rank science and robotics among their top five choices by 3.7 and 4.9 percentage points, respectively. In contrast, its relationship with children's enrollment in STEM extracurriculars is much smaller and statistically insignificant (0.4 percentage points for science and 0.9 percentage points for robotics), as shown in Table 3 and 4, Panel A.

In sum, parents' preferences for extracurricular STEM activities diverge by gender well before high school. The direct effects on their children's actual intentions can be seen in a 2020 survey of tenth graders at public high schools (i.e., Tokyo's designated high schools for academic excellence) (Usui et al., 2024), which found that female students reported a 14 percent likelihood of choosing STEM fields in college, compared to 34 percent for male students. These percentages were almost identical to the figures for their parents' expectations: parents of female students predicted a 15 percent likelihood of their daughters choosing a major in a STEM field, compared to 35 percent for parents of male students. This disparity is particularly concerning since most Japanese college-preparatory high schools require students to choose a science or humanities track by the start of eleventh grade, while only a few implement this at the start of twelfth grade (National Institute for Educational Policy Research, 2013). Consequently, these early gender differences may lead girls to opt out of the science track; this in turn would limit their exposure to advanced math and science courses in high school and ultimately narrow their future STEM opportunities in college.⁷

5 Conclusion

We find that girls are less likely than boys to participate in extracurricular STEM activities in the Tokyo area of Japan. Moreover, when parents rank their preferred extracurricular activities for their children, they are more likely to favor science and robotics classes for sons than for daughters. Parents who lean toward science classes as an extracurricular activity for a particular child also are more likely to aspire for that child to pursue (i) a graduate degree or (ii) a college major in engineering or science. Notably, these aspirations are more often directed toward boys.

These gender-differentiated parental attitudes and experiences shape children's skills, knowledge, expectations, and motivations related to science.⁸ Parents who value science and

⁷ This contrasts with the United States, where, according to Hyde et al. (2008), girls' lower enrollment in advanced math and science courses was once one of the major explanations for boys outperforming girls on standardized tests in high school. However, by 2000, high school girls were taking calculus at the same rate as boys, resulting in women earning 48 percent of undergraduate degrees in mathematics in the US.

⁸ Studies from the United States also document that gender-differentiated parental attitudes and experiences shape children's skills, knowledge, expectations, and motivations related to science (Eccles et al., 1990; Tenenbaum and Leaper, 2003).

believe their children excel in it are more likely to involve them in scientific activities—a form of positive reinforcement that fosters their children’s interest in science and a self-image aligned with a future career in the field (Eccles-Parsons et al., 1983; Sonnert, 2009; López and Cabello, 2022; Giannola, 2024).⁹ As Crowley et al. (2001) emphasize, parental encouragement not only creates opportunities for children to engage with science but also nurtures their interest and values regarding the discipline.¹⁰ It is important to note that, at present, we cannot disentangle the extent to which our results reflect (1) parental decisions based on their own preferences, or (2) parental decisions informed by their perceptions of the child’s interests or the child’s own intrinsic preferences. Although this distinction currently remains unclear, our findings indicate that parents provide different opportunities to boys and girls, with boys receiving greater exposure to STEM education from early childhood on. These insights point to the need for early interventions—by both parents and educators—to mitigate gender disparities in STEM engagement well before the high school years, when critical academic track decisions are made, in order to address the persistent underrepresentation of women in STEM careers.

⁹ Ikkatai et al. (2020) find that the Japanese public perceives several scientific fields (e.g., physics, chemistry, engineering, information science, mathematics, and biology) as masculine. They further find that this masculine perception is stronger among individuals with less egalitarian gender-role attitudes, suggesting that gender norms shape the masculine image of science in Japan.

¹⁰ Extracurricular STEM activities also matter in the United States. Using US data, Dabney et al. (2011) emphasize the importance of STEM extracurricular activities in primary and secondary education for fostering students’ interest in, and preparedness for, advanced science and mathematics coursework at the university level, with implications for future career trajectories. They argue that, beyond early interest in science, participation in STEM-related activities outside the classroom (e.g., clubs and competitions) during university is positively associated with students’ interest in pursuing STEM careers. Delaney and Devereux (2021) note that college gender gaps are large in fields such as computer science and engineering, which are less commonly taught in school. Cheryan et al. (2017) suggest that expanding exposure to these subjects, possibly by making them compulsory in school or offering them through afterschool programs or clubs, could encourage more girls to study them in higher education.

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Data Appendix

Survey Design and Sample Structure

The data used in this study come from an original survey we conducted in Japan. The questionnaire was administered to the parents, and responses were collected for up to three children per parent. All child-level questions were asked separately for each child.

This appendix documents the wording of the key survey questions and the construction of the main variables used in the analysis.

Extracurricular Activities

Current Extracurricular Activities

Parents were asked to report their child's current extracurricular activities. The question wording was: "Please select your child's current extracurricular activities. You may select all that apply."

The response options were: Abacus, Art/Crafts, Calligraphy (including penmanship), Flower Arrangement (Ikebana)/Tea Ceremony, Foreign language conversation (Conversation in English or other foreign languages), Music (Piano, etc.), Private Tutoring, Robotics/Programming, Science Experiments, Sports, Ballet/Dance, Baseball/Softball, Gymnastics, Martial Arts (Kendo, Judo, etc.), Soccer, Swimming, Tennis, Tutoring Classes in school subjects, Distance Education Course, and Other (please specify).

Past Extracurricular Activities:

Parents were also asked about past extracurricular activities that the child had attended for a sustained period. The question wording was: "Please select any extracurricular activities that your child has attended for six months or longer since the age of four. You may select all that apply." The list of response options was identical to that used for current extracurricular activities.

Construction of STEM Participation Variables

Using information from the current and past extracurricular activity questions, we construct the following indicators:

- Ever-taken science: equals one if the parent selected science experiments in either the current or past extracurricular activity lists; zero otherwise.
- Ever-taken robotics: equals one if the parent selected Robotics / Programming in either the current or past extracurricular activity lists; zero otherwise.

These variables capture cumulative exposure to structured STEM extracurricular activities.

Preference Ranking of Extracurricular Activities

To elicit parental preferences independent of actual enrollment, parents were asked to rank extracurricular activities. The exact wording was:

"Please rank the following extracurricular activities from first to fifth based on your preferences for your child's participation. Include both activities your child is currently attending and those

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they are not, ranking them according to your preference. For example, if your child is currently taking Soccer and Abacus classes, but your true preference ranking (from first to last) is Soccer, Music, Abacus, Tennis, and Calligraphy, you would answer: 1st place: Soccer; 2nd place: Music; 3rd place: Abacus; 4th place: Tennis; and 5th place: Calligraphy. Even if you do not wish for your child to participate in any activities, please answer based on what you would choose if you had to.”

The list of activities to be ranked was the same as the list used in the extracurricular activity questions. From this question, we construct indicators for whether STEM extracurricular activities appear among the parents’ top five-ranked activities for the child.

Parental Aspirations for Child’s Education

Educational Attainment Aspirations

Parents were asked about their desired level of educational attainment for their child. The question wording was:

“How far would you like your child to progress in their education in the future?”

The response options were:

(1) up to junior high school, (2) up to high school, (3) up to vocational school, (4) up to junior college or technical college, (5) up to university, (6) graduate school, (7) other (please specify), and (8) not sure yet.

Preferred Field of Study

Parents were also asked about their preferred field of study for their child. This question was asked only for children whose parents selected options (3)-(6) in the previous question. The wording was: “Which field would you prefer your child to pursue?”

The response options were: (1) science or engineering (natural sciences, engineering, and agriculture), (2) medical or health services (medicine, dentistry, and pharmacy), (3) humanities or social sciences, and (4) no specific preferences.

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Table 1. Summary statistics of variables of interest

<i>Variables</i>	Tokyo Sample	STEM-class Sample	
Father's Education			
High School or Less	0.124	0.038	***
Junior or Technical College	0.113	0.066	**
University	0.617	0.623	
Graduate School	0.146	0.272	***
Mother's Education			
High School or Less	0.129	0.029	***
Junior or Technical College	0.311	0.192	***
University	0.518	0.647	***
Graduate School	0.042	0.131	***
Family Income			
10 million yen and over	0.387	0.745	***
20 million yen and over	0.055	0.234	***
Number of Children	1.758	1.726	
First-born is a girl	0.482	0.284	***
Share of daughters among children (families with ≥ 2 children)	0.482	0.414	**
N	3112	388	

<i>Variables</i>	Tokyo Sample		STEM-class Sample	
	Girls	Boys	Girls	Boys
<i>Extracurricular Activities Children Ever Participated In</i>				
Science	0.016	0.020	0.537	0.616 *
Robotics	0.020	0.062 ***	0.171	0.341 ***
Swimming	0.462	0.517 ***	0.615	0.644
Gymnastics	0.221	0.233	0.405	0.425
Baseball	0.014	0.088 ***	0.034	0.116 ***
Soccer	0.035	0.241 ***	0.029	0.294 ***
Ballet	0.251	0.044 ***	0.493	0.066 ***
Music	0.352	0.155 ***	0.629	0.316 ***
Art	0.059	0.032 ***	0.146	0.094 *
Tutoring	0.411	0.417	0.693	0.691
Activities, Days per Week	2.136	2.290 ***	3.724	3.844
Total Number of Activities	2.640	2.549 *	4.917	4.588
<i>Parental Aspiration for Child's Future Education</i>				
Junior High School	0.005	0.004	0.000	0.009
High School	0.035	0.037	0.010	0.003
Junior or Technical College	0.042	0.026 ***	0.005	0.009
University	0.727	0.710	0.646	0.611
Graduate School	0.045	0.085 ***	0.214	0.215
Not Yet Thought about It	0.146	0.137	0.126	0.146
<i>Parental Aspiration for Child's Future Field of Study</i>				
Engineering or Science	0.145	0.317 ***	0.235	0.424 ***
Medical or Health Services	0.116	0.074 **	0.201	0.071 ***
Humanities or Social Sciences	0.146	0.099 ***	0.029	0.016
No Specific Preferences	0.593	0.510 ***	0.534	0.489
N	2,208	2,321	217	342

Note: The Tokyo Sample is the sample from the Tokyo metropolitan area. The STEM-class Sample is the sample from the parents of children who participate in the science or robotics classes of a private tutoring school.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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Table 2. Family-Level Participation in Children's Extracurricular Activities, by Family Size

(Unit of observations: Family)

Activity	1-Child Families	2+ Child Families				
	Ever participated (share of 1-child families)	Exactly one child ever participated (share of 2+ child families)	2+ children ever participated (share of families with at least one child participated)	Number of 2+ Child Families		
				none participated	one child participated	2+ children participated
	(1)	(2)	(3)	(4)	(5)	(6)
Science	0.028	0.026	0.098	1894	46	5
Robotics	0.070	0.049	0.177	1849	79	17
Tutoring	0.464	0.531	0.554	913	460	572
Swimming	0.490	0.582	0.607	813	445	687
Gymnastics	0.256	0.297	0.371	1368	363	214
Music	0.283	0.334	0.430	1296	370	279
Art	0.069	0.059	0.211	1831	90	24
Ballet	0.171	0.215	0.236	1526	320	99
Baseball	0.036	0.089	0.282	1771	125	49
N	1167	1945				

Note: The sample is from the Tokyo Sample. The unit of observation is the family. Column 1 reports the share of one-child families in which the child has ever participated in the activity. Column 2 reports, among families with two or more children, the share with at least one child who has ever participated, calculated as (5)+(6) divided by (4)+(5)+(6). Column 3 reports, among families with two or more children and with at least one child who has ever participated, the share with two or more children who have ever participated, calculated as (6) divided by (5)+(6). Columns 4-6 report, among families with two or more children, the number of families in which none, exactly one, or two or more children have ever participated in the activity. "Participation" indicates whether the child has ever participated in the activity.

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Table 3. Gendered effects on children's participation in science classes

(Unit of observations: Children)

Panel A: OLS

Independent Variables	Ever Taken	Parental Preference for Science				
	Science	1st	Up to 2nd	Up to 3rd	Up to 4th	Up to 5th
	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.004 (0.004)	-0.006*** (0.002)	-0.009** (0.004)	-0.020*** (0.006)	-0.036*** (0.008)	-0.039*** (0.010)
Number of Children:						
2 Children	-0.006 (0.005)	-0.004 (0.003)	-0.009 (0.005)	-0.016** (0.008)	-0.028*** (0.011)	-0.046*** (0.013)
3+ Children	-0.017*** (0.005)	-0.006* (0.003)	-0.008 (0.007)	-0.017* (0.010)	-0.017 (0.015)	-0.029 (0.018)
Family Income:						
Less than 6 million yen	0.000 (0.004)	0.004 (0.003)	0.007 (0.006)	0.010 (0.010)	0.026** (0.013)	0.015 (0.015)
9 to 10 million yen	-0.004 (0.006)	-0.000 (0.002)	-0.002 (0.007)	0.003 (0.012)	0.012 (0.017)	0.018 (0.020)
10 to 15 million yen	-0.003 (0.006)	0.004 (0.003)	0.008 (0.006)	0.007 (0.009)	0.010 (0.012)	0.006 (0.015)
15 to 20 million yen	0.010 (0.011)	0.001 (0.004)	0.005 (0.009)	0.009 (0.014)	0.014 (0.018)	0.015 (0.024)
20 million and over	0.032** (0.015)	0.009 (0.007)	0.002 (0.009)	0.006 (0.016)	0.042* (0.023)	0.040 (0.027)
Father's Education:						
High School Dropout	0.021 (0.016)	0.012 (0.016)	0.032 (0.027)	0.042 (0.041)	-0.007 (0.041)	-0.033 (0.042)
High School	0.004 (0.005)	-0.005*** (0.002)	-0.005 (0.006)	-0.009 (0.010)	-0.006 (0.016)	0.002 (0.019)
Some College	0.006 (0.005)	0.003 (0.005)	0.007 (0.007)	0.004 (0.010)	-0.009 (0.015)	-0.015 (0.017)
Graduate School	0.015* (0.009)	0.004 (0.004)	0.013 (0.009)	0.018 (0.012)	0.022 (0.016)	0.044** (0.019)
Mother's Education:						
High School Dropout	0.018 (0.022)	-0.005 (0.003)	-0.024*** (0.006)	-0.004 (0.037)	0.030 (0.061)	-0.005 (0.062)
High School	-0.004 (0.005)	-0.001 (0.004)	-0.005 (0.007)	-0.017 (0.011)	-0.021 (0.015)	-0.024 (0.018)
Some College	-0.011** (0.004)	-0.000 (0.002)	-0.008* (0.005)	-0.016** (0.007)	-0.020* (0.011)	-0.026** (0.013)
Graduate School	-0.003 (0.013)	-0.002 (0.006)	0.009 (0.018)	0.009 (0.023)	0.003 (0.027)	-0.004 (0.031)
Father in STEM Occupation	0.004 (0.007)	-0.001 (0.003)	0.006 (0.007)	0.005 (0.010)	0.020 (0.013)	0.039** (0.016)
R²	0.048	0.002	0.007	0.007	0.010	0.017
N	4529	4529	4529	4529	4529	4529
Male Mean	0.020	0.008	0.024	0.056	0.104	0.143

Note: The sample is from the Tokyo Sample. Each column in the table reports ordinary least squares estimates from separate regressions. The dependent variable in each regression is the science-related outcome indicated in the column header. Columns 2–6 use indicators based on parents' preference rankings of extracurricular activities. Parents were asked to rank activities from first to fifth according to how strongly they would like the child to participate, regardless of actual enrollment. The dependent variables indicate whether the STEM activity was ranked first, second or higher, third or higher, fourth or higher, or fifth or higher. The reference category for parental education is university, and the reference category for family income is 6 million to 9 million yen. All regressions control for child's grade level (kindergarten, upper elementary school, and middle school), the total number of extracurricular activities in which the

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child has ever participated, and the gender of the parent who responded to the survey. “Male Mean” is the mean of the dependent variable among boys. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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Table 3. Gendered effects on children's participation in science classes (*continued*)

(Unit of observations: Children)

Panel B: Fixed Effects (families with more than 1 child only)

Independent Variables	Ever Taken	Parental Preference for Science				
	Science	1st	Up to 2nd	Up to 3rd	Up to 4th	Up to 5th
	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.006 (0.006)	0.001 (0.003)	0.004 (0.007)	0.001 (0.011)	-0.028** (0.013)	-0.039** (0.015)
Grade Level (Reference Category: Lower Elementary School)						
Kindergarten	-0.020** (0.010)	-0.002 (0.003)	0.008 (0.006)	-0.023** (0.012)	-0.006 (0.014)	-0.018 (0.017)
Upper Elementary School	0.012* (0.007)	-0.002 (0.003)	0.007 (0.008)	-0.003 (0.011)	-0.008 (0.013)	0.006 (0.015)
Middle School	0.015* (0.008)	0.005 (0.004)	0.012 (0.008)	-0.010 (0.012)	-0.003 (0.016)	0.013 (0.019)
Parental Aspiration for Child's Future Education (Reference Category: University)						
Through High School	-0.023 (0.025)	0.003 (0.003)	-0.004 (0.042)	0.000 (0.054)	-0.050 (0.055)	-0.057 (0.058)
Junior or Technical College	-0.003 (0.033)	0.001 (0.002)	-0.003 (0.008)	0.017 (0.018)	0.087** (0.037)	0.050 (0.044)
Graduate School	0.036 (0.028)	-0.010* (0.005)	-0.024 (0.023)	0.028 (0.052)	0.109** (0.054)	0.102** (0.052)
Not Yet Thought about It	0.008 (0.006)	0.002 (0.002)	-0.001 (0.007)	0.026 (0.026)	0.023 (0.035)	-0.017 (0.044)
Parental Aspiration for Child's Future Field of Study (Reference Category: Have No Specific Preference)						
Engineering, Science	0.007 (0.011)	0.016* (0.009)	0.002 (0.018)	0.045* (0.024)	0.073** (0.029)	0.049 (0.033)
Medical, Health Services	0.009 (0.022)	0.002 (0.004)	0.017 (0.020)	0.047 (0.029)	0.089** (0.035)	0.061 (0.041)
Social Sciences, Humanities	-0.002 (0.019)	-0.016 (0.011)	-0.015 (0.017)	0.028 (0.022)	0.031 (0.037)	0.053 (0.040)
R²	0.014	0.010	0.001	0.008	0.020	0.013
N	3362	3362	3362	3362	3362	3362
Male Mean	0.015	0.004	0.018	0.042	0.080	0.114

Note: The sample is from the Tokyo Sample. Each column in the table reports family fixed-effect estimates from separate regressions, identified using only families with two or more children. The dependent variable in each regression is the science-related outcome indicated in the column header. Columns 2–6 use indicators based on parents' preference rankings of extracurricular activities. Parents were asked to rank activities from first to fifth according to how strongly they would like the child to participate, regardless of actual enrollment. The dependent variables indicate whether the STEM activity was ranked first, second or higher, third or higher, fourth or higher, or fifth or higher. The reference category for parental education is university, and the reference category for family income is 6 million to 9 million yen. All regressions control for child's grade level (kindergarten, upper elementary school, and middle school), the total number of extracurricular activities in which the child has ever participated, and the gender of the parent who responded to the survey. "Male Mean" is the mean of the dependent variable among boys. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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Table 4. Gendered effects on children's participation in robotics classes

(Unit of observations: Children)

Panel A: OLS

Independent Variables	Ever Taken Robotics	Parental Preference for Robotics				
	(1)	1st	Up to 2nd	Up to 3rd	Up to 4th	Up to 5th
Female	-0.043*** (0.006)	-0.016*** (0.005)	-0.042*** (0.008)	-0.087*** (0.010)	-0.121*** (0.012)	-0.140*** (0.014)
Number of Children:						
2 Children	-0.031*** (0.008)	-0.013** (0.006)	-0.039*** (0.010)	-0.049*** (0.013)	-0.056*** (0.016)	-0.056*** (0.017)
3+ Children	-0.033*** (0.009)	-0.020*** (0.008)	-0.050*** (0.013)	-0.067*** (0.017)	-0.100*** (0.020)	-0.097*** (0.023)
Family Income:						
Less than 6 million yen	0.007 (0.008)	-0.007 (0.008)	-0.015 (0.012)	-0.038** (0.016)	-0.042** (0.019)	-0.024 (0.022)
9 to 10 million yen	-0.000 (0.010)	-0.014* (0.008)	-0.011 (0.014)	-0.021 (0.020)	-0.035 (0.023)	-0.037 (0.027)
10 to 15 million yen	0.004 (0.008)	-0.007 (0.007)	-0.022** (0.011)	-0.025 (0.016)	-0.007 (0.019)	-0.007 (0.022)
15 to 20 million yen	0.002 (0.014)	-0.017* (0.009)	-0.018 (0.016)	-0.024 (0.022)	-0.033 (0.027)	-0.009 (0.033)
20 million and over	0.051** (0.021)	-0.026*** (0.008)	-0.050*** (0.015)	-0.035 (0.026)	-0.046 (0.032)	-0.083** (0.035)
Father's Education:						
High School Dropout	0.017 (0.014)	0.060 (0.040)	0.026 (0.041)	0.033 (0.052)	-0.002 (0.056)	-0.022 (0.061)
High School	0.012 (0.011)	0.001 (0.010)	-0.000 (0.015)	0.003 (0.021)	-0.008 (0.024)	-0.002 (0.027)
Some College	0.005 (0.010)	0.004 (0.008)	0.008 (0.013)	-0.008 (0.018)	-0.022 (0.021)	-0.019 (0.025)
Graduate School	0.010 (0.012)	0.014 (0.009)	0.004 (0.013)	-0.019 (0.016)	-0.007 (0.021)	0.003 (0.024)
Mother's Education:						
High School Dropout	-0.030*** (0.011)	0.021 (0.036)	-0.026 (0.036)	0.031 (0.079)	0.038 (0.088)	-0.024 (0.090)
High School	-0.006 (0.011)	-0.001 (0.011)	-0.008 (0.016)	-0.033* (0.019)	-0.047** (0.023)	-0.055** (0.026)
Some College	-0.020*** (0.007)	-0.002 (0.005)	-0.009 (0.009)	0.003 (0.013)	0.003 (0.016)	0.004 (0.018)
Graduate School	0.009 (0.021)	-0.005 (0.013)	0.013 (0.021)	0.026 (0.028)	0.003 (0.035)	0.016 (0.040)
Father in STEM Occupation	0.009 (0.009)	-0.001 (0.007)	0.010 (0.011)	0.028* (0.015)	0.047** (0.019)	0.049** (0.021)
R²	0.076	0.016	0.019	0.032	0.044	0.045
N	4529	4529	4529	4529	4529	4529
Male Mean	0.062	0.033	0.088	0.179	0.276	0.368

Note: The sample is from the Tokyo Sample. Each column in the table reports ordinary least squares estimates from separate regressions. The dependent variable in each regression is the science-related outcome indicated in the column header. Columns 2–6 use indicators based on parents' preference rankings of extracurricular activities. Parents were asked to rank activities from first to fifth according to how strongly they would like the child to participate, regardless of actual enrollment. The dependent variables indicate whether the STEM activity was ranked first, second or higher, third or higher, fourth or higher, or fifth or higher. The reference category for parental education is university, and the reference category for family income is 6 million to 9 million yen. All regressions control for child's grade level (kindergarten, upper elementary school, and middle school), the total number of extracurricular activities in which the child has ever participated, and the gender of the parent who responded to the survey. "Male Mean" is the mean of the dependent variable among boys. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

GENDER DIFFERENCES IN EXTRACURRICULAR ACTIVITIES

Table 4. Gendered effects on children's participation in robotics classes (*continued*)

(Unit of observations: Children)

Panel B: Fixed Effects (families with more than 1 child only)

Independent Variables	Ever Taken	Parental Preference for Robotics				
	Robotics	1st	Up to 2nd	Up to 3rd	Up to 4th	Up to 5th
	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.026*** (0.009)	-0.014** (0.006)	-0.040*** (0.011)	-0.068*** (0.015)	-0.122*** (0.019)	-0.149*** (0.020)
Grade Level (Reference Category: Lower Elementary School)						
Kindergarten	-0.022** (0.011)	-0.006 (0.008)	-0.035** (0.014)	-0.044** (0.018)	-0.060*** (0.023)	-0.074*** (0.023)
Upper Elementary School	0.029*** (0.010)	0.009 (0.007)	0.022* (0.012)	0.027* (0.016)	0.036* (0.020)	0.040** (0.020)
Middle School	0.029** (0.013)	0.009 (0.008)	0.005 (0.014)	0.005 (0.021)	0.008 (0.026)	0.058** (0.025)
Parental Aspiration for Child's Future Education (Reference Category: University)						
Through High School	0.026 (0.036)	0.035 (0.028)	0.068 (0.059)	0.078 (0.068)	0.088 (0.075)	-0.007 (0.082)
Junior or Technical College	0.017* (0.010)	0.009 (0.006)	0.001 (0.046)	0.011 (0.047)	-0.022 (0.058)	-0.069 (0.069)
Graduate School	0.072 (0.048)	-0.003 (0.037)	-0.018 (0.049)	-0.007 (0.072)	-0.001 (0.071)	-0.022 (0.070)
Not Yet Thought about It	0.046** (0.022)	0.014 (0.020)	0.004 (0.033)	0.008 (0.046)	0.066 (0.051)	0.040 (0.058)
Parental Aspiration for Child's Future Field of Study (Reference Category: Have No Specific Preference)						
Engineering, Science	0.054** (0.024)	0.024 (0.018)	0.052* (0.028)	0.115*** (0.037)	0.138*** (0.041)	0.132*** (0.041)
Medical, Health Services	0.017 (0.030)	0.023 (0.018)	0.050 (0.038)	0.090* (0.046)	0.061 (0.049)	0.134*** (0.049)
Social Sciences, Humanities	-0.021 (0.025)	0.007 (0.014)	0.022 (0.024)	0.011 (0.034)	0.013 (0.046)	-0.009 (0.050)
R²	0.042	0.014	0.028	0.039	0.065	0.084
N	3362	3362	3362	3362	3362	3362
Male Mean	0.031	0.021	0.056	0.122	0.198	0.281

Note: The sample is from the Tokyo Sample. Each column in the table reports family fixed-effect estimates from separate regressions, identified using only families with two or more children. The dependent variable in each regression is the science-related outcome indicated in the column header. Columns 2–6 use indicators based on parents' preference rankings of extracurricular activities. Parents were asked to rank activities from first to fifth according to how strongly they would like the child to participate, regardless of actual enrollment. The dependent variables indicate whether the STEM activity was ranked first, second or higher, third or higher, fourth or higher, or fifth or higher. The reference category for parental education is university, and the reference category for family income is 6 million to 9 million yen. All regressions control for child's grade level (kindergarten, upper elementary school, and middle school), the total number of extracurricular activities in which the child has ever participated, and the gender of the parent who responded to the survey. "Male Mean" is the mean of the dependent variable among boys. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

GENDER DIFFERENCES IN EXTRACURRICULAR ACTIVITIES

Table 5. Effects of within-family spillovers of STEM extracurricular activities

(Unit of observations: Children)

Panel A

	Ever Taken Science	Ever Taken Robotics
Independent Variables	(1)	(2)
Only girl	-0.006 (0.006)	-0.056*** (0.008)
Girl with no brothers	-0.015*** (0.005)	-0.042*** (0.009)
Girl with brothers	-0.004 (0.007)	-0.050*** (0.008)
Boy with sisters	-0.006 (0.007)	-0.019* (0.011)
Boy with no sisters	-0.011* (0.006)	-0.024** (0.010)
Number of Children:		
2 Children	-0.003 (0.006)	-0.028*** (0.009)
3+ Children	-0.013** (0.006)	-0.029*** (0.010)
Family Income:		
Less than 6 million yen	0.001 (0.004)	0.007 (0.008)
9 to 10 million yen	-0.003 (0.006)	0.000 (0.010)
10 to 15 million yen	-0.002 (0.006)	0.004 (0.008)
15 to 20 million yen	0.010 (0.011)	0.002 (0.014)
20 million and over	0.032** (0.015)	0.053** (0.021)
Father's Education:		
High School Dropout	0.022 (0.016)	0.018 (0.014)
High School	0.004 (0.005)	0.012 (0.011)
Some College	0.006 (0.005)	0.005 (0.010)
Graduate School	0.015* (0.009)	0.010 (0.012)
Mother's Education:		
High School Dropout	0.017 (0.022)	-0.030*** (0.012)
High School	-0.004 (0.005)	-0.006 (0.011)
Some College	-0.010** (0.004)	-0.019*** (0.007)
Graduate School	-0.003 (0.013)	0.009 (0.021)
Father in STEM Occupation	0.004 (0.007)	0.008 (0.009)
R²	0.048	0.076
N	4529	4529
Male Mean	0.020	0.062

Note: The sample is from the Tokyo Sample. Each column in the table reports ordinary least squares estimates from separate regressions. The dependent variable in each regression is the science-related outcome indicated in the column header. The reference category for parental education is university, and the reference category for family income is 6 million to 9 million yen. All regressions control for child's grade level (kindergarten, upper elementary school, and middle school), the total number of extracurricular activities in which the child has ever participated, and the gender of the parent who responded to the survey. "Male Mean" is the mean of the dependent variable among boys. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

GENDER DIFFERENCES IN EXTRACURRICULAR ACTIVITIES

Table 6. Effects of within-family spillovers of STEM extracurricular activities (*continued*)

(Unit of observations: Children)

Panel B

Independent Variables	Ever Taken Science			Ever Taken Robotics		
	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.001 (0.004)	-0.003 (0.004)	0.000 (0.004)	-0.017*** (0.006)	-0.017*** (0.006)	-0.024*** (0.007)
Oldest sibling ever took science	0.187* (0.102)					
Oldest sibling ever took science × Female	-0.106 (0.119)					
Oldest brother ever took science		0.075 (0.085)				
Oldest brother ever took science × Female		0.053 (0.124)				
Oldest sister ever took science			0.479* (0.249)			
Oldest sister ever took science × Female			-0.497** (0.249)			
Oldest sibling ever took robotics				0.275*** (0.069)		
Oldest sibling ever took robotics × Female				-0.170** (0.085)		
Oldest brother ever took robotics					0.240*** (0.073)	
Oldest brother ever took robotics × Female					-0.186** (0.083)	
Oldest sister ever took robotics						0.430** (0.195)
Oldest sister ever took robotics × Female						-0.185 (0.247)
R²	0.051	0.028	0.068	0.120	0.092	0.084
N	1850	1850	1850	1850	1850	1850
Male Mean	0.010	0.010	0.010	0.036	0.036	0.036

Note: The sample is from the Tokyo Sample and is restricted to younger siblings (i.e., second-born and later-born children). Each column in the table reports ordinary least squares estimates from separate regressions. The dependent variable in each regression is the science-related outcome indicated in the column header. The reference category for parental education is university, and the reference category for family income is 6 million to 9 million yen. All regressions control for child's grade level (kindergarten, upper elementary school, and middle school), the total number of extracurricular activities in which the child has ever participated, and the gender of the parent who responded to the survey. "Male Mean" is the mean of the dependent variable among boys. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

GENDER DIFFERENCES IN EXTRACURRICULAR ACTIVITIES

Table 7. Parental preference rankings for science/robotics classes by child's grade level

(Unit of observations: Children)

Parental Preference for Science	Kindergarten		Lower Elementary		Upper Elementary		Middle School	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st	0.0%	0.3%	0.3%	0.3%	0.0%	0.9% **	0.3%	1.4% **
Up to 2nd	1.1%	1.1%	0.7%	1.9% *	2.2%	1.9%	1.7%	4.3% **
Up to 3rd	1.8%	3.3%	2.6%	5.4% **	4.5%	5.3%	4.2%	7.3% **
Up to 4th	5.0%	7.9%	6.4%	8.9%	7.4%	11% **	7.5%	13% ***
Up to 5th	7.4%	10%	9.1%	12% **	11%	15% **	13%	18% **
N	379	366	607	644	649	684	573	627
Parental Preference for Robotics								
1st	1.3%	1.9%	1.3%	3.6% **	1.8%	3.1%	1.6%	4.0% **
Up to 2nd	4.0%	4.4%	3.5%	9.0% ***	5.2%	9.4% ***	4.7%	11% ***
Up to 3rd	7.9%	12% *	7.6%	16% ***	9.4%	18% ***	10%	23% ***
Up to 4th	12%	19% ***	14%	25% ***	15%	28% ***	18%	35% ***
Up to 5th	17%	29% ***	22%	34% ***	22%	36% ***	27%	45% ***
N	379	366	607	644	649	684	573	627

Note: The sample is drawn from the Tokyo sample, and the unit of observation is the child. In the far-left column, the numbers in boldface indicate parental preferences as follows: “1st” means that subject was the parents’ first choice, “Up to 2nd” means that subject was parents’ first or second choice; “Up to 3rd” means that subject was parents’ first, second, or third choice, and so forth. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$