Parental Investments in Early Childhood and the Gender Gap in Math and Literacy

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As early as middle school, girls self-select out of Science, Technology, Engineering and Mathematics (STEM) courses at greater rates than boys (Fiala et al., 2022; Kraft et al., 2022). Why? We link women's under-representation in STEM to their over-representation in non-STEM fields (see Charles and Bradley, 2002). Prior work argues that this over-representation arises from women's comparative advantage in language arts (Breda and Napp, 2019; Goulas et al., 2020), which emerges as early as age 5 (DiPrete and Jennings, 2011).

A key question, therefore, is why might women have a comparative advantage in language arts? Since this advantage appears to arise early, early parental investments may play a role. As List et al. (2018) and others argue, parents play a central role in the development of child skills.

In this paper, we use a longitudinal field experiment with 953 children and their parents to investigate whether there are differences in parental investments at early ages by child gender. We further investigate whether such investments are associated with test scores in math and language arts at older ages.

We first survey parents on time spent teaching to children when they are 3-5 years old. We then collect data on Math and English test scores when children are 8-14 years old. Finally, we use a field experiment to explore whether early childhood interventions affect gender gaps in parental investments.

I. Data

Our data are from the Chicago Heights Early Childhood Center (CHECC), a pre-school that we built in Chicago Heights, Illinois in 2010. Our field experiment was subsequently conducted from 2010-14. CHECC involved interventions focusing on preschool, parental investment, or both. Since CHECC ran for four years, there are four cohorts of children in the study.

In 2010-14 when participating children were 3-5 years old, we assessed child skills before, during, and after each year of program participation. We also collected survey data from parents during these assessments. Our measure of parental investment is the time that

any family member spent teaching the child on a typical weekday. We also collected measures of parental beliefs - parents were asked about their child's math abilities, reading abilities, and likelihood of attending college.

Following the CHECC program, children attended public elementary schools in the area. In 2014-19 when children were 8-14 years old (grades 3-8), we collected administrative data on Math and English standardized test scores from the Illinois State Board of Education. The test used was the Partnership for Assessment of Readiness for College and Careers (PARCC) (see Online Appendix).

CHECC randomized children to one of the following groups (see Fryer et al., 2015; 2020):

- Preschool (PK): Free full- or part-day center-based program for children.
- Parent Academy (PA): bi-monthly class for parents on how to teach similar material at home. Parents in PA received incentives to invest in their children.
- The control group did not receive educational services from us but might have received services from elsewhere.

Of the 2,185 CHECC children, parents of 953 children completed the year-end parent survey. We have data on PARCC scores for 702 of these children. These 702 children (32% of 2,185) comprise the sample used in Figure 1 and Table 1. For Figures 2-3, where we separately report effects by control or treatment condition, we use a randomly selected sub-sample of 673 children who were less likely to experience selective attrition (see Appendix A.1 and Figure B.1).

Below, we report summary statistics on the gender gap in English and Math PARCC scores through grade 7. The sample size declines starting in grade 5 since our youngest cohorts were not old enough to reach grade 5 at the time of data collection. Therefore, we only report the relationship between parental investment and PARCC scores for grades 3-5.

Control variables include child gender, race, age, home language (English or Spanish), and year of program participation.

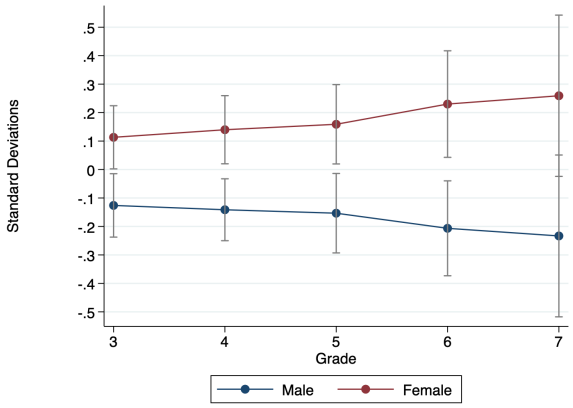
II. Results

A. Gender gaps in test scores

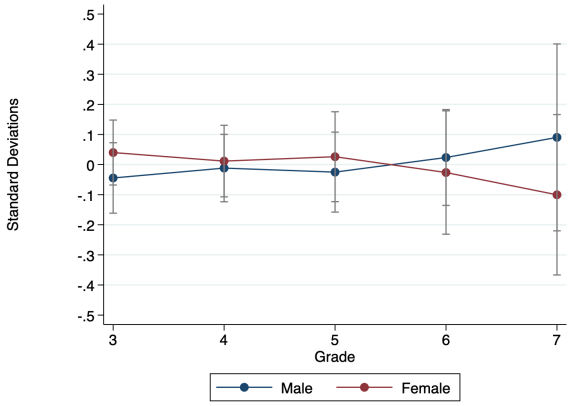
The administrative data on test scores shows that girls score higher on English than boys (see Figure 1, panel A). The gender gap is already significant by grade 3, the earliest grade for which PARCC scores are available. The English gap steadily grows from 0.24 SD in grade 3 to 0.31 in grade 5 and 0.49 in grade 7 ($p<0.01$ for each grade). These gaps are higher than gaps in related work, which range between 0.14 SD and 0.33 SD (DiPrete and Jennings, 2011; Breda and Napp, 2019; Loveless, 2015).

In contrast, Figure 1 panel B shows no significant gaps in Math scores in grades 3-7. The gap directionally favors girls in grade 3 but diminishes over time, reversing to favor boys by grade 6 ($p>0.10$ for all grades). Our results align with some prior studies which find no significant gap in math abilities (see Hyde et al., 2008). However, this literature is mixed, with other studies finding math ability gaps by grade 2 (Cimpian et al., 2016).

Figure 1. Test Scores by Child Gender, Grades 3-7



A: English



B: Math

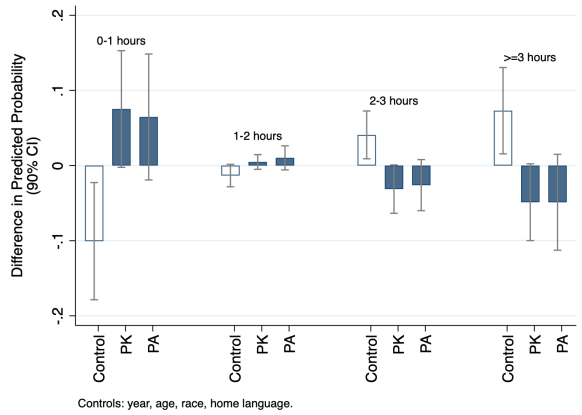
B. Parental investment in early childhood

We next investigate whether parental investment at ages 3-5 contributes to the gap in English scores. Parental investment measures are categorical, so we estimate ordered probit regression models. Figure 2 depicts the gender gap (girls - boys) in the predicted probability of teaching less than 1 hour, 1-2 hours, 2-3 hours, or more than 3 hours per typical weekday. We first describe results for the control group and discuss the treatment groups in Section II.D.

Results for the control group are depicted in the hollow bars, with 90% confidence intervals in brackets. Parents invest more in girls than in boys. Relative to parents of boys, parents of girls are 10.1 percentage points less likely to report investing less than an hour, 4.1 percentage points more likely to report teaching 2-3 hours, and 7.3 percentage points more likely to report teaching more than 3 hours ($p<0.05$ for all estimates).

We then ask whether early parental investment is associated with test scores in later grades. Table 1 displays the results from regressing English and Math scores in grades 3-5 on parental investment at ages 3-5. Panel A shows results for English scores. Relative to the omitted category of teaching 0-1 hours, we find that being taught 1-2 hours, 2-3 hours, or 3 or more hours predict higher English scores for grades 3-4. Parental investments of 1-2 or 2-3 hours predict English scores that are 0.2 SD

Figure 2: Gender Gap in Parent Teaching, Ages 3-5 (Girls – Boys)



higher than teaching 0-1 hours for grades 3-4 ($p<0.10$). Investments of 3 or more hours predict a gain of 0.30-0.37 SD in English scores relative to teaching 0-1 hours ($p<0.05$). Results for teaching less than 3 hours are smaller and insignificant by grade 5. This could be because sample size diminishes in older grades, or because associations truly fade over time.

Panel B shows that Math scores have a weaker relationship with parental investment. Relative to children who were taught 0-1 hours, children who were taught 1-2 or 2-3 hours do not exhibit a significant advantage in math at later ages. As with English scores, the largest gains occur for children who were taught 3 or more hours. These children exhibit gains of 0.25-0.30 SD in grades 3-4 ($p<0.05$) that become insignificant by grade 5.

Our results align with prior work that finds greater parental investments in girls than boys at early ages, especially in language arts, which

Table 1: Test Scores and Parental Investment

	(1)	(2)	(3)
	Grade 3	**Grade 4**	**Grade 5**
	Panel A: English		
Teach 1-2 hrs	0.185*	0.222**	0.193
	(0.112)	(0.111)	(0.133)
Teach 2-3 hrs	0.193*	0.213*	0.0747
	(0.112)	(0.118)	(0.147)
Teach 3 or more hrs	0.297**	0.367***	0.336**
	(0.116)	(0.124)	(0.159)
Female	0.220***	0.282***	0.300***
	(0.081)	(0.0820)	(0.0980)
Cons	-0.006	-0.455	-0.190
	(0.303)	(0.326)	(0.375)
Obs	592	551	369
R-sq	0.093	0.085	0.076
	Panel B: Math		
Teach 1-2 hrs	0.0689	0.0532	0.138
	(0.106)	(0.110)	(0.139)
Teach 2-3 hrs	0.180	0.0644	0.129
	(0.114)	(0.120)	(0.149)
Teach 3 or more hrs	0.235**	0.288**	0.255
	(0.111)	(0.121)	(0.177)
Female	0.0769	0.0313	0.0797
	(0.079)	(0.0835)	(0.109)
Cons	0.506*	-0.0162	0.153
	(0.279)	(0.306)	(0.390)
Obs	590	552	370
R-sq	0.069	0.046	0.043

Regressions of English and math scores in grades 3-5 on parental investment at ages 3-5. Omitted category is teaching 0-1 hours per typical weekday. Regressions control for year, gender, race, and home language. Standard errors clustered by family. *** p<0.01, ** p<0.05, * p<0.10

then contribute to the gender gap in test scores and educational attainment (Baker and Milligan, 2016).

C. Why do parents invest more in girls?

Parents may invest more if they believe their children are highly skilled and that investments are most valuable for high skilled children. Our ordered probit estimates provide some evidence that the gender gap in investments is driven by a gender gap in beliefs (see Figure 3). Beliefs about reading and math abilities are more optimistic for daughters than sons. Parents of boys are more likely to report that their child's reading and math abilities are the same or lower than other children's ($p<0.05$), while parents of girls are more likely to report that their child's abilities are higher than other children ($p<0.01$ for reading and $p<0.05$ for math). List et al. (2021a, 2021b) show that these beliefs correlate with SES and child skills at a young age.

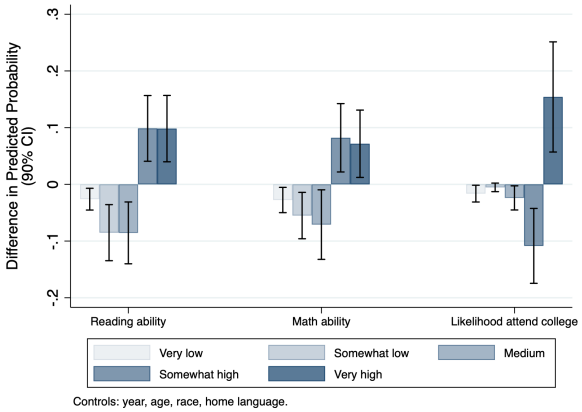
Parents of girls are more optimistic about their child's likelihood of attending college than parents of boys. While almost all parents report that their child is likely to attend college, parents of boys tend to state that their child is "somewhat likely" to attend college, while parents of girls tend to state that their child is "very likely" to attend college ($p<0.01$).

Parents may also invest more in girls if it is less costly than teaching to boys. When children were 3-5 years old, we collected data on self-regulation (e.g., ability to sit still and focus) at baseline, prior to program participation. We find that girls' self-regulation scores were higher than boys' by 0.032 SD ($p<0.05$). Parents were also 18.3 percentage points more likely to report that girls like it when they teach, compared to boys ($p<0.05$). Appendix Table B.1 reports the results.

We do not find evidence that parents' perceptions of their own teaching affect the gender investment gap. Appendix Table B.1 reports no difference by child gender on responses to questions about how much parents like teaching, parents' beliefs of how good they are at teaching, or parents' attitudes regarding the importance of their child's academic success. Together, our evidence suggests that the gender gap in investment is driven by child behavior and abilities, rather than by parents'

Figure 3: Gender gaps in parental beliefs about child ability, ages 3-5

(Girls – Boys)



perceptions of their own teaching abilities or attitudes regarding academic success.

D. Effect of our interventions on investments

The CHECC Preschool (PK) and Parent Academy (PA) programs reduce the gap in parental investment. The solid bars in Figure 2 show that there are no significant differences in parental investment by child gender in the intervention groups.

How did the interventions reduce these gender gaps? Ordered probit estimates show that treatment differentially impacted parental investment by child gender. Specifically, Parent Academy raised parental investment for boys, while Preschool lowered investment for girls. Relative to control, parents in Parent Academy were less likely to spend 0-1 hours and more likely to spend 2 hours or more teaching to their boys ($p<0.10$). In contrast, parents in the Preschool group were more likely to spend 0-1 hours and less likely to spend 2 hours or more teaching to girls ($p<0.05$) (see Appendix Table B.2).

We can only speculate why the treatments had differential impact by child gender. Since Parent Academy provides financial incentives to encourage parents to invest in their children, we expect Parent Academy to raise investment overall. However, parents of girls were already investing more than parents of boys. We may therefore expect there to be more "room" for our interventions to raise investment for boys. Alternatively, Preschool takes children away from parents for many hours of the day, which decreases the time available for parental teaching. For parents who were spending a great deal of time teaching, we would expect declines in teaching time. Since parents of girls were more likely to fall under this category, this might be a driver for why we find significant declines in parental investment received by girls.

Conclusion

We find that girls build a comparative advantage in non-STEM fields as early as grade 3, outperforming boys in English but not in Math. Parents invest more in girls than in boys at early ages, and these investments are more strongly correlated with English than Math scores. In exploring why these gaps arise early, we find that parents' beliefs are more optimistic for girls than boys, and girls have better self-regulation skills at early ages than boys, which may make them easier to teach.

Why is there a stronger link between parental investment and English, compared to Math? Our data cannot answer such questions. However, one possibility is that investments at early ages tend to focus more on reading than on math (Cannon and Ginsburg, 2008).[i]

Another is that parents are less likely to teach math to girls than to boys (Jacobs et al., 2005).[ii]

One implication of our paper is that parental investments may help shape the gender gap in children's non-STEM abilities. Girls may be more likely to choose non-STEM fields if they establish an early comparative advantage, due in part to parents' greater investment in girls than boys. Interventions that improve parental teaching in math could therefore mitigate gender disparities across STEM and non-STEM specializations.

Our take-aways are that parental investments exhibit a gender gap, and that investments are associated with later-life schooling outcomes, which also exhibit a gap. However, note that our study does not establish a causal link between parental investment and girls' advantage in English. Instead, our paper highlights the value of future work that explores these questions in a causal framework.

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[i] If so, one may expect that parental investments have a larger effect on English scores when parents speak English at home. We find no evidence of differences in the correlation between parental investments and English scores by home language. Relatedly, we find no evidence that parental investment differentially predicts English scores based on parental education. However, we may be underpowered to detect these effects.

[ii] We surveyed parents on parental teaching in math and reading. We find no significant differences in the amount of reading or math taught by child gender (Appendix Table B.3). However, we did not systematically ask parents these questions every year, so our results are not representative of all cohorts.