Amid debates about the continued salience of gender in mathematics, this report summarizes an IES-funded investigation of gender-related patterns in the Early Childhood Longitudinal Study—Kindergarten Class of 1998–99 (ECLS-K). Girls’ and boys’ mathematics achievement, confidence, and interest were examined, along with experiences at home and school. Mathematics performance gaps favoring boys appeared soon after children began kindergarten and then widened during elementary grades. Gender differences in mathematical confidence were larger than differences in both achievement and interest. Although boys’ and girls’ parent-reported home experiences differed in stereotypical ways, particularly among high-SES students, such differences appeared unrelated to gender gaps in mathematics outcomes. Teacher-reported instructional practices also shed little light on gender gaps in mathematics performance; however, teachers’ perceptions of girls and boys could play a role.

Key words: Attitudes; Early Childhood Longitudinal Study; Elementary school; Gender; Mathematics achievement; Mathematics teaching; Parenting; Socioeconomic status

This report highlights findings from an extensive analysis of data from the Early Childhood Longitudinal Study—Kindergarten Class of 1998–99 (ECLS-K). The study examined gender and mathematics with the following foci: achievement, confidence, interest, home experiences, and teachers’ instructional practices. Some of the analyses produced significant results that have been presented at the NCTM Research Presession and the AERA annual meeting and have been (or will be) published in the American Educational Research Journal and Developmental Psychology. Other components produced null or tangentially intriguing results that do not, in themselves, merit a full article but may be useful to mathematics education researchers.

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A JRME Brief Report can serve various purposes, and in this case, we use this venue to pull together a variety of findings from our ECLS-K study that mathematics education researchers might not otherwise encounter, either because the findings are unpublished or because they are published in more general or psychology-related journals. The results discussed here can inform future large-scale analyses of ECLS-K and other datasets, future studies of gender and mathematics education, as well as studies of elementary mathematics achievement more generally. Indeed, even null results can be helpful in deterring other researchers from seeking nonexistent relationships in this and other datasets, and such results have implications for the variables that should and should not be included in future examinations of gender and mathematics achievement.

In the first three sections below, we provide a cursory overview of our findings related to gender patterns in achievement, teacher ratings, and attitudes. The findings related to achievement and teacher ratings are published elsewhere (Robinson & Lubienski, 2011; Robinson, Lubienski, Ganley, & Copur-Gencturk, accepted for publication), and the findings related to attitudes have laid the groundwork for more in-depth analyses that are ongoing and will be the focus of future articles. In the remaining sections, we discuss gender patterns in home experiences and instructional practices in more detail. These findings are not published elsewhere, but the methods and results are discussed in an unpublished report submitted to the Institute of Education Sciences (Lubienski, Crane, & Robinson, 2011).

Achievement Patterns by Gender

In recent analyses of various datasets, some researchers have concluded that gender gaps in mathematics are very small (Lindberg, Hyde, Petersen, & Linn, 2010) or insignificant (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). However, such null findings may be due, in part, to the purpose of some tests used. For example, state assessments are generally designed to assess whether or not students meet specific standards or benchmarks, as opposed to measuring individual achievement accurately across the entire achievement distribution.

In contrast, the nationally representative ECLS-K assessments use item response theory (IRT) and an adaptive-stage design to precisely measure the performance of students as they progress from kindergarten through Grade 8 (with data collected in Grades K, 1, 3, 5, and 8). The ECLS-K sample began

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1 Damarin and Erchick (2010) rightly caution that large-scale analyses such as those reported here do not help us understand individuals’ experiences and agency. However, they also note that such research has helped illuminate and improve the education of females. Additionally, Damarin and Erchick warn about the conflation of the terms sex and gender. Although we use a binary ECLS-K variable (boy versus girl), we use gender and not sex throughout this manuscript for the sake of consistency and in recognition of the social factors that influence boys’ and girls’ experiences and outcomes.

2 More specifically, at each wave of data collection, each student was given a brief math routing test and then a math test at the appropriate level. Based upon students’ responses to the questions administered, psychometric models were used to estimate the total number of items each student would have answered correctly, if he or she had been given all items (for more details on the ECLS-K IRT-based test, see Najarian, Pollack, & Sorongon, 2009).
with approximately 21,000 kindergarten students from 1,277 schools.

We estimated the achievement gap between boys and girls using several analytic techniques, including quantile regression, a method that allows us to compare the achievement of boys at a given percentile (e.g., the 90th percentile) of their distribution with that of girls at the same percentile of their distribution. We found that boys’ and girls’ mathematics proficiency does not significantly differ at the start of kindergarten, but a significant advantage for boys is evident at the top of the achievement distribution by the end of kindergarten. This disparity spreads throughout the distribution (i.e., to the lower percentiles of achievement), and the average gap peaks at roughly 0.24 SDs in Grades 3 and 5 (Robinson & Lubienski, 2011). These findings are consistent with other analyses of ECLS-K (e.g., Penner & Paret, 2008). Surprisingly, we also found that the gender gap narrowed slightly between Grades 5 and 8.

Our unpublished analyses also revealed that gender gaps in mathematics performance are larger among high-SES than low-SES students beginning in Grade 3 (Lubienski, Crane, & Robinson, 2011). We examined gaps for African-American, Latino/a, White, and Asian-American students and found them to be most prevalent among Asian-American students (0.1–0.4 SDs at all grades) and smallest among Latino/a students (0.1 SDs or less). Unlike prior research indicating no gender gap for African-American students (e.g., McGraw, Lubienski, & Strutchens, 2006), we found that gender gaps tended to favor African-American boys at Grades 3, 5, and 8 (0.1–0.4 SDs).

Teacher Ratings by Gender

In initial examinations of teachers’ perceptions of students’ mathematical proficiency, we were surprised to see that teachers rated girls higher than equally achieving boys (Robinson & Lubienski, 2011). We also found that teachers rated girls significantly higher (0.3–0.4 SDs) than boys on self control and work ethic, and rated boys almost 0.5 SDs higher than girls in externalizing problem behaviors, a composite variable that included acting impulsively and disturbing the class (Lubienski, Crane, & Robinson, 2011).³

Upon further investigation, we discovered that teachers appeared to conflate girls’ compliance with their mathematics proficiency. Using multilevel models, we found that after statistically accounting for students’ test scores and teacher-rated classroom behavior, teachers, particularly female teachers, rated boys’ proficiency in mathematics higher than that of similarly achieving and behaving girls. Furthermore, we found that this differential rating appeared to contribute substantially to the growth of the gender gap in ECLS-K mathematics performance (Robinson et al., accepted for publication). The highly complex details of this analysis of teacher ratings and achievement are beyond the scope of this report. In

³ Variable names and descriptions used throughout this article are taken from the ECLS-K Questionnaires for teachers and parents. Composite variables are described in the ECLS-K User’s Manuals. These documents are available at http://nces.ed.gov/ecls/kinderinstruments.asp.
brief, this analysis incorporated propensity-score matching and instrumental variables. We found that, among matched sets of boys and girls with similar mathematics performance and behavior, the tendency for teachers to underrate the performance of girls explained a substantial portion of the growth in the gender gap. For example, between kindergarten and Grade 1, the gender gap grew (favoring boys) by about 0.15 SDs among boys and girls who were matched in terms of prior achievement and behavior, but after accounting for teacher ratings, the gender gap grew by only 0.08 SDs among this same matched sample. Thus, teacher ratings mediated about half of the growth in the gender gap from kindergarten to Grade 1. Similar patterns were found at other grade levels.

Although one could argue that teacher ratings are at least as valid a measure of student understanding as test performance, it is worth noting that this pattern of teachers rating boys’ mathematics proficiency higher than that of girls with similar behavior and test scores is unique to gender and mathematics—we found no such pattern for groups that differ by race/ethnicity or SES, nor did we see similar gender patterns in reading.

**Gender and Attitudes**

Although women in the United States are at least as likely as men to pursue many science-related careers (e.g., biology), women remain underrepresented in higher paying, mathematics-intensive fields. For example, women still earn less than 20% of bachelor’s degrees in engineering and computer science (Snyder & Dillow, 2011). Previously, Noddings (1998) raised the question of whether girls are simply less interested than boys in mathematics and suggested that perhaps society should encourage and value girls’ preferred pursuit of other fields.

However, our analysis of ECLS-K data tells a different story. We found that gender gaps in mathematical confidence were substantially larger than gaps in actual performance, with disparities in interest being smallest of all (see Figure 1). Specifically, the effect sizes of the boy-girl disparities in mathematics achievement, confidence, and interest were 0.19, 0.33, and 0.14, respectively, at Grade 3 and 0.23, 0.29, and 0.07 at Grade 5 (Lubienski, Crane, & Robinson 2011).

These findings are consistent with TIMSS and PISA reports of girls throughout the world having substantially less mathematical confidence than boys (Else-Quest, Hyde, & Linn, 2010). However, our ECLS-K findings highlight that gender gaps in mathematics confidence are larger than what is warranted by achievement differences. Furthermore, the findings highlight that it is gaps in confidence—not interest—that appear most problematic. Still, some caution is warranted, given

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4 Grades 3 and 5 are the two grades for which ECLS-K contains consistent measures of students’ mathematical confidence and interest. Each of the six differences tested were significant at the $p < .001$ level, with the exception of fifth-grade interest, for which $p < .05$.

5 We are following up on these descriptive findings with a more detailed analysis using structural equation modeling to examine potential reciprocal relationships between confidence, achievement, and interest as students progress through school.
that girls and boys might interpret and report survey questions about confidence and interest differently, and this could influence the findings reported here.

Gender and Home Experiences

Parents of children in the ECLS-K sample answered hundreds of questions (via telephone interviews) regarding children’s experiences and resources at home. Our analyses involving these parent-reported variables are not published elsewhere and are therefore presented in some detail here.

We selected the roughly 100 kindergarten parent-reported variables that could reasonably differ by child gender and influence student achievement. In order to identify which of these variables were most closely related to gender, we used stepwise logistic regression, with gender as the outcome and the parent-reported variables as predictors. The forward–backward stepwise approach involved first selecting the strongest predictor to include in the model, then selecting the next strongest predictor, and then the next, but ultimately deleting any previously selected predictors that became nonsignificant when other significant predictors were included. The change in \( p \)-value of the \( F \)-statistic required for inclusion of potential variables was set at the standard .05, and the value for removal was set at .10. To decrease the probability that a variable would appear significant by chance, a split-sample design was employed, with half of the data used to confirm the findings initially found in the other half (Lubienski, Crane, & Robinson, 2011).

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Figure 1. Effect sizes for significant gender differences in achievement, confidence, and interest, Grades 3 and 5

6 Logistic regression was used because the predicted outcome (gender) is binary. Although it might feel backward to have gender as the outcome, this method allowed us to identify which of many different predictors related most closely to gender.
Table 1 contains the girls’ and boys’ means for those variables that significantly differed by gender within each half of the split sample. We found no significant gender differences for many items, including weekday bedtimes, several computer-related variables, most parent discipline practices, and a variety of family activities. Most of the gender differences that were significant were consistent with traditional stereotypes, with parents more often building things and encouraging sports with their sons, versus reading, singing, and encouraging arts participation with their daughters. Parents of sons were also slightly more likely to have contacted the school about their child and to discipline by removing privileges.

**Gender and Parenting Patterns by SES**

We examined whether gender patterns in students’ home experiences differed by demographics and found that, consistent with Lareau (2003), patterns varied more by SES than by race/ethnicity. Despite higher-SES parents’ assertions of egalitarian views regarding gender roles (Marks, Lam, & McHale, 2009), we found that gender disparities in children’s experiences were larger in high-SES families than in low-SES families (see Table 2). These disparities appear linked to high-SES parents’ initiation of activities, such as dance lessons and team sports. In fact, it is worth noting that gender differences were far larger for organized group sports (generally requiring parent registration and transportation) than for informal sports more likely to be initiated by children (e.g., biking), with differences particularly large for high-SES children. Despite their intentions, it seems that high-SES parents’ concerted cultivation efforts (i.e., fostering children’s abilities through numerous organized activities—see Lareau, 2003) might contribute to the gendering of their sons and daughters.

**Gender, Home Experiences, and Mathematics Achievement**

After identifying the home experience variables that differed consistently by gender, we examined the relationship between those variables and students’ kindergarten mathematics achievement using OLS regression (with typical demographic variables in the models, including SES and race/ethnicity). Of the variables more prevalent for boys, only participation in athletic events correlated positively with kindergarten mathematics achievement. Moreover, girls’ traditional activities, such as dance lessons, tended to be positive—not negative—correlates of kindergarten mathematics achievement. We conducted further analyses and found that these gendered activities did not consistently predict achievement within each SES quintile, suggesting that these activities likely serve as proxies for more active parenting and are not necessarily causal predictors of achievement.

Through the use of additional OLS regression models, we found that none of the gender-related variables examined at kindergarten actually predicted mathematics achievement gains for boys or girls during elementary school. Despite the availability of a wide variety of parent-reported variables on children’s home experiences, the ECLS-K data shed little light on parenting differences that shape early
Table 1
Descriptive Statistics of Parent-Reported Variables That Significantly Differed by Gender

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
<th>Girls Mean</th>
<th>Girls SD</th>
<th>Boys Mean</th>
<th>Boys SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Boy Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How Often Build Things Together</td>
<td>1.00</td>
<td>4.00</td>
<td>2.15</td>
<td>0.88</td>
<td>2.52</td>
<td>0.92</td>
</tr>
<tr>
<td>Child in Group Sports</td>
<td>0.00</td>
<td>1.00</td>
<td>0.29</td>
<td>0.46</td>
<td>0.46</td>
<td>0.50</td>
</tr>
<tr>
<td>Child in Martial Arts</td>
<td>0.00</td>
<td>1.00</td>
<td>0.02</td>
<td>0.13</td>
<td>0.05</td>
<td>0.21</td>
</tr>
<tr>
<td>How Often Do Sports Together</td>
<td>1.00</td>
<td>4.00</td>
<td>2.58</td>
<td>0.92</td>
<td>2.75</td>
<td>0.91</td>
</tr>
<tr>
<td>Participates in Athletic Events</td>
<td>0.00</td>
<td>1.00</td>
<td>0.37</td>
<td>0.48</td>
<td>0.52</td>
<td>0.50</td>
</tr>
<tr>
<td># Days Per Week 20 Min Exercise</td>
<td>0.00</td>
<td>7.00</td>
<td>3.75</td>
<td>2.32</td>
<td>4.19</td>
<td>2.32</td>
</tr>
<tr>
<td>Parent Contacted School</td>
<td>0.00</td>
<td>1.00</td>
<td>0.52</td>
<td>0.50</td>
<td>0.57</td>
<td>0.49</td>
</tr>
<tr>
<td>Parent Discipline: Take Away a Privilege</td>
<td>0.00</td>
<td>1.00</td>
<td>0.31</td>
<td>0.46</td>
<td>0.37</td>
<td>0.48</td>
</tr>
<tr>
<td>Higher Girl Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Look at Picture Books Outside School</td>
<td>1.00</td>
<td>4.00</td>
<td>3.58</td>
<td>0.67</td>
<td>3.35</td>
<td>0.79</td>
</tr>
<tr>
<td>How Often You Read to Child</td>
<td>1.00</td>
<td>4.00</td>
<td>3.28</td>
<td>0.78</td>
<td>3.20</td>
<td>0.81</td>
</tr>
<tr>
<td>How Often You Sing Songs With Child</td>
<td>1.00</td>
<td>4.00</td>
<td>3.23</td>
<td>0.89</td>
<td>3.00</td>
<td>0.97</td>
</tr>
<tr>
<td>Child Takes Dance Lessons</td>
<td>0.00</td>
<td>1.00</td>
<td>0.30</td>
<td>0.46</td>
<td>0.03</td>
<td>0.18</td>
</tr>
<tr>
<td>Child Participates in Organized Clubs</td>
<td>0.00</td>
<td>1.00</td>
<td>0.18</td>
<td>0.39</td>
<td>0.09</td>
<td>0.28</td>
</tr>
<tr>
<td>Child Participates in Performing Arts</td>
<td>0.00</td>
<td>1.00</td>
<td>0.20</td>
<td>0.40</td>
<td>0.09</td>
<td>0.28</td>
</tr>
</tbody>
</table>

*p < .05 for all variables*
Table 2
Means for Lowest and Highest SES Quintiles by Gender for Activities With Magnified Gender Differences Among Highest SES Families

<table>
<thead>
<tr>
<th>Activity</th>
<th>Lowest SES quintile</th>
<th>Highest SES quintile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girls</td>
<td>Boys</td>
</tr>
<tr>
<td>Higher Boy Mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How Often Build Things Together&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.11</td>
<td>2.39</td>
</tr>
<tr>
<td>Child in Group Sports</td>
<td>13%</td>
<td>21%</td>
</tr>
<tr>
<td>Child in Martial Arts</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Child Plays Informal (Recreational) Sports&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25%</td>
<td>27%</td>
</tr>
<tr>
<td>Higher Girl Mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Takes Dance Lessons</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>Child Participates in Organized Clubs</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Child Participates in Performing Arts</td>
<td>10%</td>
<td>5%</td>
</tr>
</tbody>
</table>

<sup>a</sup> This variable was on a 4-point scale with 1 = not at all, 2 = once or twice per week, 3 = three to six times per week, and 4 = every day.

<sup>b</sup> This variable is included here as contrast.
gender disparities in mathematics performance. We ran similar models to see if students’ home experiences differentially predicted changes in girls’ and boys’ mathematical confidence and interest, but we found no such patterns.

**Mathematics Instruction and Gender Patterns in Achievement**

We used 2-level linear models (students nested within classrooms) to examine whether teacher-reported instructional practices differentially predicted girls’ and boys’ mathematics gains between Grades 1 and 3 and between Grades 3 and 5. These grades were chosen because of the growth in the gender gap between Grades 1 and 5 and the availability of relevant teacher-reported variables. The variables available differed slightly at each grade level but included attention to group work, problem solving, manipulatives, teacher-directed activities, integration of curriculum, calculators, computers, and classroom desk arrangement (Lubienski, Crane, & Robinson, 2011).

Our more general analysis of the relationships between the instruction-related variables and student achievement gains revealed few significant relationships. The few relationships identified were consistent with Crane’s (2010) ECLS-K research suggesting that instructional practices advocated by the National Council of Teachers of Mathematics (2000) correlate with greater mathematics gains in elementary grades. However, our primary interest was whether the ECLS-K instruction-related variables related to achievement in different ways for girls versus boys.

The short answer is no, with the possible exception of one marginally significant interaction indicating that the benefits of solving and discussing real-life mathematics problems might be stronger for girls than boys. More specifically, the HLM analysis examining Grade 3–Grade 5 mathematics gains indicated an effect size of 0.1 SDs for girls ($p < .05$)—but no effect for boys—for the predictor identified as how often students “work on and discuss mathematics problems that reflect real-life situations” (U.S. Department of Education, 2004, p. 6). However, given the number of interactions tested and the fact that significance for this variable was inconsistent across models, this finding was not terribly compelling and requires further research to confirm the pattern.

Finally, we ran similar models to see if instructional practices differentially predicted changes in girls’ and boys’ mathematical confidence and interest. As with the parent-reported variables, we found no consistently significant interactions.

**Gender and Age at Start of School**

An incidental but potentially important pattern that emerged in our analyses is that high-SES boys are particularly likely to begin kindergarten at age 6 instead of 5 (consistent with Bassok & Reardon, 2012). Specifically, as shown in Figure 2, we found that mid- and high-SES parents are 40%–70% more likely to have a 6-year-old boy than a 6-year-old girl begin kindergarten. Holding boys back an extra year before the start of kindergarten appears to be a luxury that the
lowest-SES parents do not have. This finding is important for researchers because influences of kindergarten achievement that seem related to SES or gender might actually be due to the age of the children. In fact, even if we adjust for age differences in kindergarten models, we are comparing a slightly more select group of boys whose parents thought they were ready for kindergarten with a more general population of girls, particularly among high-SES students. Although the various regression and multilevel analyses reported here adjusted for age differences between boys and girls, we could not fully account for the possible bias introduced by parent selection.

![Figure 2](image-url)

*Figure 2. Percentage of kindergarten girls and boys age 6 or older as of September 1, by SES quintile*

**Conclusion**

According to the ECLS-K data, gender disparities in U.S. mathematics achievement consistently favor boys and are clearly evident by Grade 3. Substantial gender disparities in mathematical confidence also appear in elementary school. Hence, gender-focused interventions appear more important in elementary grades than previously thought.

The fact that teachers underrate the mathematics proficiency of girls when compared to boys with similar achievement and behavior merits further attention, particularly given that this pattern is unique to gender and mathematics. Other research suggests that boys are more likely than girls to exhibit a performance goal orientation, striving to demonstrate their knowledge to others (Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006). This tendency, combined with girls’ greater diligence and the common view of mathematics as something one is either “good
at” or not, might shape teachers’ (and students’) views of who is “smart” and lead teachers to attribute boys’ mathematics success to ability and girls’ success to effort (Fennema, Peterson, Carpenter, & Lubinski, 1990). Further research on these patterns is needed to find ways to confront teachers’ and girls’ unwarranted uncertainty about girls’ mathematics abilities. Researchers should explore whether gender disparities in achievement and confidence might be narrowed if teachers confronted biases about boys’ and girls’ mathematics abilities and promoted the view of mathematical ability as malleable (Dweck, 2007) in their classrooms.

The results of this study also indicate that high-SES parents may be unintentionally gendering their children through their concerted cultivation efforts. Still, there is no consistent evidence from this study that students’ home experiences predict later gender gaps in achievement or affect. The same is true for teachers’ mathematics instructional practices. However, these null results could be due to an inability of the ECLS-K variables to detect subtle gendering processes, rather than to a true lack of relationship between parenting or teaching practices and gender patterns in mathematics outcomes. These null findings suggest both that qualitative analyses are important for illuminating home and school practices that relate to gender equity and that such analyses should inform the creation of future survey questions used in large-scale data collection efforts, including federal datasets and new state data systems.

References


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