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Gender stereotyping in mothers' and teachers' perceptions of boys' and girls' mathematics performance in Ireland

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ABSTRACT

Parents' and teachers' beliefs and evaluations of young people are important. Using a feminist institutionalist perspective, and drawing on rich data from one in seven nine-year-old children in Ireland, this paper examines mothers' (who make up the overwhelming majority of primary care-givers) and teachers' perceptions of boys' and girls' mathematics performance. The evidence shows that girls' mathematics performance is under-estimated by both relative to boys'. Mother's gender bias was evident among high performing children, at all levels of children's academic self-concept, and among mothers with at least third level education. While the judgements reflect children's actual performance and engagement, a notable gender gap remains. It is suggested that the results reflect gender stereotypes: overestimating boys' and underestimating girls' mathematics achievements. The article indicates the importance of the informal dimension of institutions and the part played by women in the effective devaluation of girls by endorsing gendered stereotypes. Women teachers are less likely to rate children highly in mathematics, taking account of performance: arguably reflecting their own lack of confidence in mathematics assessment. The findings raise concerns for girls' futures since mathematics is seen as an indicator of intelligence. Given the move towards teacher-assessed grading during COVID-19, understanding, and challenging, gender-stereotyping is pressing.

KEYWORDS
Gender stereotypes; mathematics; teachers' perceptions; mothers' perceptions; children's agency; academic performance

Introduction

This paper explores whether there is a misalignment between boys' and girls' actual mathematics performance and teacher and mother assessments of it, and the effect of children's agency, background and learning context. Children's mathematical performance has attracted considerable attention nationally and internationally, with a good deal of evidence about the extent and nature of boys' and girls' relative achievements in

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the area (Borgonovi et al., 2018; OECD, 2015). There are growing gender disparities in perceived abilities from primary to secondary school (Copur-Gencturk et al., 2020a) with teachers at primary level less likely to believe mathematics requires innate ability.

While much of the research in the area has focused on either teacher or parental perceptions of performance (see for example, Gentrup & Rjosk, 2018; Papageorge et al., 2020; Räty & Kasanen, 2007), this study looks at the perceptions of both of these (an approach also taken by Tiedemann, 2000) in the context of the child's agency as reflected in engagement with school in general and mathematics in particular. It also examines the extent to which perceptions vary by school composition (reflected in gender mix) and teacher characteristics (i.e. gender and length of teaching experience). Reflecting the richness of the data, it also includes multiple indicators of family background: economic, educational and cultural. Finally, the study is unusual in focusing on a much earlier age cohort (mid-primary/ 9 years of age) than typically examined.

Gender stereotypes are used in this paper as an explanatory concept to understand the over-estimation of boys' mathematics performance and the under-estimation of girls'. The need to examine gender dynamics in teachers' perceptions of children's mathematics ability has become all the more pressing given the move towards teacher assessed grading in many education systems, as a result of the Covid-19 pandemic. In this context, the primary purpose of this study is to examine whether primary caregivers[1] and teachers estimate girls' mathematics performance less highly than that of boys, at any given level of performance. Specifically, we look at the gendered misalignment between teachers' and mothers' assessments and children's actual mathematic performance. If teachers and mothers hold lower assessments of girls, net of the pupils' background, mathematics achievement, engagement, and self-concept, this is likely to indicate the existence of gendered stereotypes, in that their assessments appear to be informed at least in part by their general beliefs about girls' and boys' mathematics ability. The following research questions are addressed:

(1) What shapes mothers' and teachers' perceptions of children's mathematics performance? Do mothers and teachers endorse gender differentiated views of children's mathematics ability?
(2) Do mothers and teachers rely on certain characteristics of children, their families, or their school context to attribute higher mathematical abilities to boys than girls? That is, is there evidence of gender bias in perceptions of children's mathematics ability?

Theory and evidence

The theoretical perspective is ultimately drawn from feminist institutionalism (FI), which recognises the importance of gendered power and is concerned with 'the gendered patterning of institutional rules and norms', both in the formal and informal arenas (Mackay et al., 2010, p. 581; Krook & Mackay, 2011), many of which reflect gender stereotypes and the differential gendered evaluation of these. Such stereotypes involve 'the repertoire of actions and behaviour . . . .that society makes available to its members for doing gender . . . . [including] the actions and interests that are culturally available to and normatively or stereotypically associated with one or the other gender' (Martin, 2006,

p. 257). Thus FI recognises that gendered stereotypes not only underpin the formal structures but also informal interactions, with male and female stereotypes being differentially evaluated.

For Connell (2005, p. 13), 'One of the most important circumstances of young people's lives is the gender order they live in' within which constructions of masculinity and femininity exist. Families and schools reflect and reinforce this gender order. In it what Connell (1995, p. 82) called 'a patriarchal dividend' persists, from which the majority of men benefit 'in terms of honour, prestige or the right to command. [They] men also gain a material dividend'. Among young men, this dividend is less tangible but can be seen as reflected in an over-estimation of their abilities and/or the value of such abilities.

Gender in this perspective is seen as 'an ongoing activity embedded in everyday interaction' (West & Zimmerman, 1987, p. 130). For Butler (1990, p. 25) gender 'is performatively constituted by the very "expressions" that are said to be its results'. In this 'performative concept' gender is something people 'do' or 'perform''. Thus, what comes to be seen as natural is in fact a social accomplishment, achieved through constant repetition and regulation. Implicit in this perspective is a rejection of biological essentialism (Connell, 1995). In an era of increasing gender fluidity, binary gender stereotypes appear increasingly archaic but none the less persist in the home and the school and are activated in interactional contexts (Ridgeway & Correll, 2004).

For Ridgeway (2011, p. 92) 'gender is at root a status inequality – an inequality between culturally defined types of people'. This perspective suggests that stereotypical cultural beliefs do not simply define boys and girls as different; they implicitly define boys as superior to girls. In Fraser's (2008, p. 58) terms, formal and informal evaluative contexts are characterised by gender differentiated 'institutionalised patterns of interpretation and evaluation'. These evaluative contexts include parents and teachers and their perceptions of boys' and girls' mathematical abilities.

Connell (1995, pp. 76–81) distinguished between various stereotypical forms of masculinity, including one that occupies 'a hegemonic position in a given pattern of gender relations' and which is 'culturally exalted' at a particular time, and in a particular societal context. It is possible to see mathematics ability, construed as a 'true' indicator of innate intelligence, as a site of hegemonic masculinity for boys. It is particularly useful in legitimating claims to male privilege in meritocratic societies where girls are doing better than boys in state examinations, but where assumptions about the legitimacy of male patriarchal privileging persist. In this context the stereotype of boys' 'innate' male intelligence, reflected in 'natural' mathematical ability, is particularly attractive.

Gender stereotyping and the practicing of gender in mathematics

Mathematics is a gender marked subject: with boys doing better than girls at the highest level other than in a small number of countries such as Sweden (OECD, 2015, 2011). Perceptions of gender differences may both affect and reflect actual achievement (OECD, 2015). Recent research shows that primary school mathematics teachers demonstrate gender-based implicit biases even in decontextualised experimental settings (Copur-Gencturk et al., 2020b, 2020a), with males being seen as better at mathematics (Hyde et al, 2009; Guiso et al., 2008). Since stereotypes about male superiority reflects dominant cultural norms, we would expect them to be endorsed by both men and women and by the most highly educated.

Insofar as performances conform to stereotypes, they are seen as 'natural' and 'inevitable'. Boys' above average performance at mathematics is compatible with the stereotype in a way that girls' above average performance is not. Given the strength of such mathematical gender stereotypes we would expect that there would be no difference between male and female teachers in their endorsement of them. However, since the stereotypes are modified somewhat by performance one would expect that teachers, being exposed on a daily basis to their pupils' mathematics performance, might be less influenced by the underlying stereotypes than mothers who are, at most, only likely to be exposed to their own child's mathematics performance. It is also possible that mothers and teachers use other indicators (such as liking for mathematics, diligence in performing homework) to dilute gender stereotypes and thus to perceive girls who are excellent/above average as such.

High-achieving girls face challenges in trying to balance academic success with being seen as a 'proper girl' (Frawley et al., 2014; Renold & Allen, 2006; Walkerdine et al., 2001) treading a precarious line between 'doing girls' and 'doing success' and devising ways to minimise their cleverness. Such pressures seem likely to be greatest in co-educational settings and since mathematics is a gender marked subject, such pressures may impact on both girls' performance and teacher perceptions of their mathematics ability in such contexts. It is also expected that more established teachers might have become firmer in their stereotypical views over time.

Evidence: parents' perceptions of children's performance

Räty and Kärkkäinen (2011) argue that mathematics is perhaps the most gender-marked academic subject. Cross-cultural research has traditionally shown that parents impart, and children take on, the view that boys are good at mathematics from a very young age (Lummis et al., 1990; Muntoni & Retelsdorf, 2019). In Finland, for example, despite girls' and boys' equal school performance in mathematics, parents' assessments favour boys and this does not change during the first few years of school (Räty, 2006). Moreover, there is evidence that parents' underestimation of girls' mathematics capacity is also manifested in their inclination to explain girls' mathematics accomplishments with reference to hard work and boys' mathematical accomplishments with reference to natural ability (Räty & Kasanen, 2007). However, Tiedemann (2000), for example, shows that parents' beliefs about their child reflect their child's own self-perceptions of their mathematical ability.

Teachers' perceptions of children's performance

International evidence shows that judgements by highly educated professionals can reflect gender stereotypes. Several studies found no gender bias in relation to teacher assessments, controlling for students' actual achievement (Lorenz et al., 2016). However, a range of studies find that teachers tend to associate 'natural mathematical' ability with boys more often than girls (Fennema et al., 1990; Tiedemann, 2002) and explicitly stereotype mathematics as a male domain (Keller, 2001; Leedy et al., 2003; Li, 1999). Tiedemann

(2000) finds that teachers viewed boys as more logical thinkers and saw mathematics as less difficult for boys than girls at the same achievement level, although differences were significant only for mid-performers. Gentrup and Rjosk (2018) find that girls' mathematics achievement was more adversely affected by negatively biased expectations and benefitted less from positive bias than boys' achievement. Riegle-Crumb and Humphries (2012) find evidence of a bias against white females, which, although relatively small in magnitude, suggests that teachers believe that mathematics is just easier for white males than it is for white females.

In their large-scale study of Dutch primary school students, Timmermans et al. (2016) find that girls' compliance and work orientation can increase teachers' perceptions of their ability. Tiedemann (2000) also finds that teachers attributed girls' failure to low ability but attributed boys' failure to effort. Among US children, Cimpian et al. (2016) show that teachers consistently rate girls' mathematical proficiency lower than that of boys with similar achievement and learning behaviours, with a particular reluctance to identify girls as excellent. Girls' more studious approaches appear to have more payoff at the bottom of the distribution than at the top. On average girls were only perceived to be as mathematically competent as similarly achieving boys when the girls are also seen as working harder, behaving better, and being more eager to learn.

Robinson-Cimpian et al. (2014) find that teachers rate boys' mathematics proficiency higher than that of girls, taking account of both teachers' ratings of behaviour and approaches to learning as well as past and current test scores. Holder and Kessels (2017) also find that teachers consider male students to perform better in mathematics than female students when actual student achievement is kept constant. There is some limited evidence to suggest that beliefs around mathematical ability vary by teacher experience, with less evidence of variation by teacher's gender. Copur-Gencturk et al. (2020a), for example, find that more experienced teachers believed less in the role of hard work in mathematics success, with no differences in their beliefs about the importance of innate ability in achieving it. Further, they didn't find any differences in male and female teachers' beliefs about mathematical ability.

Children's engagement and self-concept

Relatively little attention has been paid to children's views, attitudes and behaviour. OECD (2015) PISA evidence suggests that girls' lack of self-confidence in their own ability in science and mathematics may be responsible for the underachievement among girls in these subjects, particularly among high-achieving girls. Pajares (2005) concludes that 'most studies' indicated that male students had higher mathematics self-efficacy than females, when males and females have comparable achievement levels or even when females outperform males. In a meta-analysis of over 187 studies, Huang (2013, p. 11) finds that the extent of gender gaps in mathematical self-efficacy increased with age, with gender differences among primary school cohorts typically not being significant.

Self-efficacy and academic self-image are strong predictors of performance, with Usher and Pajares (2008) noting that self-efficacy 'predicts students' academic achievement across academic areas and levels', while Cvencek et al. (2015) find a link between mathematics self-concept and achievement. There is much less research on the motivational mechanism that mediates the self-efficacy-achievement relationship (Doménech-Betoret et al., 2017). A number of studies suggest that children's self-concept (Friedrich et al., 2015), attitudes and behaviour are important mediating factors. There is evidence that teachers' perceptions of students' ability respond to students' academic self-image, level of aspiration and self-efficacy. Zhu et al. (2018) find that teacher judgment had relatively strong associations with primary school students' expectancy for success. The impact of the gender profile of the teaching context (single sex girls'/boys' schools or co-educational) or indeed the gender of the teacher has been rarely considered. One notable exception is Lynch and Lodge (2002) who show how single-sex schools differ from each other, and from co-educational schools, in the formation of gendered identities, but the implications in relation to mathematics have not been explored.

Data and method

We use data from the first wave of the *Growing Up in Ireland* (GUI) child cohort study – the National Longitudinal Study of Children in Ireland – a nationally representative study of 9-year-old children living in Ireland. The GUI used a two-stage sampling design with schools as the primary and nine-year-old children as the secondary units. *Growing Up in Ireland* interviewed 8,568 nine-year-old children (representing one-in-seven nine-year-old children), their parents and their teacher between September 2007 and May 2008. Teachers completed the questionnaires as part of a school phase, during which standardised mathematics achievement tests and Piers-Harris self-concept instruments (see below) were completed by the children on a group basis. The school phase of data collection preceded the home phase when survey data was collected from children and parents.

Dependent variables

Each study child's teacher was asked 'How would you rate the study child's performance in mathematics relative to children in his/her age group?', to which they could respond 'below average', 'average' and 'above average'. Mothers were also asked: 'How well is the child doing in mathematics relative to other children of their age?', to which they could respond 'poor', 'below average', 'average', 'above average' and 'excellent'. In the models below, teacher perceptions of the study child being 'above average' are predicted against the merged reference categories of 'average' or 'below average', while mother perceptions of the study child being 'excellent' is predicted against the merged reference categories of 'above average', 'average' and 'below average'. These binary categorical variables served as our key dependent variables. While we acknowledge that they are relatively crude, they are in line with established potential measures of bias (see Räty & Kasanen, 2007; Riegle-Crumb & Humphries, 2012).

Independent variables

Mathematics test performance

To assess students' academic performance in mathematics, we included an indicator of mathematics performance at age nine which was measured using standardised mathematics tests developed for school children in Ireland (Educational Research Centre, 2007). The test items are linked to the national curriculum, are grade specific, are widely used in the Irish context (Dempsey et al., 2020) and have strong reliability and validity. The assessments used by the GUI team were revised versions of the standardised test and were new in that year. This means that they would not have been used or seen by the schools prior to their use in Growing Up in Ireland. Furthermore, neither teachers nor parents were privy to children's scores on the standardised mathematics test. In order to adjust for the age and stage of children, the raw mathematics performance data of each child were transformed into logit scores by the Educational Research Centre (Educational Research Centre, 2007) using standardisation. In our models, the mathematics test score is presented in the form of quintiles of logit scores to easily distinguish those who achieved the highest levels of mathematics achievement.

Children's engagement and self-concept

In order to consider children's agency in learning (Corsaro, 1997) we focused on children's engagement in mathematics, their self-concept and school engagement. The children were asked whether they like mathematics, to which they could respond either 'always', 'sometimes' or 'never'. An objective measure of academic self-concept was assessed using the Piers-Harris II scale (Piers et al., 2002) – a widely used measure of psychological health in children and adolescents (McCoy et al., 2016). We used the 16-item Intellectual and School Status subscale (scores 0–16) which measures the child's evaluations of their own abilities in intellectual and academic tasks.

Two subjective measures of school engagement were used in the analysis. Individual absenteeism levels were measured by asking mothers the number of days their child was absent from school in the recent school year, with responses grouped into three categories indicating no absenteeism, low absenteeism (less than 10 days) or high absenteeism (11+ days). Teachers were asked to report the frequency with which the study children completed their homework, with a distinction between those who 'regularly' or 'occasionally' did not do homework and all others. Such measures may affect how mothers and teachers evaluate children's performance. We also controlled for whether the child was identified by teachers and mothers as having special educational needs. Such children are less engaged at school compared to their peers (McCoy & Banks., 2012).

Family background

Two measures were included as indicators of the socio-economic background of children: household social class and household income. Each captures different dimensions of socio-economic background, reflecting occupational position and economic resources. Household social class was assigned using a dominance criterion: identified as the higher of the primary and secondary caregiver's class (where the latter is resident); a classification adopted by the Irish Central Statistics Office (Murray et al., 2010). The measure of household income is based on the combined income of the primary and secondary caregivers, with households grouped into three income quintiles.

In order to capture the educational and cultural resources within the home which are likely to influence parent and teacher expectations, we drew on information on the mothers' level of educational attainment and access to books in the home, which has been found to be a strong predictor of educational performance (Marks et al., 2006). The highest education level of the mother was classified in line with the International Standard Classification of Education (ISCED). The mother was asked to report the number of children's books in the home; here we distinguish between 10 or less (including none), 11–30 and more than 30. We also controlled for the immigration background of students (defined as those with at least one parent born outside Ireland).

Teacher and school characteristics

The GUI study captures the characteristics of the teachers themselves, including their gender (binary variable) and teaching experience (years) using a continuous variable. We also included a binary variable indicating the gender mix of the school (i.e. single sex girls/ boys, and co-educational) to assess if ratings of girls and boys vary across single-sex and co-educational settings.

Summary information on the two dependent variables and the fifteen independent variables are presented in Table 1. Each of these independent variables hold theoretical relevance and/or have statistically significant binary associations with the dependent variables. The levels of missing data on the measures were low (ranging from 0% up to 6% on the school gender intake variable, but higher (7%) on the years of teaching experience variable). After excluding missing data from key variables, the final valid sample size used in this paper is 6,521. An analysis of missing data shows few statistically significant differences between the full sample and the reduced sample. There are two exceptions: children in the final sample had a marginally higher share of 'excellent' ratings by mothers (22.6% compared to 22%) and teachers (33% compared to 32.4%).

Analytic strategy

Analyses were conducted using Stata and took place in three stages. Firstly, a descriptive analysis of gender differences in each of the dependent and independent variables was undertaken (Table 2). Secondly, binary logistic regression models were used to predict mothers' and teachers' perceptions of children's mathematics ability controlling for the gender of the child, mathematics test performance, children's engagement and self-concept and teacher and school characteristics.[2] Separate models were estimated for mothers' and teachers' ratings (Tables 3 and 4). The results of the binary logistic regression models are presented as odds ratios, in which values greater than one indicate a higher likelihood of the outcome compared to the reference category, and values less than one indicate a lower likelihood.

In a final step, using interaction terms, we investigated the extent to which mathematics achievement, mothers' educational level and the child's academic self-concept moderates the relationship between gender and mothers' and teachers' assessments of children's mathematics ability. We also tested an interaction term between the gender of the teacher and the gender of the child. Results are presented in Models 2–4 in Table 3 and Models 2–5 in Table 4. Figures of predictive margins are used to illustrate variation in predicted probabilities for boys and girls (Figures 3–5).

Table 1. Descriptive Statistics (weighted)

Variable	N	Mean	S.D.
Drumcondra Maths Logit Score	8417	-.7560	.93394
Piers Harris Subscale	8062	12.3236	2.85249
Years of Teaching	7971	12.76	11.294
Variable	**N**	**Category Percentages**	
Teacher Rating	8218	16.7% Below Average, 50.9% Average, 32.4% Above Average	
Mother Rating	8560	1.4% Poor, 5.4% Below Average, 38% Average, 32% Above Average, 23.3% Excellent	
Gender of Child	8568	51.1% Male, 48.9% Female	
Maths Performance (Quintiles)	8417	20% Q1 (low), 20% Q2, 20% Q3, 20% Q4, 20% Q5 (high)	
Child Engagement in Maths	8503	47.3% Always like it, 42.6% Sometimes like it, 10.1% Never like it	
Number of Days Absent from School	8554	10.4% 0 days, 32.7% 1-3 days, 26.1% 4-6 days, 17.9% 7-10 days, 10.5% 11-20 days, 2.4% 20+ days	
Frequency that homework is incomplete	8237	71.9% Never or almost never, 22.9% Occasionally, 5.2% Regularly	
Special Educational Need	8568	24.2% have SEN; 75.8% no SEN	
Family Social Class	8551	41.6% Professional/Managerial, 35.5% Other non-manual/skilled manual, 11% semi-unskilled manual; 12% no social class.	
Household Income	8007	20% Q1 (lowest), 20.1% Q2, 20.1% Q3, 19.9% Q4, 20% Q5 (highest)	
PCG Highest Level of Education	8568	6.4% No/Primary level, 23.8% Lower Secondary, 36.7% Higher Secondary/Technical/Vocational, 15.9% Third level non-degree, 11.2% Primary Degree, 6% Postgraduate Degree	
Children's Books in the Home	8565	0.8% None, 9.5% Less than 10, 18.9% 10 to 20, 14.8% 21 to 30, 56% More than 30	
Family Recent Migrant History	8565	22.4% recent migrant history, 77.6% no recent migrant history	
Teacher Gender	8134	14.4% Male, 85.6% Female	
School Gender-Mix	8051	24.3% Single-sex school, 75.7% Co-educational school	

Results

Descriptive analysis of gender differences

Table 2 shows differences in the social and academic background, mathematics performance, children's engagement with mathematics and school, their self-concept and teacher and school characteristics. Among mothers, 23% assess their child as 'excellent' in relative mathematics ability, while teachers rate a third (33.1%) of nine-year-olds as 'above average'. There are clear gender differences in perceptions of mathematics performance by teachers and mothers. Almost a quarter (24.9%) of boys are rated by mothers as 'excellent' compared to just one-fifth (20.3%) of girls. Likewise, over a third (37.1%) of boys are perceived by teachers to be 'above average' by relative standards, compared to 28.8% of girls.

Boys demonstrate higher levels of actual mathematics achievement and more positive attitudes towards mathematics compared to girls. Forty-two per cent of boys can be found in the two highest achievement quintiles compared to 37% of girls, and the average raw score (percentage correct) for boys was 55.5% compared to 52.2%. Furthermore, almost half of boys indicated that they 'always like' mathematics compared to 44% of girls. While girls score marginally higher on an objective measure of their ability with regard to intellectual and academic tasks than boys, the difference is not significant. Findings relating to children's engagement with school (non-attendance, incomplete homework) are mixed.

Table 2. Descriptive Statistics

	All	Boys	Girls	Sig
Dependent Variables				
Mother Assessment				***
Poor	1.7	1.3	2.1	
Below Average	6.6	5.5	7.6	
Average	39.0	36.4	41.6	
Above Average	30.2	31.9	28.5	
Excellent	22.6	24.9	20.3	
Teacher Assessment				***
Below Average	15.4	13.5	17.4	
Average	51.5	49.4	53.8	
Above Average	33.1	37.1	28.8	
Independent Variables				
Mathematics Attainment				***
Q1 (Low)	20.0	20.4	19.5	
Q2	20.0	18.8	21.0	
Q3 (Median)	20.0	18.5	22.9	
Q4	20.0	19.7	19.8	
Q5 (High)	20.0	22.6	16.9	
Engagement in Mathematics				***
Always like	47.1	49.7	44.4	
Sometimes like	42.8	40.4	45.4	
Never like	10.1	9.9	10.3	
Absenteeism				***
No absenteeism	10.1	10.1	10.1	
Absent 1-3 days	32.7	34.8	30.5	
Absent 4-6 days	26.0	26.6	25.4	
Absent 7-10 days	18.2	17.1	19.3	
Absent 11 + days	13.0	11.4	14.6	
Homework Behaviour				***
Never	72.2	68.5	75.9	
Occasionally	22.8	25.2	20.3	
Regularly	5.0	6.3	3.7	
Special Educational Need				***
SEN	23.1	26.1	20.1	
No SEN	76.9	73.9	79.9	
Family Social Class				***
Professional/Managerial	42.3	44.1	40.4	
Non-Manual/Skilled Manual	35.5	36.0	35.0	
Semi-Unskilled Manual	10.6	9.1	12.2	
No Social Class	11.6	10.8	12.4	
Family Income				*
Q1 Low Income	19.6	18.6	20.7	
Q2	19.8	19.4	20.3	
Q3	20.5	21.2	19.8	
Q4	20.0	19.6	20.5	
Q5 High Income	20.0	21.3	18.7	
	All	**Boys**	**Girls**	**Sig**
Mother Education Level				***
Low Education Level	29.8	27.3	32.4	
Secondary/Vocational Education	36.5	36.4	36.6	
Third Level Non-Degree	15.8	17.2	14.4	
Degree +	17.9	19.1	16.6	
Books in the home				***
Less than 10	10.5	12.8	8.1	
10-20 Books	18.8	20.5	17.0	
21-30 Books	14.8	14.5	15.1	
31+ Books	55.9	52.2	59.8	
Family Migrant History				NS
Recent migrant history	22.9	22.4	23.3	
No recent migrant history	77.1	77.6	76.7	

(*Continued*)

Table 2. (Continued).

Teacher Characteristics				
Teacher Gender				***
Male	14.2	18.1	10.1	
Female	85.8	81.9	89.9	
School Gender-Mix				***
Co-educational	75.4	69.2	81.8	
Single-sex	24.6	30.8	18.2	
Drumcondra Maths Logit Score	-.7605	-.7137	-.8089	***
Drumcondra % Correct	53.9	55.5	52.2	***
Piers Harris Subscale	12.3259	12.2957	12.3573	NS
Years of Teaching Experience	12.7	12.85	12.52	NS

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3. Logistic regression model of mothers' perceptions of children's mathematics performance.

	Model 1	Model 2	Model 3	Model 4
	OR (se)	OR (se)	OR (se)	OR (se)
Child Gender				
Male	1.326***	1.274	2.932***	0.913
Ref: Female	(4.40)	(1.16)	(3.31)	(−0.55)
Mathematics Attainment				
Q2	1.479**	1.628*	1.485**	1.476**
	(2.93)	(2.58)	(2.96)	(2.92)
Q3	2.011***	2.052***	2.015***	1.999***
	(5.48)	(3.98)	(5.49)	(5.43)
Q4	2.800***	3.116***	2.803***	2.786***
	(8.25)	(6.41)	(8.26)	(8.21)
Q5 (High)	5.837***	4.669***	5.858***	5.795***
Ref: Q1 (Low)	(14.47)	(8.73)	(14.49)	(14.40)
Child Engagement in Mathematics				
Always like Mathematics	2.268***	2.270***	2.269***	2.255***
	(6.22)	(6.22)	(6.21)	(6.17)
Sometimes like Mathematics	1.104	1.113	1.103	1.106
Ref: Never like Mathematics	(0.74)	(0.79)	(0.73)	(0.75)
PH Intellectual and School Subscale	1.056***	1.057***	1.093***	1.057***
	(4.38)	(4.41)	(4.73)	(4.42)
Child Absenteeism				
Absent 1–10 Days	0.763**	0.765**	0.763**	0.759**
	(−2.80)	(−2.77)	(−2.80)	(−2.85)
Absent 11+ Days	0.855	0.858	0.858	0.850
Ref: Never Absent from school	(−1.22)	(−1.19)	(−1.19)	(−1.26)
Child Homework Behaviour				
Occasionally/Regularly Incomplete	0.768**	0.776**	0.765**	0.765**
Ref: Never Incomplete	(−3.21)	(−3.08)	(−3.26)	(−3.27)
Household Social Class				
Professional/Managerial	0.852	0.847	0.849	0.864
	(−1.25)	(−1.30)	(−1.28)	(−1.14)
Non-Manual	0.899	0.893	0.896	0.910
	(−0.85)	(−0.90)	(−0.88)	(−0.75)
No Social Class	1.069	1.077	1.066	1.075
Ref: Semi-unskilled manual	(0.37)	(0.41)	(0.36)	(0.40)
Household Income				
Highest Income Quantile	0.966	0.963	0.964	0.963
	(−0.32)	(−0.35)	(−0.34)	(−0.35)
Middle Income Household	0.822*	0.824*	0.818*	0.821*

(*Continued*)

Table 3. (Continued).

	Model 1	Model 2	Model 3	Model 4
	OR (se)	OR (se)	OR (se)	OR (se)
Ref: Income Poverty Household	(−2.14)	(−2.10)	(−2.19)	(−2.15)
Mother Education Level				
Upper Secondary and/or Vocational	0.945	0.952	0.945	0.846
	(−0.55)	(−0.48)	(−0.55)	(−1.23)
Third level non-degree	1.036	1.043	1.033	0.813
	(0.33)	(0.38)	(0.30)	(−1.41)
Degree +	1.267*	1.273*	1.268*	0.974
Ref: Lower secondary or less	(2.08)	(2.12)	(2.09)	(−0.18)
Family Recent Migrant History				
Recent migrant history	1.180*	1.178*	1.181*	1.179*
Ref: no recent migrant history	(2.28)	(2.25)	(2.28)	(2.26)
Children's books in the home				
10–20 Books	1.053	1.043	1.053	1.037
	(0.36)	(0.30)	(0.37)	(0.26)
20–30 books	0.779	0.773	0.779	0.760
	(−1.68)	(−1.73)	(−1.69)	(−1.84)
30+ books	1.087	1.080	1.086	1.067
Ref: less than 10 books	(0.65)	(0.59)	(0.64)	(0.51)
Teacher Gender				
Female	1.103	1.111	1.101	1.099
Ref: Male	(1.10)	(1.17)	(1.08)	(1.06)
Years of Teaching Experience	0.993*	0.993*	0.993*	0.993*
	(−2.38)	(−2.37)	(−2.38)	(−2.33)
School Gender Intake				
Single-sex school	1.108	1.105	1.110	1.115
Ref: Co-educational school	(1.44)	(1.39)	(1.46)	(1.52)
Mathematics Q*Gender				
Q2 Mathematics*Gender		0.817		
		(−0.76)		
Q3 Mathematics*Gender		0.955		
		(−0.18)		
Q4 Mathematics*Gender		0.803		
		(−0.90)		
Q5 Mathematics*Gender		1.481^		
		(1.67)		
Piers Harris*Gender				
Piers Harris*Gender			0.941*	
			(−2.50)	
Mother Education*Gender				
Upper Secondary and/or Vocational*Gender				1.301
				(1.33)
Third Level non-degree*Gender				1.669*
				(2.49)
Degree +*Gender				1.728**
				(2.75)
Observations	6,521	6,521	6,521	6,521

Exponentiated coefficients; *t* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ^ approached significance.

With respect to social and academic background, girls are more socially disadvantaged (in terms of social class, mother's education level), but reside in households with greater exposure to books in the home. Boys show a higher prevalence of special educational needs than girls (26% compared to 20%). While the majority of children are taught by a female teacher in co-educational schools, a greater share of boys have a male teacher compared to girls (18% compared to 10%), and attend single sex schools (31% compared to 18%).

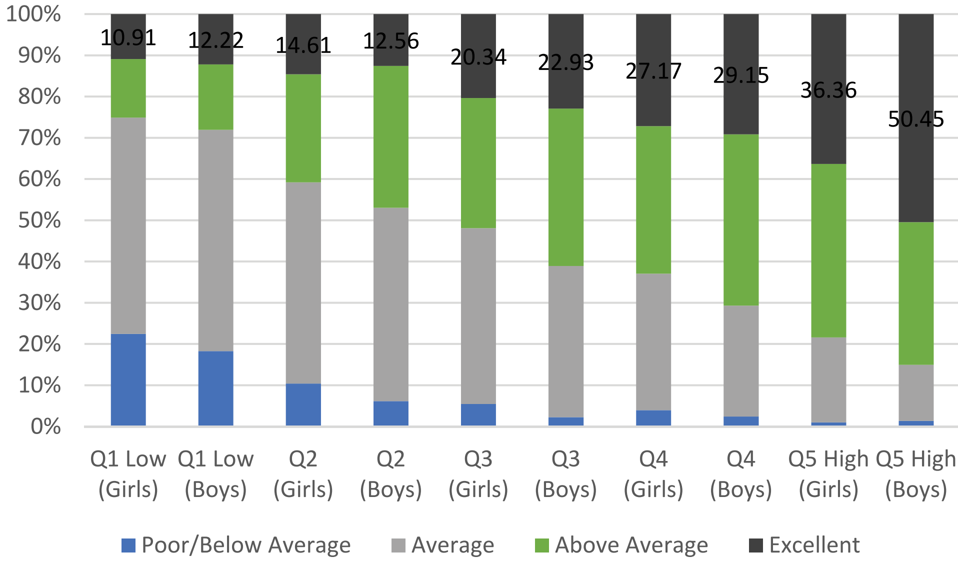

Figure 1. Mothers' ratings of mathematics ability for girls and boys by mathematics achievement quintile.

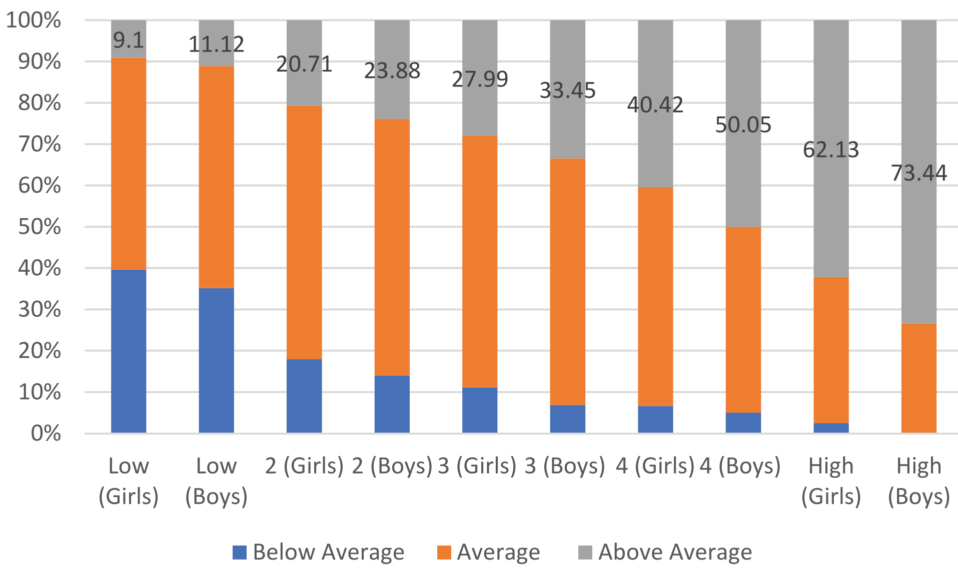

Figure 2. Teachers' ratings of mathematics ability for girls and boys by mathematics achievement quintile.

Table 4. Logistic regression model of teachers' perceptions of children's mathematics performance.

	Model 1	Model 2	Model 3	Model 4	Model 5
Child Gender					
Male	1.478***	1.170	2.551**	1.604**	1.384*
Ref: Female	(6.50)	(0.78)	(3.18)	(2.95)	(2.07)
Mathematics Attainment					
Q2	1.917***	1.702**	1.923***	1.924***	1.916***
	(5.26)	(3.04)	(5.28)	(5.28)	(5.25)
Q3	3.060***	2.756***	3.068***	3.060***	3.060***
	(9.48)	(6.15)	(9.50)	(9.48)	(9.48)
Q4	4.833***	4.140***	4.842***	4.829***	4.831***
	(13.53)	(8.70)	(13.54)	(13.52)	(13.53)
Q5 (High)	11.84***	10.18***	11.88***	11.85***	11.84***
Ref: Q1 (Low)	(21.05)	(13.97)	(21.06)	(21.04)	(21.05)
Child Engagement in Mathematics					
Always like Mathematics	1.326*	1.320*	1.323*	1.327*	1.326*
	(2.54)	(2.49)	(2.52)	(2.54)	(2.54)
Sometimes like Mathematics	0.951	0.948	0.949	0.950	0.951
Ref: Never like Mathematics	(−0.45)	(−0.48)	(−0.47)	(−0.46)	(−0.46)
PH Intellectual and School Subscale	1.083***	1.083***	1.107***	1.082***	1.083***
	(6.90)	(6.90)	(6.12)	(6.88)	(6.90)
Child Absenteeism					
Absent 1–10 Days	1.068	1.068	1.067	1.067	1.068
	(0.70)	(0.70)	(0.69)	(0.69)	(0.70)
Absent 11+ Days	1.051	1.050	1.053	1.049	1.050
Ref: Never Absent from school	(0.39)	(0.39)	(0.41)	(0.38)	(0.39)
Child Homework Behaviour					
Occasionally/Regularly Incomplete	0.435***	0.435***	0.434***	0.435***	0.436***
Ref: Never Incomplete	(−10.59)	(−10.58)	(−10.63)	(−10.57)	(−10.57)
Household Social Class					
Professional/Managerial	1.156	1.155	1.154	1.152	1.155
	(1.19)	(1.19)	(1.18)	(1.17)	(1.18)
Non-Manual	1.001	1.001	0.998	0.997	1.000
	(0.01)	(0.01)	(−0.01)	(−0.03)	(−0.00)
No Social Class	0.994	0.994	0.993	0.991	0.995
Ref: Semi-unskilled manual	(−0.03)	(−0.03)	(−0.04)	(−0.05)	(−0.03)
Household Income					
Highest Income Quantile	1.178	1.177	1.177	1.179	1.180
	(1.59)	(1.59)	(1.59)	(1.60)	(1.61)
Middle Income Household	1.090	1.090	1.087	1.087	1.091
Ref: Income Poverty Household	(0.98)	(0.97)	(0.95)	(0.95)	(0.99)
Mother Education Level					
Upper Secondary and/or Vocational	1.241*	1.242*	1.243*	1.304*	1.241*
	(2.22)	(2.22)	(2.23)	(1.99)	(2.22)
Third level non-degree	1.338**	1.338**	1.337**	1.500**	1.338**
	(2.81)	(2.81)	(2.80)	(2.88)	(2.81)
Degree +	1.740***	1.738***	1.743***	1.702***	1.739***
Ref: Lower secondary or less	(5.14)	(5.12)	(5.16)	(3.73)	(5.14)
Family Recent Migrant History					
Recent migrant history	1.032	1.034	1.032	1.035	1.032
Ref: no recent migrant history	(0.46)	(0.48)	(0.46)	(0.49)	(0.45)
Children's books in the home					
10–20 Books	1.077	1.073	1.078	1.080	1.078
	(0.54)	(0.51)	(0.54)	(0.55)	(0.54)
20–30 books	1.024	1.021	1.023	1.025	1.024
	(0.17)	(0.15)	(0.16)	(0.18)	(0.17)
30+ books	1.298*	1.295*	1.296*	1.302*	1.298*
Ref: less than 10 books	(2.07)	(2.05)	(2.06)	(2.10)	(2.07)
Teacher Gender					
Female	0.756***	0.756***	0.756***	0.756***	0.723*
Ref: Male	(−3.41)	(−3.41)	(−3.42)	(−3.42)	(−2.53)
Years of Teaching Experience	0.998	0.998	0.998	0.998	0.998
	(−0.82)	(−0.81)	(−0.82)	(−0.80)	(−0.80)

(*Continued*)

Table 4. (Continued).

	Model 1	Model 2	Model 3	Model 4	Model 5
Child Gender					
School Gender Intake					
Single-sex school	0.929	0.930	0.930	0.927	0.934
Ref: Co-educational school	(−1.07)	(−1.06)	(−1.06)	(−1.10)	(−0.99)
Mathematics Performance*Gender					
Q2 Mathematics*Gender		1.252			
		(0.91)			
Q3 Mathematics*Gender		1.213			
		(0.82)			
Q4 Mathematics*Gender		1.351			
		(1.30)			
Q5 Mathematics*Gender		1.332			
		(1.24)			
Piers Harris*Gender			0.958		
			(−1.89)		
Mother Education*Gender					
Upper Secondary and/or Voc*Gender				0.902	
				(−0.55)	
Third level non-degree*Gender				0.794	
				(−1.18)	
Degree +*Gender				1.039	
				(0.20)	
Teacher Gender*Child Gender					1.080
					(0.46)
Observations	6,521	6,521	6,521	6,521	6,521

Exponentiated coefficients; *t* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

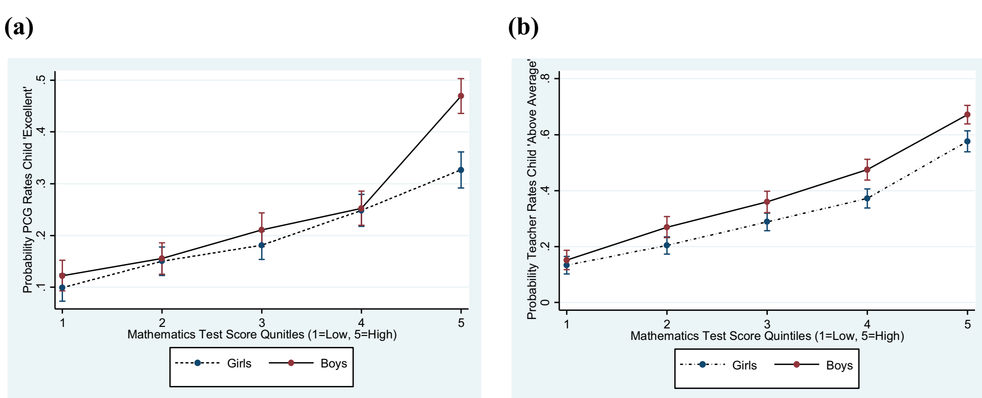

Figure 3. Interaction effect of student gender and mathematics performance on (A) Mothers' and (B) Teachers' perceptions of mathematics performance.

Figures 1and 2 show the descriptive results of mothers' and teachers' perceptions of the mathematics performance of nine-year-old girls and boys at each mathematics achievement quintile. As evidenced by a series of chi-square tests of association, with the exception of those at the lowest level of achievement, mothers rate boys more highly than girls at all levels of achievement. As illustrated by Figure 1, disparities in the assessment of boys' and girls' mathematics ability are particularly evident among high-achievers: 36% of girls in the highest mathematics achievement quintile were assessed as 'excellent' by their mother

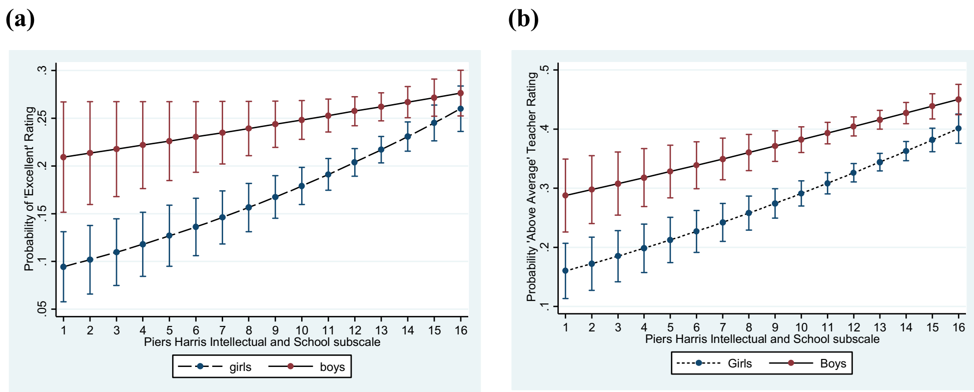

Figure 4. Interaction effect of student gender and Piers Harris intellectual and school subscale on (A) Mothers' and (B) Teachers' perceptions of mathematics performance.

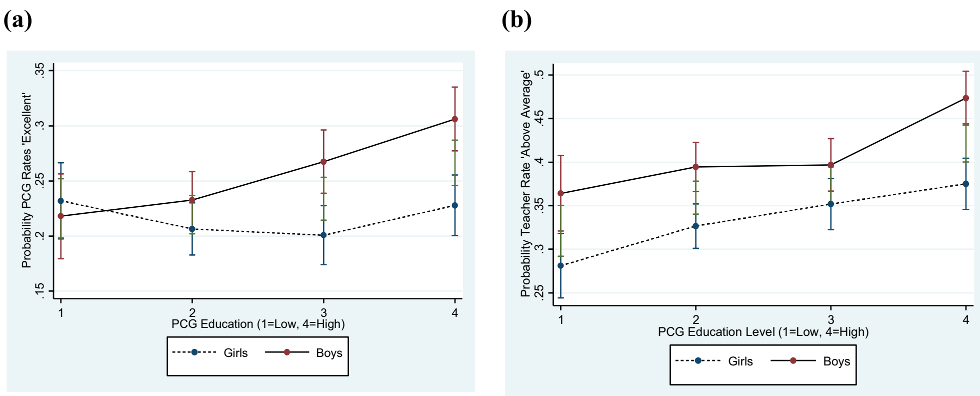

Figure 5. Interaction effect of student gender and PCG (Mother's) Education level on (A) Mothers' and (B) Teachers' perceptions of mathematics performance.

compared to 50% of boys. Teachers also rate boys more highly than girls, at all levels of achievement, and disparities are particularly pronounced among high-achieving girls. As shown by Figures 2, 62% of girls in the highest mathematics achievement quintile were rated 'above average' by their teacher, compared to 73% of boys.

What shapes mothers' and teachers' perceptions?

The first two columns in Tables 3 and 4 show that, all else being equal, both mothers and teachers are more likely to perceive boys as 'excellent' or 'above average' respectively than girls. That is, controlling for mathematics achievement, children's engagement with mathematics and school, self-concept, family background and teacher and school characteristics, boys are 1.3 times more likely than girls to be perceived as 'excellent' by mothers and 1.5 times more likely than girls to be perceived as 'above average' by teachers. In order words, girls are systematically less likely to be rated as ‘excellent’ or ‘above average’ than boys, even taking account of their actual performance levels. It also provides strong evidence that both teachers and mothers over-estimate boys’ and under-estimate girls’ performance in mathematics.

The models also show that perceptions in the case of both mothers and teachers are shaped by children’s actual mathematics achievement and their engagement with mathematics. As mathematics achievement increases, so too does the odds of being perceived as ‘excellent’ or ‘above average’. Furthermore, children who report that they ‘always like mathematics’ are 2.3 and 1.3 times more likely to be perceived as high-attainers by mothers and teachers respectively compared to those who ‘never like mathematics’. Children’s academic self-concept, as measured using Piers-Harris school and intellectual subscale scores, is also associated with a higher odds, while having incomplete homework is associated with a lower odds of being perceived as ‘excellent’ or ‘above average’.

Highly educated mothers (i.e. at least a higher education degree) are 1.3 times more likely to perceive their child’s mathematics ability as ‘excellent’ compared to those with lower levels of education (Table 3, Model 1). Teachers’ perceptions are informed by the education level of the mother, as evidenced by a gradient in odds ratios. Thus, children with more highly educated mothers are more likely to be rated as ‘above average’ by teachers compared to children whose mothers have lower levels of education (Table 4, Model 1). Parents who had recent migration experiences were also 1.2 times more likely to perceive their sons as ‘excellent’ in mathematics compared to those without a recent migrant history. Migrant history did not influence the teacher’s assessment.

The gender of the teacher appears to influence teacher assessments, as female teachers are less likely to rate nine-year-olds as ‘above average’ compared to male teachers. Furthermore, for every year increase in teaching experience, there was a lower chance of children being assessed as ‘excellent’. This highlights an important and unexpected consequence of impact of female gender. Contrary to our expectations, the gender composition of the school does not explain variation in teachers’ and mothers’ perceptions of mathematics performance.

Factors affecting the attribution of higher mathematical abilities to boys than girls

We tested to see if key characteristics of children (their mathematics achievement, academic self-concept), their families (mother’s education level) and school context (teacher gender or school context) have differential effects for boys and girls using interaction terms. In the teacher models, none of these interaction terms were statistically significant, suggesting little evidence of a gender biasing effect of teachers’ perceptions. However, some insights can be gleaned from the plots of the interaction terms (see Figures 3,4 and 5).

The interaction term between Q5 mathematics achievement and gender of the child approaches significance in Model 2 of Table 3 suggesting that mothers of children with high mathematics achievement attribute higher mathematical abilities to boys than girls. The interaction plots shown in Figure 3 show that both mothers and teachers rate boys higher than girls at all levels of the mathematics achievement distribution. However, among children in the highest quantile, boys are almost 1.5 times more likely than girls to be rated ‘excellent’ by their mother.

The interaction term between the child's academic self-concept and gender was significant, indicating that irrespective of the child's level of academic self-concept, boys are more likely than girls to receive a higher rating by mothers (Model 3, Table 3). As illustrated by Figure 4, mathematical gender bias on the part of mothers is reduced for children with very high levels of self-concept.

Model 4 of Table 4 also shows a significant interaction term between mother's education and the gender of the child meaning that more highly educated mothers are more likely to endorse gender differentiated views of their children's mathematics ability compared to those with lower levels of education. That is, gender bias is highest among more educated mothers.

Discussion

This paper shows that mothers and teachers are 1.3 and 1.5 times more likely to rate boys as 'excellent' or 'above average' in mathematics than girls. While mothers and teachers use actual mathematics achievement, as well as children's engagement with mathematics and school and academic self-concept to inform their perceptions, when comparing like with like, girls are underrated in mathematics relative to their academically similar male peers. This study thus supports the evidence of studies by Cimpian et al. (2016) and Tiedemann (2000, 2002), among others, showing gender bias in teacher and parent perceptions of performance. However, in taking account of rich individual, family and school level characteristics, our study advances previous evidence, in finding that both teachers and mothers over-estimate boys' performance in mathematics and underestimate high performing girls' abilities in the area, all else being equal. This devaluing occurs throughout the achievement distribution and we suggest that it reflects stereotypes about boys' 'superior mathematical ability'. Interpreting this in terms of an FI perspective, it can be seen as indicating the importance of the informal dimension and its impact in perpetuating gendered devaluation — particularly as regards mathematical ability, which is widely seen as an indicator of intelligence in western society.

The fact that female teachers are less likely than male teachers to rate nine-year-old children as 'above average' compared to male teachers can be seen from an FI perspective as reflecting their internalised devaluation of themselves: with their inability to identify excellence, arguably reflecting their own stereotypical lack of confidence as professional women making such assessments in mathematics.

Using interaction terms, our analyses show that mothers, rather than teachers, use children's characteristics and their backgrounds to attribute higher mathematical abilities to boys than girls and so a gender biasing effect on their perceptions is produced. Mothers' gender bias was evident among the highest mathematics achievers, at all levels of children's academic self-concept (although it did narrow at very high levels), and among mothers with high levels of education (third level or higher).

Gender bias is more evident among mothers than teachers — presumably because mothers have less day-to-day evidence of their children's mathematics performance. As found by Tiedemann (2000, 2002), Räty (2006), and others, it appears that mothers who are the major figures in most nine-year-olds' lives, endorse gendered stereotypes about mathematics. In our study this leads them to underestimate high-achieving girls' mathematics performance. In the case of mothers (but not teachers, who are more exposed to girls' day to-day achievements), it haloes out to a wider devaluation of girls' academic self-concept. However, gender bias is highest among more highly educated mothers. It is suggested that these trends reflect stereotypes about boys being excellent/ above average in mathematics. These stereotypes are so strong that, for mothers and female teachers, they override the evidence of the girls' and boys' own achievements. It is possible that the smaller gap in the case of teachers may reflect the impact of girls' diligent behaviour and may indicate the relevance of the children's agency.

In much of western society, mathematics is a gender marked subject: with boys doing better than girls in most countries (OECD, 2015, 2011) and typically doing better at the highest level. Mathematical ability is perceived as a marker of intelligence. In Ireland this is reflected in the fact that in the final state examination (the Leaving Certificate) bonus points are attached to young people's performance in this area. However, girls are significantly less likely to take the advanced (higher level) course in mathematics and hence be potentially eligible for these bonus points (McCoy et al., 2019, p. 9). The fact that as early as nine years old, high-achieving girls' performance at mathematics is being underestimated by both mothers and teachers is worrying. It is highly likely that this will impact on girls' subsequent performance. It will certainly impact on their career choice, since mathematics is seen as a key element in pursuing highly valued careers in Science, Technology, Engineering and Mathematics. Thus, calls for girls by nation states in Western society, including the EU, to consider such careers are likely to be ineffective: girls from as young as nine years old will have learned that even if they excel in this area, their teachers and mothers will not necessarily perceive them as such. They may well feel that they are better off choosing areas which are more compatible with existing gender stereotypes: thus, in many cases perpetuating their position in lower paid and less personally satisfying career positions. It illustrates the importance of the informal evaluative institutional dimension, highlighted by FI and its impact on the under-estimation of girls' abilities as reflected in gendered stereotypes. The fact that this effect is mediated through primary caregivers (who are mainly women) and particularly through female primary teachers illustrates the way in which women can (inadvertently) perpetuate a system which devalues them by perpetuating such gendered stereotypes.

The results highlight a role for teacher education and broader awareness, so that children are receiving clear and consistent messages around the importance of effort in supporting mathematical learning. Both teachers and mothers are likely to react in a positive manner when informed about the often unconscious, unintended and 'taken for granted' way in which stereotyping operates (Šimunović & Babarović, 2020). The extent to which this over-estimation exists in other subject areas in the primary school curriculum and whether it is reflected in boys' wider sense of entitlement (a phenomenon which is related to the international reproduction of male privilege inside the home, in educational institutions and in the wider society), warrants further investigation. For educators, this research raises interesting questions about the conditions under which gender stereotypes are reinforced or challenged by schools and the part played by teachers and mothers in perpetuating/modifying such stereotypes.

Notes

1. The vast majority (99%) of primary caregivers were mothers, so henceforth we refer to mothers.
2. The substantive results and interpretation of the influence of gender on mathematics ability does not differ when we run nested and un-nested models and so we are confident in presenting the un-nested results in the paper.

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Disclosure statement

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Data availability statement

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