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Geary WP2020/10
September 24, 2020

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Abstract

This paper is concerned with the underlying question of what shapes the assessment of children's mathematical ability: focusing particularly on parents' and teachers' perceptions of that ability in the context of children's attainment (measured using standardised mathematics tests). We suggest that such perceptions may reflect the impact of gender stereotypes: overestimating boys' and underestimating girls' achievements in the area. The influence of the children's own interests, attitudes and behaviour on these gender stereotypical perceptions are also explored. The paper draws on the *Growing Up in Ireland* study, providing rich data on children, their families and school contexts. The results show that as early as nine years old, girls' performance at mathematics is being underestimated by teachers and primary care givers alike relative to boys'. While teacher (and parent) judgments reflect children's attitudes towards school and academic self-concept, as well as their actual performance, there remains a notable gender differential in judgements. The findings raise concerns for girls' subsequent mathematics performance and for their academic self-concept in a society where mathematics is highly valued as an indicator of intelligence. Importantly, in the context of the move towards teacher-assessed grading in many education systems during the COVID-19 pandemic, understanding, and challenging, gender-stereotyping by both parents and teachers becomes critically important.

Key words

Gender stereotypes; mathematics; teacher perception; parent perception; academic self-concept; academic performance.

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Introduction

This article is concerned with the underlying question of what shapes the assessment of children's mathematical ability: focusing particularly on parents' and teachers' perceptions of that ability in the context of children's attainment (measured using standardised mathematics tests). We suggest that such perceptions may reflect the impact of gender stereotypes: overestimating boys' and underestimating girls' achievements in the area. A key contribution of this study is the inclusion of the influence of the children's own interests, attitudes and behaviour, and particularly their academic self-concept, on the parent and teachers' gender stereotypical perceptions. Are teachers and parents responding to children's own beliefs about their mathematical ability, and what implications will this have for the expectations and confidence of girls (and boys) in relation to mathematics as they progress through the education system?

While much of the research in the area has focused on either teacher or parental perceptions of performance (see for example Papageorge, Gershenson and Kang 2020; Rätty and Kasanen 2007; Genthrop et al. 2018), this study is able to consider the perceptions of both of these significant others (an approach also taken by Tiedemann, 2000). In doing so it examines whether teacher and primary caregivers' views of children's academic competencies in mathematics are obscured by gender stereotypes. The paper also examines the extent to which perceptions vary across different school and teacher contexts – examining indicators of school composition (like gender mix) and teacher characteristics (including gender and teaching experience). This allows a much more comprehensive assessment of the extent to which teachers and/or parents adopt gender-stereotyped views of children's mathematics performance, focusing on a much earlier age cohort (mid-primary/ 9 years of age) than typically examined. In addition, the analysis also considers the extent to which such perceptions are also affected by the child's motivation and engagement with school in general and mathematics in particular.

Considerable attention has been given to the educational attainment of boys and girls in an Irish context (Hannan et al. 1983; Hannan et al. 1996; Smyth et al. 2010). Children's mathematical performance has attracted particular attention nationally and internationally, with a good deal of evidence about the extent and nature of boys' and girls' relative achievements in the area (Borgonovi et al. 2018; OECD 2015). The evidence shows growing gender disparities from primary to secondary to postsecondary school suggesting that gender differences in mathematics attainment, in some countries, developed and widen over time (Copur-Gencturk et al. 2020). Examining the prevalence of mathematics teachers' explicit general and gender-specific beliefs about mathematical ability, Copur-Gencturk et al (2020) found teachers at secondary level were more likely to believe mathematics requires innate ability compared with teachers of primary years students. Their evidence also suggests that more experienced teachers and teachers who worked with students with additional needs seemed to believe less in the role of hard work in success in mathematics. 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.

The data is drawn from the first wave of the *Growing Up in Ireland* child cohort study – the National Longitudinal Study of Children in Ireland, a nationally representative study. This article draws on interview data collected on 8,578 nine-year-old children (representing one-in-seven nine-year-old children) and their parents and their teachers. The research questions in this paper are:

- Do parents and teachers have differential perceptions of boys' and girls' mathematics achievement, taking account of their actual performance?
- Are there particular regions of the achievement distribution where we see differences between achievement and perception?
- To what extent does this discrepancy between children's achievement reflect gender stereotypes and/or children's academic orientation and self-image?

Gender stereotypes are thus being used in this paper as an explanatory concept to understand the over/under estimation of boys'/girls' maths abilities in a context where this is seen as likely to lead to gender disparities in mathematics attainment.

Gender Stereotyping

The repertoire of actions and behaviours that society makes available for doing gender includes stereotypes (Martin 2003). Such stereotypes impact on expectations and evaluations and are activated in interactional contexts (Ridgeway and Correll 2004). Insofar as performances conform to the stereotype, they are seen as 'natural' and 'inevitable'. In an era of increasing gender fluidity, such binary gender stereotypes appear increasingly archaic.

For Ridgeway (2011, 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 men/boys and women/girls as different; they implicitly define men/boys as superior to women/girls. In Fraser's (2008, 58) terms, evaluative contexts are characterised by gender differentiated 'institutionalised patterns of interpretation and evaluation'.

The persistence of gender stereotypes and their impact on the differential evaluation of men/boys' and women/girls' achievements has been widely documented. And while it is possible that teachers' perceptions of gender differences may be grounded in actual attainment differences (OECD, 2015), recent research shows that primary and secondary school mathematics teachers demonstrate gender-based implicit biases even in decontextualised experimental settings (Copur-Gencturk, Cimpian, Lubienski, and Thacker 2020; Copur-Gencturk et al. 2020). Beyond educational settings, Moss-Racusin et al. (2012) found that in an experimental study involving two identical CVs, both men and women in a US university assessed the one with a boys' name more positively than the identical one with a girls' name. The vaguer the criterion and the more male dominated the

area, the greater the likelihood of gender stereotypes being activated. Thus, the Irish Research Council found that obscuring the gender of the applicant increased the success rates for girls' in applications for post-doctoral funding in Science, Technology, Engineering and Mathematics (IRC 2020).

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; OECD 2011). The weakness of gender stereotypes in Sweden and their strength in Ireland challenges assumptions about their inevitability (O'Connor and Goransson 2015). However even in Sweden, there was evidence of the differential evaluation of men and women's scientific competence in applications for Swedish research funding (Wenneras and Wold 1997), with doubts about applicants' intellectual autonomy much more likely to be raised in the case of applications from women than from men (Ahlqvist et al. 2013). Although frequently stereotypes are depicted as immutable there is evidence that they can change (Ely and Meyerson 2010; Deutsch 2007; O'Connor et al. 2015).

Parents' Perceptions of Children's Performance

In attempting to understand gender differences in educational performance, the educational psychology literature has established the importance of parents' expectations in influencing their children's achievement, attitudes and academic performance. A number of studies found that parents' expectations were related to their children's performance on cognitive tasks (McGillicuddy – De Lisi 1985) and, more broadly to children's self-perceptions of their ability and academic expectancies. Chipman et al. (1985) argue that parents' beliefs appear to play a particularly important role in the area of mathematics achievement; and Jacobs (1991) suggests that its impact is greater than the children's previous performance. Cross-cultural research has traditionally shown that parents impart, and children take on, the view that boys are good at mathematics and girls are good at literacy from a very young age (Lummis et al. 1990; Muntoni and Retelsdorf 2019).

Räty and Kärkkäinen (2011) argue that mathematics is perhaps the most gender-marked academic subject. They argue that mathematics is generally regarded as a domain in which parents' gender-bound expectations are the strongest and this tendency shows a measure of cross-cultural generalisability. 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 and Kasanen 2007).

Teachers' Perceptions of Children's Performance

It is frequently assumed that professional judgements are entirely evidence based. However, international evidence shows that judgements by highly educated professionals can reflect gender stereotypes, although not all studies find such gender effects. Looking at mathematics performance among US children, Cimpian et al. (2016) find that teachers consistently rate girls' mathematical proficiency lower than that of boys with similar achievement and learning behaviours. Gender differences in learning approaches are found to be fairly consistent across the achievement distribution, but girls' more studious approaches appear to have more payoff at the bottom of the distribution than at the top. Thus, even in these situations there appears to be a reluctance to identify girls as excellent in mathematics. On average girls are 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. Thus, in the US, Robinson-Cimpian et al. (2014) find that teachers rate boys' mathematics proficiency higher than that of girls when taking account of both teachers' ratings of behaviour and approaches to learning as well as past and current test scores. Ultimately, teachers' beliefs send signals to students about who belongs in mathematics and who does not. There is some evidence to suggest that such beliefs also vary by teacher experience and gender, but there is somewhat less evidence here (Copur-Gencturk et al. 2020).

A range of studies have found that teachers tend to associate 'natural mathematical' ability with boys more often than girls (Fennema, Peterson, Carpenter, and Lubinski 1990; Tiedemann 2000, 2002) and explicitly stereotype mathematics as a male domain (Keller, 2001; Leedy, LaLonde, & Runk, 2003; Li, 1999). Tiedemann (2000) surveyed 52 German teachers of grades 1–5 about their perceptions of boys and girls in their classes. They were asked to choose six of their students, three boys and three girls, from the same performance categories for each gender, one low-performing, one mid-performing, and one high-performing. Teachers then reported on each student's mathematical ability, effort, and potential for success in mathematics and provided their causal attributions for boys' versus girls' successes in mathematics. The author found that teachers viewed boys as more logical thinkers and viewed mathematics as less difficult for boys than girls of the same achievement level, although differences were significant only for mid-performers. Tiedemann also found that teachers believed girls profited less than boys from additional effort and attributed girls' unexpected failure to low ability but attributed boys' failure to effort.

Holder and Kessels (2017) found that teachers consider male students to perform better in mathematics than female students when actual student achievement is kept constant. Several studies found no gender bias in relation to teacher assessments, even when controlling for students' actual achievement (Lorrenz, et al. 2016). However, a number of studies suggest that teacher expectancy effects are at least partially mediated by students' self-concept

(Freidrich et al. 2015), thus highlighting the importance of children's own attitudes and behaviour in teacher's expectations and gendered stereotypes.

Children's Attainment, Attitudes and Work habits

Within the literature on teacher and parent perceptions of mathematics ability, relatively little attention has been paid to children and their views and attitudes. The Growing up in Ireland Study, from which the data is derived, places a central focus on the child's perspective and behaviour, eliciting their views and experiences on a range of topics including their likes and dislikes, their attitudes towards school and their aspirations. It thus offers a unique opportunity to examine the role of children's agency and assess how they shape (or indeed are shaped by) parents' and teachers' expectations and evaluations.

There is evidence that teacher perceptions are likely to be coloured by student characteristics other than achievement (Genthrop and Rjosk 2018). In their large-scale study of Dutch primary school students, Timmermans et al. (2016) find that differences in teacher expectations of boys and girls could partly be explained by the teachers' perceptions of students' work habits. Thus, girls' compliance and work orientation can increase teacher's perceptions of their ability while male students can experience a fundamental conflict between putting effort into schoolwork or following rules at school and maintaining a cool and masculine image in front of their peers (e.g. Kessel et al. 2014; Hadjar, Lupatsch, and Grünewald-Huber 2010; Mac an Ghail 1994). Tiedemann (2000) also found that teachers believed girls profited less than boys from additional effort and attributed girls' unexpected failure to low ability but attributed boys' failure to effort. Hence the question arises as to the extent to which stereotypes about mathematical ability can be modified by evidence about such day to day practices.

Theorists have addressed the challenges girls face in trying to balance academic success with being seen as a 'proper girl' (Walkerdine et al. 2001). Frawley et al. (2014) similarly find higher anxiety levels among 9-year-old girls. Renold and Allen (2006) showed that high achieving girls tread a precarious line between 'doing girls' and 'doing success': devising ways to minimise their cleverness and expending efforts to fit in with others at the cost of not perceiving themselves as 'high achievers' and/or being isolated from girls' friendship groups. It seems possible that such pressures are greatest in coeducational settings and these may affect teacher perceptions of girls' mathematics ability in such contexts.

OECD (2015) Pisa evidence also highlights how girls' lack of self-confidence in their own ability in science and mathematics may be responsible for the observed underachievement among girls in these subjects, particularly among high achieving girls. In a review of evidence, Pajares (2005) concluded that 'most studies' indicated that male students had higher mathematics self-efficacy than females, even when males and females have comparable achievement levels or when females outperform males. More recently, in a meta-analysis of over 187 studies, Huang (2013) 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 (p.11).

Research has provided strong evidence that self-efficacy and academic self-image are strong predictors of performance outcomes, with Usher and Pajares (2008), for example noting that self-efficacy “predicts students’ academic achievement across academic areas and levels”. However, there is much less research on the motivational mechanism that mediates the self-efficacy-achievement relationship (Domenec-Betoret et al. 2017).

Finally, there is evidence to suggest that teachers’ perceptions of students’ ability respond to student academic self-image, level of aspiration and self-efficacy. In their study of primary school students (Zhu et al. 2018: 661), for example, teacher judgement was found to have relatively strong associations with students’ expectancy for success.

The Irish context?

The educational system in Ireland operates simultaneously with two conflicting assumptions: that gender is irrelevant in the sense that gender stereotypes do not exist and that gender is vitally important and affects subject choice (Byrne and Murray 2020). The question of whether teachers’ assessment of their students is affected by gender stereotypes, and whether this varies depending on the gender of the teacher or the gender profile of the teaching context (single sex girls or boys schools or coeducational) is typically not even considered (for exceptions see Lynch and Lodge 2002).

The COVID-19 pandemic brought about the abandonment of traditional state examinations in Ireland (Mohan et al. 2020), as in many countries. The 2020 Leaving Certificate provided an unusual opportunity to assess the impact of teachers’ subjective assessments, since they were effectively asked to predict how their students would do in the Leaving Certificate, taking into account continuous assessment, projects, mock exams (‘with caveats’), previous results and any other relevant information. Intriguingly the picture that emerged was one in which they presented highly positive assessments of the girls they taught- arguably reflecting both their own perceptions of their competence as teachers and the girls’ willingness to co-operate with them. Thus, in this context they appeared to be able to transcend the negative stereotypes surrounding girls’ achievements, even in areas such as mathematics, and even in co-educational settings.

Methodology

The paper is based on data from the first wave of the *Growing Up in Ireland* child cohort study – the National Longitudinal Study of Children in Ireland, a nationally representative study. The underlying framework of the study emphasises children’s connectedness to the world in which they live (Bronfenbrenner and Morris 2006) emphasising the multifaceted and multi-layered influences on children’s development. Between September 2007 and May 2008, *Growing Up in Ireland* interviewed 8,578 nine-year-old children (representing one-in-seven nine-year-old children), their parents and their teachers about a wide range of topics and experiences. In addition, information was collected from other key people including each child’s primary caregiver and their teacher. Standardised academic tests were also administered to the children. The sample design was based on a two-stage selection process in which the school was the primary sampling unit with the children within school being the secondary units. This design meant that a virtually comprehensive frame of 9-year-old children in Ireland was provided; it allowed for direct access to the children’s teachers (who were key study informants); and it facilitated the self-completion of academic assessment tests in a group setting. Further details on the study are available in Murray et al. (2010).

Variable Description:

Dependent Variables

Our analysis is focused on how teachers and primary caregivers rate the study child in their mathematics performance, and the extent to which each estimates girls or boys more highly at any given level of performance. 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’. Primary caregivers^d 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’. These categorical variables serve as our key dependent variables, and seek to examine misperceptions along the lines of gender. Teacher perceptions of the child being ‘above average’ is predicted against the reference categories of ‘average’ or ‘below average’. Parent perceptions of the child being ‘excellent’ is predicted against the reference categories of ‘above average’, ‘average’ and ‘below average’.

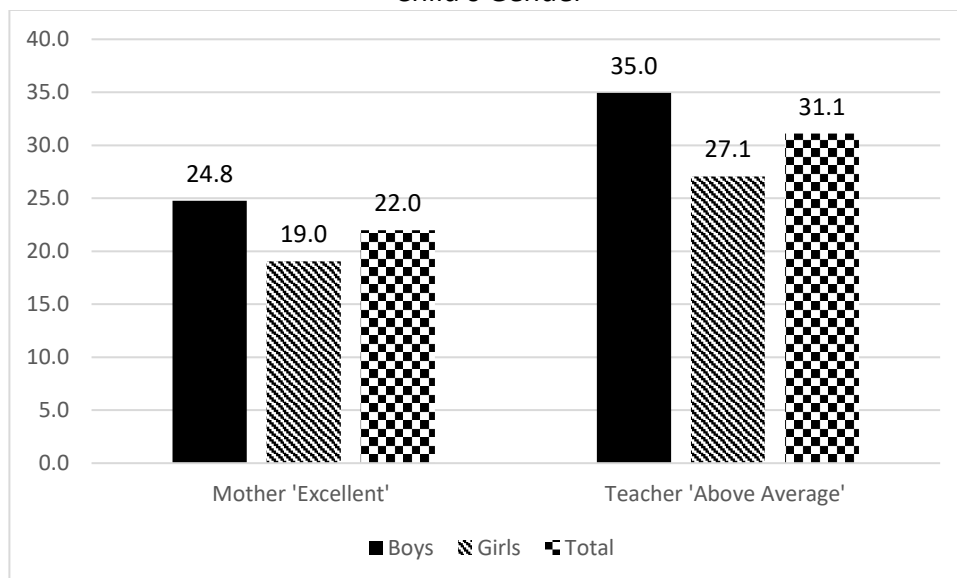
We acknowledge that these measures are relatively crude, but they do constitute established potential measures of bias (see Rigele-Crumb and Humphries 2012 in the US; Rätty and Kasanen 2007 in Finland). The importance of these measures lie in the evidence they produce, on a national scale, that girls and their mathematics ability are more likely to be underestimated by teachers and

^d 98% of primary care givers who completed wave 1 are female.

parents but also that boys' mathematics ability is more likely to be overestimated by both teachers and parents.

As shown in Table 1 and Figure 1, more boys than girls receive high ratings by both teachers and parents. Over one-third (34.9%) of boys are rated as 'above average' in relative mathematics ability compared to just over a quarter of girls (27%). Likewise, almost a quarter (24.7%) of boys are perceived by parents to be 'excellent' by relative standards, compared to 19% of girls. Thus, these measures capture two slightly different dimensions of potential biased perceptions, and are consistent between parents and teachers and thus represent an important contribution to prior research.

Figure 1: Parent and Teacher Perception of Child's Mathematics Performance by Child's Gender



Independent Variables

In our analyses we include a number of independent variables captured at the child, family, teacher and school levels. A descriptive analysis of the distribution of these variables by gender is shown in Table 1.

In terms of children's characteristics, children's current mathematics performance was measured using standardised mathematics tests (ERC 2007, Murray et al. 2010). These tests are developed for school children in Ireland, are linked to the national curriculum and are grade-specific. They have strong reliability and validity and are widely used in the Irish context (for recent example see Dempsey et al. 2020). As shown in Table 1, boys experience significantly higher levels of mathematics achievement than girls at age nine.

In order to capture children's agency (Corsaro 1997) we focus on measures of children's attitudes to their schooling and a measure of their academic self-concept. A subjective measure of children's attitudes towards mathematics was

collected through child self-completion questionnaires. The children were asked whether they like mathematics (always, sometimes, never). Boys are more likely to respond that they like maths 'all the time' compared to females, supporting findings from Pajares (2005) (see Table 1). We also draw on the Piers Harris self-concept measure, drawing on the Intellectual and School Status Sub-Scale^e, providing valuable insights into how children rate their academic ability. Here, girls typically experience higher scores on this measure than boys. However, it is not possible to differentiate academic self-concept in different domains; evidence suggests that gender differences in self-concept are more likely in relation to mathematics self-concept (Cvencek et al. 2015). Two objective measures of school engagement were also used in the analysis. Individual absenteeism levels were measured by asking primary caregivers about the number of days their child has been absent from school in the last school year, with results grouped into four categories. As shown in Table 1, girls experience higher levels of absenteeism than boys. Teachers were asked to report the frequency with which the study children completed their homework (distinguishing those who 'regularly' or 'occasionally' did not do homework from all others). Here, boys are more likely than girls to attend school with incomplete homework. While a common omission from previous studies, these measures of children's agency may well bear some relationship to how parents and teachers evaluate their performance. These indicators of children's characteristics, attitudes and performance may either reflect or create under-estimations of their performance by teachers and/or the primary care giver (predominantly the mother).

Finally, we also assess the potential impact of special educational needs on parent and teacher ratings of children's performance in mathematics based on the teachers' and parents' responses). Research by McCoy and Banks (2012) shows that children with special educational needs in Ireland are less engaged at school compared to their peers without such needs and face considerable social and academic barriers at school. In our sample, a higher share of boys than girls are considered by teachers and parents to have a special educational need.

In relation to family context, two measures of social background factors were included in the analyses: social class and household income, with the assumption that these measures may capture different dimensions of parental background, reflecting occupational position and economic resources. Social class is based on the primary and secondary caregivers' occupation. The classification was adopted by the Irish Central Statistics Office (Murray et al. 2010). Household social class was assigned using a dominance criterion, whereby the classification

^e The Piers-Harris scale (Piers, Harris, Herzberg 2002) is a multidimensional construct containing six sub-scales, including the Intellectual and School Status subscale. This is a 16 item scale that measures the child's evaluation of his or her own abilities in terms of intellectual and academic tasks. The Piers-Harris measure is argued to be 'one of the best if not the best questionnaire of it's type' (Kelley 2004) and has been used in a wide range of settings, including in the measurement of self-concept in children with complex needs (Buckroyd and Flitton 2004).

is taken as the higher of the primary and secondary caregiver's class (where the latter is resident). The measure of household income is based on the combined income of the primary and secondary caregivers, with households grouped into income quintiles. The girls' in our sample fare less well on these measures than boys'.

To tap into the educational and cultural resources within the home which are likely to influence parent and teacher expectations, we draw on information on the primary caregivers' level of educational attainment and access to books in the home, which has been previously found to be a strong predictor of educational performance (Marks et al. 2006). The measure of parental education is based on that of the primary caregiver and is based on the classification used in the Irish Census of Population. Using this measure, a greater share of boys live in high education households compared to girls (Table 1). The primary caregiver was asked to report the number of children's books in the home; here we distinguish between fewer than 10 or less (including none), 11–30 and more than 30. Females typically live in household with a greater number of children's books in the home. An additional measure tapped into the recent migrant history of the family, with second generation children defined as those with at least one parents born outside Ireland.

At the school level, we assess the role played by the teacher's gender and their years of teaching experience using an ordinal variable. In the Irish context, the vast majority of primary school teachers are female (Byrne and Murray 2020). Yet, more girls than boys are taught by a female teacher, and more boys than girls are taught by a male teacher (Table 1). Few differences exist between boys and girls in terms of years of teaching experience. Finally, we consider the gender mix of the school (i.e. single sex boys, single sex girls and coeducational) to assess if ratings of girls and boys vary across single-sex and coeducational settings. In our sample, a greater share of boys than girls are taught in single-sex schools (28.6% compared to 17% respectively).

Analytic Approach

Using binary logistic regression, the analyses will assess the potential influence of child, family, teacher and school characteristics on teacher and parent ratings. Using the range of characteristics, we examine whether parents and teachers have differential perceptions of boys' and girls' mathematics achievement, even when actual performance and indicators of children's agency is taken into account. 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 (see Model 1 Table 2, Model 1 Table 3).

To examine the possibility that each of the independent variables contributes differently to teacher and parent perceptions for boys and girls, we include interaction terms (Model 2 Table 2, Model 2 Table 3). When appropriate, figures of predictive margins are used to illustrate variation in predicted probabilities for boys and girls.

Results

Parent and Teacher Ratings

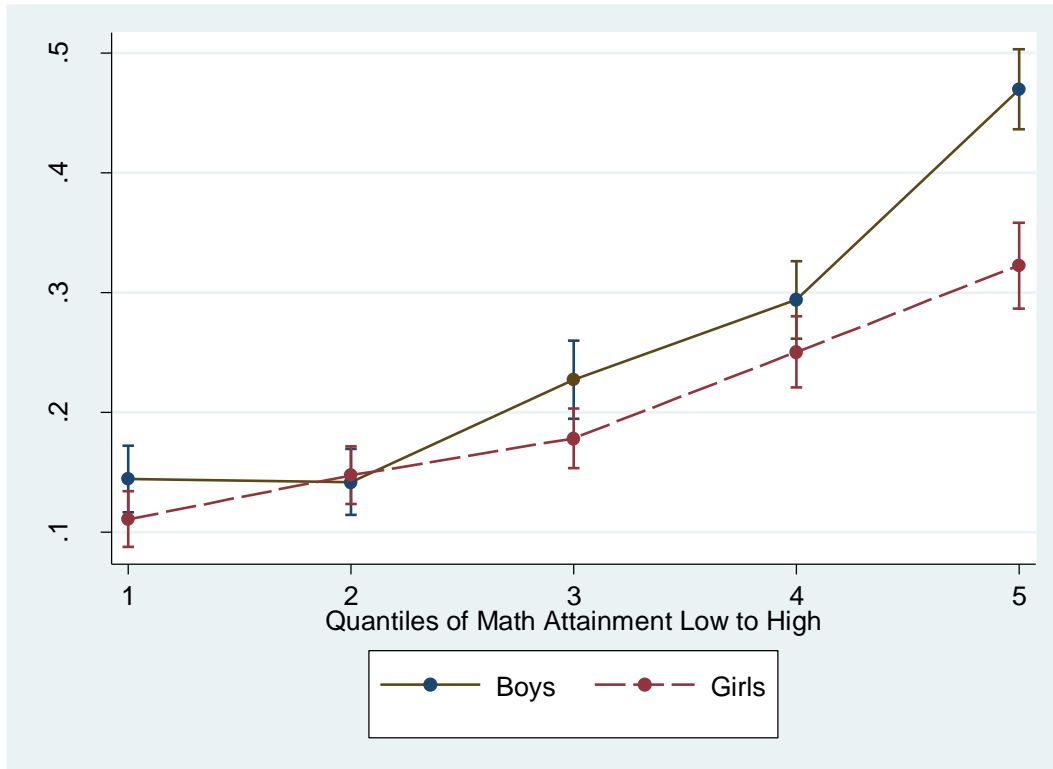
We now consider the ways in which teachers and parents evaluate children's mathematics performance controlling for actual performance in national standardised mathematics tests and children's agency; this will allow a much clearer assessment of the extent to which teachers and/or parents rate boys more highly than girls in their mathematics performance. Multivariate analyses presented in Table 2 and Table 3, show that all else being equal, parents and teachers are more likely to rate children with median or above levels of mathematics achievement as 'excellent' or 'above average' respectively.

Gender, Mathematics Performance and Parent and Teacher Ratings

The models also reveal important differences in ratings of boys' and girls' mathematics performance, with strong evidence that both teachers and primary care givers over-estimate boys' performance. In the case of primary caregivers, there is a strong reluctance for parents to rate high performing daughters as excellent (Model 1, Table 2), arguably reflecting gender stereotypes. While an interaction term between mathematics attainment and gender of the child was not significant – meaning that the relationship between mathematics attainment and parent ratings does not differ by the gender of the child (Model 2, Table 2) – it is clear from Figure 2 that girls are systematically less likely to be rated 'excellent' than boys, even taking account of their actual performance levels.

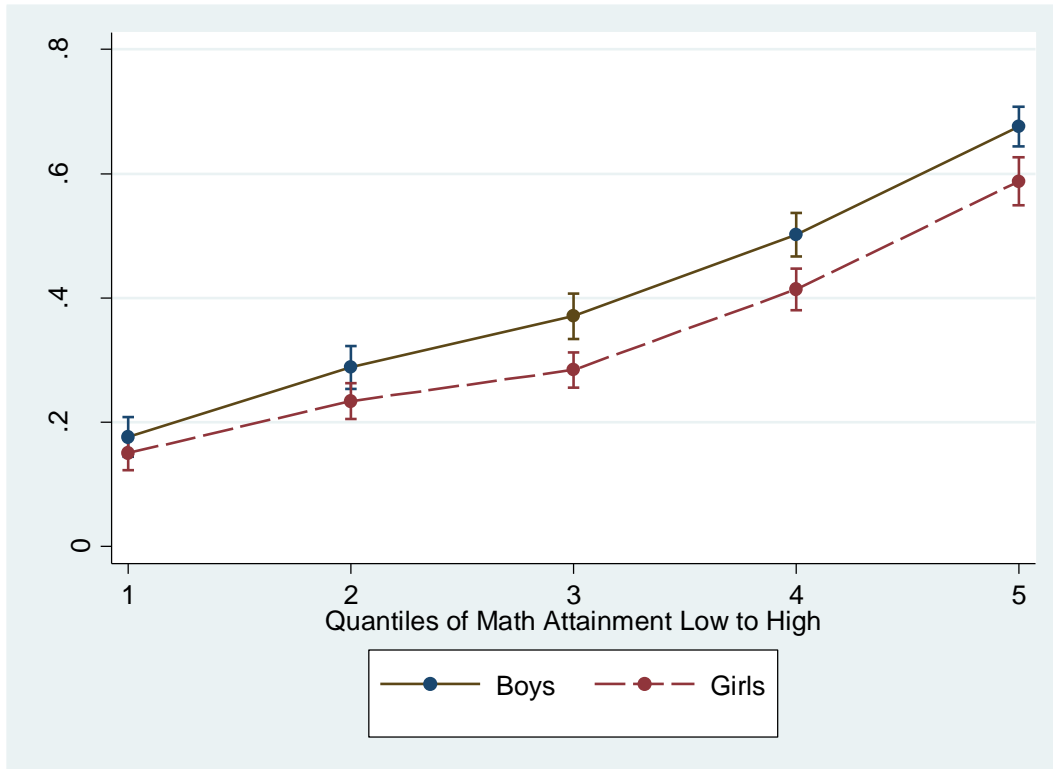
Figure 2 also illustrates that the gap is largest at higher levels of mathematics attainment. It is striking that the perceived gap between boys and girls at the highest level is much wider in the case of the primary care giver than in the case of the teacher, which we turn to next. This suggests that parental stereotypes may be less amenable to change than the teachers ones- arguably reflecting the greater day-to-day experience by the teachers of the children's academic agency.

Figure 2: Predictive Margins of Probability of Being Rated 'Excellent' in Mathematics by Primary Caregiver



In the case of teachers (Table 3), the findings also show that teachers are significantly less likely to rate girls as 'above average' than boys, even taking account of their actual performance in robust mathematics tests. As shown in Model 2, Table 3, we included an interaction term between mathematics attainment and gender of the child. While the interaction term was not significant – meaning that the relationship between mathematics attainment teacher ratings does not differ by gender – it is clear from Figure 3 that at all levels of attainment, teachers are more likely to estimate boys' performance highly than girls' performance.

Figure 3: Predictive Margins of Probability of Being Rated 'Above Average' in Mathematics by Teacher



Gender, Child Characteristics and Parent and Teacher Ratings

Is there evidence to suggest that the indicators of children’s agency (attitudes toward school and mathematics and academic self-concept) and characteristics may either reflect or create under-estimations of their performance by teachers and/or the primary care giver? In order to capture children’s agency (Corsaro 1997) we focused on measures of children’s self-report attitudes to their schooling and a measure of their academic self-concept. These results show that teachers and caregivers assessments significantly and positively relate to children’s academic self-concept. Here, we find that all else being equal, children with higher levels of academic self-concept are more likely to be rated by teachers as ‘above average’ and by parents as ‘excellent’ (Model 1 Table 2, Table 3). In the case of teachers, there is evidence that this relationship is mediated by the role of gender^f. While absenteeism shows no significant association with

^f However, a review of the predicted probabilities (not shown here) reveals the interaction effects are not large enough to matter. As scores of academic self-concept increase, so too do teacher ratings of children’s math ability, for boys’ and for girls’. On the part of teachers, even at the same level academic self-concept, they rate boys’ more highly than girls’.

teacher or parental perceptions of mathematics ability, homework behaviour and attitudes to mathematics clearly do. The relationship between homework behaviour and teacher and parental perceptions of mathematics ability is also mediated by the gender of the child. Children who have homework incomplete 'sometimes' or 'often' are under-estimated by both teachers and caregivers. Both teachers and primary caregivers respond to children's motivations toward maths, as children who 'sometimes' or 'never' like maths are less likely to be perceived by parents as 'excellent' or by teachers as 'above average'. These associations also vary by gender.

Consistent with earlier research (McCoy et al., 2016), there is also strong evidence that both parents and teachers hold lower expectations for children who are identified with a special educational need (Model 1 Table 2, Table 3). Furthermore, the relationship between having a special educational need and teachers' perceptions of mathematics ability differs by gender (Model 2, Table 3).

Gender, Home Characteristics and Parent and Teacher Ratings

A range of measures were used to capture the socio-economic status of the household and to capture access to resources in the home. Household income and the educational level of the primary caregiver each are associated with parent perceptions of the child's mathematics ability. Contrary to previous research, children living in middle income households are less likely to be rated by their caregiver as 'excellent' at math, compared to children living in households that experience income poverty (Model 1, Table 2). The relationship between household income and parent perceptions of mathematics ability is also mediated by gender, but this is not the case for teachers' perceptions.

Primary care-givers who have a Higher Education degree or higher are 1.3 times more likely to perceive their child as 'excellent' at mathematics compared to those with very low levels of education (Model 1, Table 2). Teachers also rate children as 'above average' in this way, and in both instances, the associations are also mediated by gender. Thus, even where girls score above average/excellent on the objective maths assessment test, they are not perceived as such by parents or teachers in these situations. This illustrates the difficulties that very able girls from such backgrounds face, with their mathematics abilities not even recognised by their primary care giver.

Gender, Teacher and School and Parent and Teacher Ratings

It would appear that teacher experience rather than teacher gender is associated with teachers and parents' perceptions of mathematics ability. The more experienced the teacher, the less likely parents are to perceive their child as 'excellent', and the less likely teachers are to perceive a child's mathematics ability as 'above average'. In the case of parents, this relationship is also mediated by gender (Model 2, Table 2). Contrary to our expectations, the gender composition of the school could not explain variation in teacher and caregivers perceptions of mathematics ability.

Discussion

In sum, the results show that both parents' and teachers' assessments of children's relative competence in mathematics are shaped not solely by the children's actual achievement in mathematics, but reflect stereotypes that boys possess 'superior mathematical ability'. Thus, in line with studies in other national contexts (Cimpian et al. 2016) our findings show that girls are underrated in mathematics relative to their academically similar male peers. This devaluing occurs throughout the achievement distribution, showing clear gender bias for girls in general. That said, the gap is widest among high-performing girls. While teacher (and parent) assessments do reflect children's attitudes towards school and academic self-concept, there is a notable gender differential in assessment – teachers and parents appear to over-estimate boys' performance in mathematics.

Evidence points to the importance of teachers' perceptions for students' learning outcomes and processes (e.g., de Boer et al. 2010 in the Netherlands; McCoy et al. 2016 in the Irish context), but they also have far-reaching implications for students' academic and professional careers (Holder and Kessels 2017). In this context, addressing teacher and parental attitudes offers an important way of securing equal educational opportunities for each child regardless of gender, social background, special needs status or other characteristics. In the context of COVID-19 and the move to calculated grading based on teacher judgement, understanding whether and why gender-stereotyping occurs becomes even more pressing.

We acknowledge the need for caution in attributing causality, as the factors are all measured at the same time-point. However, in the models presented, we examine sets of variables which are at least logically, if not temporally, 'prior' to the outcome in focus. Despite the limitations involved in attributing causal relationships, the analyses indicate important associations between child, home, teacher and school factors and how teachers and parents rate children's performance.

This paper has made an important contribution to the literature in a number of respects. Firstly, while much of the research attention has focused on the high school years/adolescence and the influence gender stereotyping has on both parent's and young people's self-assessments, little attention has focused on the early childhood years. This paper has addressed this gap and provides important insights into the processes shaping wide differences in parent and teacher expectations of boys and girls, even at this relatively early age. By focusing on both parent and teacher evaluations we provide a fuller understanding of the processes shaping expectation formation. Finally, unlike much of the research in this area, we place a central focus on the child and regard children as active agents in their own educational development (see, for example Corsaro 1997) and so we focus on measures of children's attitudes regarding their schooling and their academic self-concept as well as their academic performance. Essentially, we argue that children have a central role to play in challenging the cultural stereotypes and hence in influencing how parents and teachers evaluate them.

Conclusions

In Ireland mathematical ability is perceived as a marker of intelligence. 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, in much of western society, mathematics is also a gender marked subject: with boys doing better than girls at the highest level, with a few exceptions (OECD 2015; OECD 2011).

It is clear from this article that stereotypes about boys being excellent/above average in mathematics persist among both teachers and primary care givers (mainly mothers). These stereotypes are so strong that they override the evidence of the girls and boys own achievements in nationally validated mathematics assessments. Thus girls, even where their performance on these tests is objectively excellent, are not perceived as such- and the gap is greater among the primary care givers than among the teachers. It is possible that the smaller gap in the case of teachers reflects the impact of another stereotype- viz that of girls as compliant responsible students and its impact on their teacher's assessment of their mathematics performance.

Nevertheless, the fact that, as early as nine years old, girls' performance at mathematics is being underestimated by teachers and primary care givers alike is worrying. It is highly likely that this will impact on girls' subsequent mathematics performance and indeed on their academic self-concept in a society where mathematics is highly valued as an indicator of intelligence. 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. In this context it is obvious that the frequent 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 primary care givers will not 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.

This article has shown that teachers and primary care givers estimate boys' performance on mathematics more highly than girls' performance, even taking account of actual performance. Other work needs to be done on the extent to which this over-estimation exists in other subject areas and the extent to which it is reflected in boys' wider sense of entitlement: a phenomenon which is related to the international reproduction of privilege inside the home and in the wider society. Theoretically it raises interesting questions about the conditions under which gender stereotypes are influenced and the part played by agentic factors in perpetuating/modifying such stereotypes under particular conditions.

Acknowledgements

Growing Up in Ireland has been funded by the Government of Ireland through the Department of Children and Youth Affairs (DCYA) in association with the Central Statistics Office (CSO) and the Department of Social Protection (DSP). These data have been collected in accordance with the Statistics Act, 1993. The DCYA, CSO and DSP take no responsibility for the views expressed in the research. The project has been designed and implemented by the joint ESRI-TCD Growing Up in Ireland Study Team.

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Table 1: Descriptive Statistics

	All	Boys	Girls
Dependent Variables			
Teacher 'above average'	31.1	34.9	27.0
Parent 'excellent'	21.1	24.7	19.0
Independent Variables			
<i>Current Maths Attainment</i>			
Q1 Maths (Low)	24.1	24.3	23.9
Q2 Maths	20.6	18.9	22.3
Q3 Maths (Median)	19.5	17.3	21.7
Q4 Maths	18.8	19.3	18.3
Q5 Maths	16.9	20.0	13.6
Special Educational Need	24.1	27.2	20.9
Piers Harris Intellectual sub-scale	12.49	12.42	12.55
<i>Absenteeism</i>			
Absent 0-6 Days	69.2	71.9	66.6
Absent 7-10 Days	17.8	16.7	19.0
Absent 11+ Days	12.9	11.4	14.5
<i>Homework Behaviour</i>			
Homework incomplete	26.9	30.0	23.8
<i>Attitudes Toward Maths</i>			
Always like maths	47.2	50.1	44.3
Sometimes like maths	42.6	40.2	45.1
Never like maths	10.1	9.6	10.5
<i>Family Social Class</i>			
Professional/Managerial	41.6	44.0	39.2
Non-Manual/Skilled Manual	35.4	35.7	35.2
Semi-Unskilled Manual	11.0	9.4	12.6
No Social Class	11.9	10.9	13.0
<i>Family Income</i>			
Income Poverty	25.0	23.5	26.6
Middle Incomes	49.7	49.5	49.9
High Income	18.6	20.1	17.1
Household Income Unknown	6.5	6.8	6.2

Table 1: Descriptive Statistics continued

	All	Boys	Girls
<i>PCG Education Level</i>			
Low Education Level	30.1	27.9	32.5
Secondary/Vocational Education	36.7	36.7	36.6
Third Level Non-Degree	15.9	16.8	14.8
Degree +	17.2	18.4	15.9
Second Generation Family	27.6	26.1	28.4
Books in the Home			
10 Books or less	10.3	12.6	7.9
11-20 Books	18.8	20.0	17.6
21-30 Books	14.7	14.3	15.1
31+ Books	56.0	52.9	59.1
Teacher Female	81.2	76.9	85.7
Years Teaching Experience	12.7	12.6	12.7
Single-sex school	23.0	28.6	17.0

Table 2: Binary Logistic Regression Model of the Factors Associated with Parents' Perceptions of Children's Mathematics Ability (Odds Ratios)

	Model 1 Baseline Model	Model 2 Interaction Terms
Q2 Maths Score	1.188 (1.51)	0.998 (-0.01)
Q3 (Median) Maths Score	1.779*** (5.29)	1.841*** (3.94)
Q4 Maths Score	2.671*** (9.28)	2.620*** (6.52)
Q5 (High) Maths Score <i>Ref: Q1 (Low) Maths Score</i>	4.946*** (15.17)	5.956*** (12.35)
Female <i>Ref: Male</i>	0.752*** (-4.73)	0.778 (-0.51)
Female*Q2 Maths		1.383 (1.40)
Female*Q3 (median) Maths		0.928 (-0.34)
Female*Q4 Maths		1.039 (0.18)
Female*Q5 Maths		0.661 (-1.93)
Second Generation <i>Ref: Not Second Generation</i>	1.092 (1.35)	1.067 (0.69)
Female* Second Generation		1.072 (0.53)
SEN	0.746*** (-3.54)	0.874 (-1.25)
Female* SEN		0.667* (-2.34)

Piers Harris Intellectual sub-scale	1.052 ^{***} (4.33)	1.030 (1.84)
Female*Piers Harris		1.053 [*] (2.19)
Absent 7-10 Days	1.069 (0.85)	1.096 (0.83)
Absent 11+ Days <i>Ref: Absent 10 or less days</i>	1.106 (1.06)	0.959 (-0.30)
Female* Absent 7-10 Days		0.930 (-0.46)
Female* Absent 11+ Days		1.312 (1.42)
Homework Incomplete <i>Ref: Homework complete</i>	0.773 ^{***} (-3.31)	0.895 (-1.08)
Female* Homework Incomplete		0.688 [*] (-2.31)
Sometimes like maths	0.516 ^{***} (-10.67)	0.527 ^{***} (-7.26)
Never like maths <i>Ref: Always like maths</i>	0.438 ^{***} (-6.61)	0.547 ^{***} (-3.60)
Female* Sometimes like maths		0.986 (-0.11)
Female* Never like maths		0.619 (-1.87)
Non-Manual/Skilled Manual	1.021 (0.29)	1.004 (0.04)
Semi-Unskilled Manual	1.146 (1.14)	0.783 (-1.31)
No Social Class <i>Ref: Professional/Managerial</i>	1.083 (0.48)	1.017 (0.07)

Female*Non-Manual/Skilled Man		1.046 (0.31)
Female*Semi-Unskilled Manual		1.954** (2.71)
Female*No Social Class		1.187 (0.50)
Middle Income	0.810* (-2.35)	0.989 (-0.08)
High Income	0.945 (-0.54)	1.033 (0.22)
Household Income Missing Ref: Income Poverty	0.762* (-1.99)	0.837 (-0.93)
Female*Middle Income		0.678* (-2.16)
Female*High Income		0.856 (-0.74)
Female*Income Unknown		0.829 (-0.68)
Secondary/Vocational	0.988 (-0.12)	1.054 (0.37)
Third Level Non-Degree	1.045 (0.43)	1.121 (0.77)
Degree + Ref: Low Education	1.336** (2.72)	1.509** (2.67)
Female* Secondary/Vocational		0.925 (-0.40)
Female*Third Level Non-Degree		0.901 (-0.50)
Female*Degree +		0.799 (-1.04)

Single Parent Family Ref: Coupled Family	1.143 (1.26)	1.371* (2.10)
Female*Single Parent		0.698 (-1.68)
10-20 Books in the home	1.011 (0.08)	1.092 (0.49)
21-30 Books in the home	0.753* (-2.01)	0.776 (-1.32)
31+Books in the home Ref: 10 books or less	1.098	1.290
Female*10-20 Books in the home		0.767 (-0.97)
Female*21-30 Books in the home		0.821 (-0.69)
Female*31+ Books in the home		0.627 (-1.89)
Teacher Female Ref: Teacher Male	1.076 (0.87)	1.041 (0.37)
Female*Teacher Female		1.019 (0.11)
Years of teaching experience	0.994* (-2.42)	0.988** (-3.20)
Female*Yrs of teaching experience		1.011* (2.10)
Single-sex school Ref: Coeducational school	1.117 (1.63)	1.076 (0.81)
Female*Single-sex school		1.183 (1.20)
<hr/> <i>N</i>	7506	7506

Table 3: Binary Logistic Regression Model of the Factors Associated with Teachers' Perceptions of Children's Mathematics Ability (Odds Ratios)

	Model 1 Baseline Model	Model 2 Interaction Terms
Female <i>Ref: Male</i>	0.752*** (-4.73)	0.939 (-0.14)
Q2 Maths Score	1.188 (1.51)	1.949*** (4.53)
Q3 (Median) Maths Score	1.779*** (5.29)	2.969*** (7.52)
Q4 Maths Score	2.671*** (9.28)	5.317*** (11.87)
Q5 (High) Maths Score <i>Ref: Q1 (Low) Maths Score</i>	4.946*** (15.17)	12.29*** (17.42)
Female*Q2 Maths		0.919 (-0.41)
Female*Q3 (median) Maths		0.796 (-1.13)
Female*Q4 Maths		0.818 (-1.01)
Female*Q5 Maths		0.758 (-1.34)
Second Generation <i>Ref: Not Second Generation</i>	1.092 (1.35)	0.993 (-0.08)
Female* Second Generation		1.034 (0.27)
Special Educational Need <i>Ref: No SEN</i>	0.746*** (-3.54)	0.510*** (-6.47)
Female* Special Educational Need		1.281 (1.59)

Piers Harris Intellectual sub-scale	1.052 ^{***} (4.33)	1.061 ^{***} (3.95)
Female* Piers Harris Intellectual		1.030 (1.36)
Absent 7-10 Days	1.069 (0.85)	1.121 (1.05)
Absent 11+ Days <i>Ref: Absent 10 or less days</i>	1.106 (1.06)	1.265 (1.76)
Female* Absent 7-10 Days		0.979 (-0.14)
Female* Absent 11+ Days		0.808 (-1.17)
Homework Incomplete <i>Ref: Homework complete</i>	0.773 ^{***} (-3.31)	0.439 ^{***} (-8.32)
Female* Homework Incomplete		0.961 (-0.26)
Sometimes like maths	0.516 ^{***} (-10.67)	0.793 ^{**} (-2.77)
Never like maths <i>Ref: Always like maths</i>	0.438 ^{***} (-6.61)	0.892 (-0.75)
Female* Sometimes like maths		0.853 (-1.37)
Female* Never like maths		0.690 (-1.75)
Non-Manual/Skilled Manual	1.021 (0.29)	1.029 (0.30)
Semi-Unskilled Manual	1.146 (1.14)	0.862 (-0.87)
No Social Class <i>Ref: Professional/Managerial</i>	1.083 (0.48)	0.927 (-0.32)

Female*Non-Manual/Skilled Man		0.701** (-2.67)
Female*Semi-Unskilled Manual		0.963 (-0.17)
Female*No Social Class		0.604 (-1.48)
Middle Income	0.810* (-2.35)	0.979 (-0.17)
High Income	0.945 (-0.54)	1.101 (0.67)
Household Income Missing <i>Ref: Income Poverty</i>	0.762* (-1.99)	1.074 (0.39)
Female*Middle Income		1.128 (0.69)
Female*High Income		1.082 (0.39)
Female*Income Unknown		0.913 (-0.35)
Secondary/Vocational	0.988 (-0.12)	1.191 (1.32)
Third Level Non Degree	1.045 (0.43)	1.223 (1.44)
Degree + <i>Ref: Low Education</i>	1.336** (2.72)	1.728*** (3.76)
Female* Secondary/Vocational		1.033 (0.18)
Female*Third Level Non Degree		1.155 (0.74)
Female*Degree +		0.889 (-0.58)

Single Parent Family <i>Ref: Coupled Family</i>	1.143 (1.26)	1.149 (0.94)
Female*Single Parent		0.957 (-0.21)
10-20 Books in the home	1.011 (0.08)	1.265 (1.37)
21-30 Books in the home	0.753* (-2.01)	1.273 (1.35)
31+Books in the home <i>Ref: 10 books or less</i>	1.098 (0.77)	1.643** (3.16)
Female*10-20 Books in the home		0.641 (-1.66)
Female*21-30 Books in the home		0.697 (-1.33)
Female*31+ Books in the home		0.640 (-1.84)
Teacher Female <i>Ref: Teacher Male</i>	1.076 (0.87)	0.746** (-2.84)
Female*Teacher Female		0.943 (-0.37)
Years of teaching experience	0.994* (-2.42)	0.997 (-0.87)
Female*Yrs of teaching experience		1.004 (0.74)
Single-sex school <i>Ref: Coeducational school</i>	1.117 (1.63)	0.869 (-1.60)
Female*Single-sex school		1.086 (0.61)
<i>N</i>	7506	7506

Exponentiated coefficients; t statistics in parentheses

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