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Parental stereotypes and early gender gaps in mathematical attitudes. Evidence from Italian primary schools

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Abstract: This article investigates gender differences in mathematical attitudes among 8-year-old students at the beginning of Grade 3 in two Italian metropolitan areas, Milano and Napoli. Drawing on data from the MATES project—a PRIN-funded study involving 3,312 students across 180 classes—we examine differences in students' liking for mathematics, confidence in mathematics, and perceived everyday use of mathematics. Although both boys and girls report broadly positive attitudes at this early age, gender differences are already observable: girls report higher overall school enjoyment, while boys display slightly higher self-efficacy and stronger liking for mathematics. No significant differences emerge in the use dimension. A key contribution lies in the analysis of parental influences (based on a subsample of 1,452 students): parental attitudes toward mathematics are positively associated with children's attitudes, while the endorsement of gender stereotypes—such as the belief that males are more naturally suited to mathematics—plays a critical and asymmetric role. These stereotypes are associated with lower liking for mathematics and self-efficacy among girls, while reinforcing more positive attitudes among boys. The findings highlight the role of parental beliefs in children's early attitude formation and suggest that gender stereotypes held by parents may contribute to gender gaps well before differences in performance become pronounced.

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Keywords: mathematics education; gender differences; primary school; mathematical attitudes; self-efficacy; parental stereotypes.

1. Introduction

Mathematics education in the early years of schooling plays a foundational role in shaping children's long-term academic trajectories. Despite extensive research on gender disparities in STEM fields, the specific mechanisms through which attitudinal and motivational differences emerge remain a subject of active scholarly debate [13, 21], and studies focusing on very young

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students, such as primary school children, remain relatively rare [16, 6]. Recent reviews confirm that research on mathematical attitudes has been predominantly conducted with adolescents and adults, and that the emergence of gender differences during the early primary years represents an understudied area [30, 12]. Nevertheless, available evidence suggests that attitudinal and motivational gender differences can already be detected as early as second grade, before meaningful performance gaps appear [11], underscoring the importance of investigating this critical developmental window.
A recent European Commission report highlights a critical paradox: while girls frequently match or exceed boys' academic performance in early schooling, they consistently report lower self-efficacy, which serves as a primary predictor of future STEM persistence [20]. These disparities are tied to a "leaky pipeline" and entrenched societal stereotypes that begin to erode girls' STEM identities as early as primary education.
Italy presents a particularly instructive case. National standardised assessment data from INVALSI consistently document gender gaps in mathematical performance, yet these patterns have received comparatively little scrutiny in the quantitative education research literature, especially at the primary school level [9].

The MATES project (MAtematica per Tutti in Estate), funded under the Italian PRIN programme and conducted across the metropolitan areas of Milano and Napoli, offers a rare opportunity to investigate these dynamics.
With 3,312 students enrolled in Grade 3 across 180 classes, MATES combines standardised cognitive assessments, attitudinal questionnaires, sociometric network data, and parental surveys to analyse summer learning loss in mathematics. This article focuses specifically on attitudinal and motivational dimensions related to mathematics, asking whether 8-year-old girls and boys differ in terms of self-reported school enjoyment and perceptions of mathematics. We argue that gender differences in mathematical attitudes are already detectable at age 8, before the more pronounced divergences typically documented at the secondary school level, and that parents' attitudes and stereotypes play a crucial role in shaping them [14, 29, 16, 38, 39, 37, 11, 22, 9, 30].

The remainder of the article is structured as follows. Section 2 reviews the relevant literature on gender and mathematical attitudes. Section 3 describes MATES project design, sample characteristics, measures, and empirical strategy. Section 4 presents the main empirical findings, while Section 5 discusses the results. Section 6 concludes.

2. Theoretical Framework and Literature Review

The relationship between gender and mathematical achievement has been extensively studied since at least the 1970s; early meta-analyses, beginning in the 1990s, documented a male advantage in specific domains such as spatial reasoning and problem-solving, although these differences have narrowed substantially across cohorts [26, 27]. More recent scholars have shifted attention from performance gaps to the attitudinal and motivational mechanisms that may precede and sustain them [17, 39].

From an economic perspective, early mathematical skills and attitudes represent key components of human capital formation [23, 10]. Cognitive and non-cognitive skills develop dynamically and interact over time, implying that early differences in motivation, confidence, and preferences may generate persistent inequalities in educational trajectories and labour market outcomes. In this framework, gender differences in mathematical attitudes can be interpreted as early inputs into later choices, particularly in STEM-related fields [3]. Attitudinal gaps—operating through reduced expectations of success and lower self-efficacy—function as early

negative inputs into the human capital accumulation process, potentially generating persistent inequalities well before performance differences become measurable.
Within the psychological literature, Eccles and colleagues' Expectancy-Value Theory (EVT) provides a central framework for understanding these processes [17, 18]. EVT posits that students' academic engagement is shaped by two main factors: their expectations of success and the subjective value they attach to a domain. Both are influenced by family and school environments, including parental beliefs, teacher expectations, and peer relations [40]. The economic logic maps naturally onto EVT: attitudinal gaps can be modelled as distortions in the formation of expectations and valuations that, once established early, generate persistent misallocation of effort and human capital investment.

Self-efficacy—defined as the belief in one's ability to succeed in a specific task [5]—is a key construct within this framework. Within the EVT framework, self-efficacy can be understood as the psychological mechanism underlying the expectancy component: a child's belief in her own mathematical ability directly shapes her expectation of success, which in turn determines engagement and persistence in the domain. In mathematics, a robust body of evidence shows that boys tend to report higher self-efficacy than girls [34, 31]. These differences emerge early: girls as young as six already report lower self-efficacy in mathematics [22]. Experimental evidence from economics further supports the importance of confidence in shaping educational decisions, showing that gender differences in beliefs about ability influence willingness to compete and to enter mathematically intensive fields [32, 35].
A related dimension concerns affective responses to mathematics, particularly enjoyment and anxiety. Mathematics anxiety—a feeling of tension that interferes with numerical tasks [36]—is consistently higher among girls across countries and age groups [24]. At the same time, boys tend to report slightly higher levels of mathematics enjoyment, although the magnitude of these differences varies [33].
A third dimension concerns the perceived utility of mathematics—the extent to which students view mathematics as useful in everyday life. This "use" dimension has attracted increasing attention, as it may be more responsive to pedagogical interventions than deeper motivational constructs [25]. Evidence on gender differences in perceived utility is mixed, with some studies suggesting similar or even higher perceived usefulness among girls [17].

Parental beliefs play a central role in shaping children's attitudes. Economic models of skill formation emphasise that parents act as key investors in their children's human capital, influencing both the quantity of educational inputs and the formation of beliefs about ability [10]. When parents hold gender-biased expectations—tending to overestimate boys' mathematical competence relative to girls'—they alter the incentive environment faced by children, affecting their self-efficacy and motivation through differential encouragement, resource allocation, and implicit signals [38, 8].
These parental influences operate both through explicit messages and through less visible channels (i.e. implicit channels), such as role modelling and differential reinforcement, which shape children's beliefs via repeated observation of behavioural patterns within the family environment [4, 37]. The resulting distortions in early belief formation may have lasting consequences, shaping educational choices at secondary school and university well before any performance gap becomes evident. From this perspective, gender stereotypes held by parents operate as a source of misallocation in the early stages of human capital accumulation [29, 22, 30].

In this study, to analyse students' math attitudes we adopt the framework of the Math and Me Survey (M&MS) proposed by [1], adapted to the Italian context and to this age group. M&MS conceptualises students' attitudes toward mathematics along three dimensions: enjoyment (E, i.e., affective dimension, such as "I love math"), self-efficacy (SE, i.e., cognitive/self-belief, such as "I'm very good at math"), and use (U, i.e., behavioural disposition, such as "I use math also in other disciplines at school"). These dimensions are operationalised through the Mathematics ATtitudes and Engagement Scale (MATES) [7]. MATES originated from M&MS: while the Enjoyment and Self-efficacy subscales are closely derived from the original framework, the Use subscale was substantially redesigned to capture concrete, age-typical everyday uses of mathematics rather than abstract future-oriented perceived usefulness, making the instrument more developmentally appropriate for early primary school children and for the Italian context. The psychometric properties of MATES have been evaluated on a sample of 2,297 third-grade students. The three-factor structure was supported by both exploratory and confirmatory factor analyses, with the confirmatory model showing good fit (CFI = .968, TLI = .962, RMSEA = .040). Internal consistency is satisfactory across all subscales and for the total score, with Cronbach's alpha ranging from .717 to .867 and McDonald's omega from .718 to .857. Concurrent validity was confirmed through strong correlations between the enjoyment subscale and global liking of mathematics (r=.719) and between the self-efficacy subscale and perceived mathematical ability (r=.623). Although Boerchi et al. (2026) is currently under review, the validation evidence summarised above provides a sufficient basis for using MATES as the measurement instrument of mathematics attitudes in the present study.

Taken together, these perspectives offer complementary lenses for interpreting the empirical evidence presented below: the human capital framework situates early attitudinal differences within a broader developmental trajectory, highlighting their potential long-run consequences for educational and occupational choices; EVT identifies the motivational mechanisms through which gender gaps emerge and are sustained; and self-efficacy theory specifies the cognitive-affective pathway—namely, beliefs about one's own ability—through which parental stereotypes translate into children's attitudinal differences.

3. MATES project: data, measures, and empirical strategy

MATES (MAtematica per Tutti in Estate) is a project funded under the Italian PRIN programme (https://progetto-mates.it). The project's central focus is the magnitude and social distribution of summer learning loss in mathematics among early primary school students. In May 2024, a questionnaire was administered to teachers to identify their practices in teaching mathematics. Later, at the beginning of Grade 3 in 2024, a questionnaire was administered to students to investigate attitudes towards mathematics, perceptions of school, and help-seeking networks in mathematics. In October 2024, a questionnaire was administered to parents to identify summer habits, their personal attitudes towards mathematics, and their usual habits with their children in dealing with mathematics and homework. MATES also included the implementation of an online web-app targeted at parents and pupils, aimed at supporting their reasoning about mathematical problems during the summertime [2].
For the purposes of the current article, we draw on the questionnaire related to students' attitudes towards school and mathematics, and parents' attitudes toward mathematics.

The overall MATES sample comprises 3,312 students enrolled in Grade 3 at the beginning of the 2024–2025 school year, distributed across 180 classes in 73 school buildings and 44 school institutes in the metropolitan areas of Milano and Napoli. Participating schools voluntarily joined the project, which was formally incorporated into their academic activities.
The two metropolitan areas are represented as follows: 1,492 students across 75 classes in the Milano metropolitan area, and 1,820 students across 105 classes in the Napoli metropolitan area. Average class size is 20 in Milano and 17 in Napoli. The gender distribution is broadly

balanced across the sample, with a slightly larger proportion of male students (53% male versus 47% female)—a pattern consistent with national demographic data for this age cohort [28]. Parental survey responses were obtained for 1,452 families (659 in Milano and 793 in Napoli), representing approximately 44% of all students participating in the project.

The students' questionnaire, administered in September–October 2024, covers several aspects of young students' lives: families' socio-economic conditions; students' attitudes towards school and mathematics; a psychological scale on mathematics attitudes; summertime lifestyle and extra-curricular activities during the school year; and mathematics help-seeking networks. In this work, we focus on self-reported attitudes towards school and mathematics – overall school enjoyment, liking for mathematics and confidence in mathematics – and on three dimensions of students' mathematics attitudes – enjoyment, self-efficacy, and use – as derived from MATES [7].

In the questionnaire, we assessed three key self-perceptions of 8-year-old students, drawing on self-efficacy theory [5]. Students reported their emotional adjustment to school by indicating how they felt about returning to school after the summer break, using a 5-point Likert scale ranging from "very sad" to "very happy". This measure captures students' affective response to the school context, which is conceptually related to school-related well-being and may influence subsequent motivation and engagement.
Students rated how much they like mathematics on an 11-point scale (0 = "not at all", 10 = "very much"). This item represents the degree of liking for mathematics. To facilitate interpretation and account for the limited substantive distinction between adjacent response categories, the original scale was collapsed into three analytically meaningful groups: 0–3, "I do not like math"; 4–6, "I like math"; and 7–10, "I like math a lot". The last category, "I like math a lot", is used as a binary outcome in the regression analysis.
Students indicated how well they believe they can perform in mathematics on an 11-point scale (0 = "I cannot do it at all", 10 = "I can do it very well"). This measure captures students' perceived competence in mathematics, reflecting their expectations about their ability to succeed in this domain. Similarly to the previous item, responses were classified into three categories: 0–3, low confidence; 4–6, moderate confidence; and 7–10, high confidence. The last category, defined as "I am very confident in math", is used as a binary outcome in the regression analysis.

Beyond these self-reported attitudinal items, the student questionnaire includes MATES items. This scale includes 20 items and uses a five-point Likert response scale ranging from "strongly disagree" to "strongly agree". For each student ($i = 1, \dots, N$), we computed composite scores for the three attitudinal dimensions—enjoyment (E)[2], self-efficacy (SE)[3], and use (U)[4]—by averaging the relevant items within each dimension.
Let x_{ij}^{d} denote the response of student i to item j within dimension d, where $d \in \{\mathrm{E}, \mathrm{SE}, \mathrm{U}\}$. This procedure yielded three mean scores per student. Next, we computed the sample mean

[2]Items are "I love math"; "Math is fun"; "I enjoy studying math"; "Solving math problems is fun"; "I enjoy playing math games".

[3]Items are "I am really good at math"; "Doing math is easy for me"; "I can solve difficult math problems"; "I can tell if my answers in math make sense"; "I understand math".

[4]Items are "I use math in other subjects in school"; "I use math outside school"; "Math is all around us in our everyday life"; "I count the days until my birthday"; "When I play a game, or watch a game, I count the points to understand who is winning"; "If I must buy something by myself (like an ice cream), I check the money I have and the change"; "When there is food on my plate that I don't like, I count the pieces I have left to finish it"; "When I must climb many stairs, I count them to see how many I've done"; "When the teacher gives us homework, I count the number of pages I have to complete"; "When I want to know how much time is left until the end of lessons, I calculate the remaining time by looking at the clock". These last 7 items are the Italian adaptation of the original scale.

and standard deviation for each dimension across the full sample of observations. Finally, to standardise the scores, we computed z-scores for each student and each dimension using the following formula:

$$z_i^d = \frac{x_i^d - \overline{x}^d}{s^d} \tag{3.1}$$

where $\overline{x}^d$ indicates the mean value of dimension d, while s^d indicates its standard deviation.

To examine the relationship between gender, parental attitudes, stereotype endorsement, and school- and mathematics-related outcomes, we estimate two linear models. The first model examines the average association between the outcomes and parental attitudes towards mathematics, stereotype endorsement, and student's gender controlling for parents' sociodemographic characteristics:

$$Y_i = \alpha + \beta_1 PA_i + \beta_2 PS_i + \beta_3 Female_i + \gamma X_i + \varepsilon_i \tag{3.2}$$

The second model additionally includes an interaction term between gender and stereotype endorsement in order to assess whether the association between parental stereotypes and students' outcomes differs between boys and girls:

$$Y_i = \alpha + \beta_1 PA_i + \beta_2 PS_i + \beta_3 Female_i + \beta_4 (PS_i \times Female_i) + \gamma X_i + \varepsilon_i \tag{3.3}$$

where Y_i represents one of the five outcomes considered in the analysis: enjoyment of mathematics, self-efficacy in mathematics, use of mathematics, self-reported confidence in mathematics, and liking for mathematics. While MATES dimensions are standardised continuous scores (as defined in Equation (3.1)), the last two variables are binary indicators capturing the probability of reporting high confidence in mathematics and strong liking for mathematics. The variable PA_i represents parents' attitudes toward mathematics, measured through a self-reported question asking respondents to evaluate their overall disposition toward the subject on a 5-point Likert scale ranging from "very positive" (1) to "very negative" (5). We define a binary variable equal to 1 if parents report a positive attitude toward mathematics, i.e. values 1 or 2 on the scale. PS_i is a binary indicator of parental stereotype endorsement, equal to 1 if the responding parent agrees with the statement that "males are more naturally suited to mathematics", and 0 otherwise. We distinguish between these two parental dimensions (PA_i and PS_i) because parental attitudes capture a general orientation towards mathematics, whereas stereotypes specifically capture gendered beliefs about mathematical ability. $Female_i$ is a binary indicator equal to 1 for female students and 0 otherwise.

The vector X_i includes a set of parental control variables:

$$X_i = \{\text{education level}_i, \text{age}_i, \text{mother}_i\}$$

education level is a dummy variable equal to 1 if the responding parent holds a university degree, and 0 otherwise; age represents the responding parent's age; mother is a dummy variable equal to 1 if the respondent declares being the student's mother, 0 otherwise.
All models are estimated using ordinary least squares (OLS) with standard errors clustered at the class level, to account for the nested structure of the data whereby students are grouped within the same classes. The first three outcomes are continuous MATES subscale scores, while the last two are binary and estimated as linear probability models.

4. Main results

Across the full MATES sample, students report broadly positive attitudes toward both school and mathematics. However, systematic gender differences emerge across several dimensions.

First, girls report higher levels of general school enjoyment than boys. In the full sample, 73% of girls report being happy or very happy to return to school, compared to 56% of boys. This pattern persists in the subsample matched with parental responses (77% for girls versus 63% for boys), suggesting that the difference is robust. Second, gender differences emerge in self-reported mathematics-specific attitudes. Boys report slightly higher levels of liking for mathematics and self-reported confidence in mathematics. In the full sample, 71% of boys versus 68% of girls report strong liking for mathematics, while in the matched subsample this difference widens (80% versus 70%). Similarly, boys report marginally higher confidence in mathematics: 64% of boys versus 63% of girls report high confidence in mathematics in the full sample, with a larger gap in the matched subsample (76% versus 70%).

These initial statistics show that boys and girls differ in their self-reported attitudes toward mathematics. Turning to the MATES composite measures, mean scores for both mathematics enjoyment and self-efficacy are above the scale midpoint for boys ($\bar{x}_E^B = 0.036, \bar{x}_{SE}^B = 0.113$), indicating generally positive attitudes at age 8. Girls show lower values ($\bar{x}_E^G = -0.039, \bar{x}_{SE}^G = -0.118$). These differences are statistically significant, consistent with previous findings [7]. By contrast, the use dimension does not display statistically significant gender differences, suggesting that boys and girls report similar scores on the use dimension ($\bar{x}_U^B = -0.018$ and $\bar{x}_U^G = 0.020$).

Figure 1 shows the overall distributions of these scores for both the full sample and the subsample of students matched with parents responding to the questionnaire. Results highlight two main findings, confirmed by Kolmogorov–Smirnov (KS) tests.
First, the matched subsample closely resembles the full sample across almost all attitudinal dimensions. The only statistically significant difference concerns male self-efficacy ($D = 0.086$, $p < 0.01$), suggesting that boys included in the matched parental sample report slightly different levels of self-efficacy compared with the full sample. This pattern may reflect a modest selection effect, whereby families participating in the parental survey are somewhat more positively oriented towards schooling and academic engagement.
Second, gender differences persist in the matched subsample. KS tests reveal significant differences between boys and girls in both mathematics enjoyment and self-efficacy in the full sample and in the matched subsample, while no statistically significant gender differences emerge for the use dimension.

Geographical differences between Milano and Napoli are limited in magnitude and do not substantially alter these patterns, indicating that the observed gender differences are not primarily driven by local socio-economic contexts.

Starting from these results, now we move to a regression framework to estimate how different aspects of students' mathematical attitudes are associated with parents' attitudes towards mathematics and with parental beliefs about gender differences in mathematics.

The first result, based on the estimation of Model 3.2, is that parental attitudes PA toward mathematics are positively and significantly associated with children's attitudes across all MATES dimensions. A more positive parental attitude is associated with higher levels of

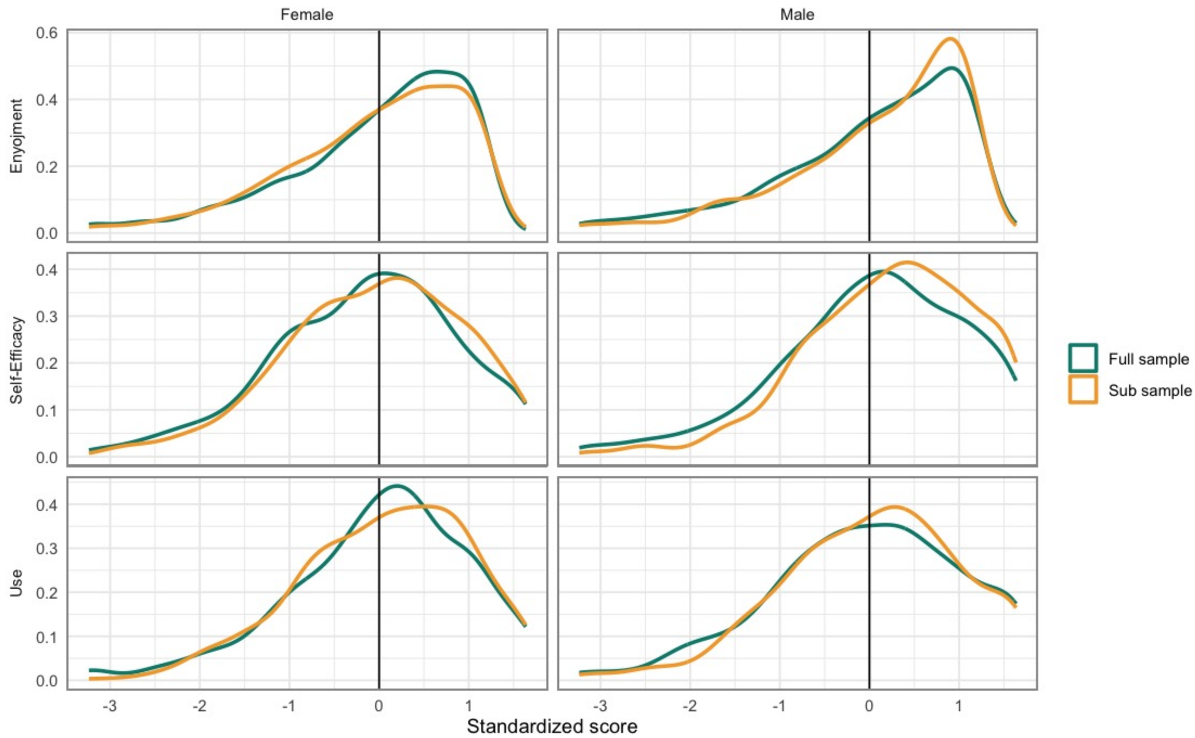

Figure 1. Distribution of standardised scores for the full sample and for the subsample

children's mathematics enjoyment, self-efficacy, and use of mathematics ($\hat{\beta}_E^{PA} = .217$, $t = 4.02$; $\hat{\beta}_{SE}^{PA} = .114$, $t = 2.25$; $\hat{\beta}_U^{PA} = .123$, $t = 2.44$). In other words, positive parental attitudes toward mathematics are significantly associated with more favourable attitudes toward mathematics among young students, even at this early age.

The second result shows that parental endorsement of the stereotype PS that "males are more naturally suited to mathematics" does not exhibit a statistically significant average effect when considered in isolation ($\hat{\beta}_E^{PS} = -.036$, $t = -0.47$; $\hat{\beta}_{SE}^{PS} = -.064$, $t = -0.77$; $\hat{\beta}_U^{PS} = .055$, $t = 0.73$).

The overall explanatory power of these models (over 1,442 observations) remains modest, with R^2 values equal to 3.3%, 4.1%, and 0.9% for enjoyment, self-efficacy, and use, respectively, and standard errors of the regression (SER) equal to 0.963, 0.942, and 0.950. This pattern suggests that, although parental attitudes are systematically associated with children's mathematical attitudes, a large share of the variability remains explained by other individual and school-related factors, including school environment, peer interactions, individual personality traits, and classroom experiences, not captured in the models.

When considering the binary outcomes, the coefficient associated with parental attitudes is never statistically significant.

When the interaction term between child gender and parental stereotype endorsement is introduced, estimating Model 3.3, a clear asymmetric pattern emerges. Figure 2 reports the predicted values by child gender and parental stereotype endorsement for all five outcomes. For the three continuous MATES subscales, predicted values represent expected standardised scores (z-scores); for the two binary outcomes, predicted values represent predicted probabilities from the linear probability models.

The explanatory power of all these models remains modest but consistent with the literature on attitudinal outcomes among young children. The models explain between 3% and 4%

of the variance for the continuous MATES dimensions related to enjoyment and self-efficacy (R^2 = 0.0351, SER = 0.96231 for enjoyment; R^2 = 0.0438, SER = 0.94199 for self-efficacy), while the explanatory power is substantially lower for the use dimension (R^2 = 0.0094, SER = 0.95062). Similarly, the binary outcomes display limited goodness of fit, with R^2 = 0.0053 (SER = 0.44023) for the outcome "I like math a lot" and R^2 = 0.0241 (SER = 0.42347) for "I'm very confident in math".

Nevertheless, despite the limited overall explanatory power, the interaction coefficients reveal statistically meaningful and theoretically coherent patterns.
Girls exposed to parental stereotypes display significantly lower levels of mathematics enjoyment and self-efficacy compared to boys whose parents do not endorse gender stereotypes (i.e. the reference group). For mathematics enjoyment, girls whose parents endorse stereotypes score 0.332 standard deviations below the baseline, while boys in the same condition score 0.110 standard deviations above it.
The marginal effect of stereotype exposure is −0.206 standard deviations for girls and +0.110 for boys, though the latter is not statistically significant. The pattern is clear: parental stereotypes are associated with less favourable attitudes among girls and somewhat more favourable attitudes among boys, widening the gender gap considerably relative to families where no stereotype is endorsed.
Results for self-efficacy follow the same direction and are even stronger in magnitude. Girls whose parents endorse the stereotype score 0.475 standard deviations below the baseline, with a marginal effect of −0.231 standard deviations. Boys in stereotype-endorsing families score slightly higher than the baseline (+0.079), though again not significantly so. As shown in Figure 2, the gender gap in self-efficacy is more than twice as large among children exposed to parental stereotypes than among those whose parents do not endorse such beliefs, making self-efficacy the dimension most strongly associated with stereotype endorsement.
By contrast, no comparable effects emerge for the use dimension. Neither the direct effect of stereotypes nor the interaction with gender is statistically significant, confirming that the use dimension appears substantially unaffected by parental stereotypes at this age. Notably, in the absence of parental stereotypes, girls score marginally higher than boys on the use dimension, a reversal of the direction observed for mathematics enjoyment and self-efficacy, further supporting the interpretation that gender differences at this age emerge primarily in affective and self-evaluative dimensions rather than in routine perceptions of the usefulness of mathematics. This finding is particularly relevant because it suggests that stereotypes are not associated with children's scores on the use dimension, but rather with their mathematics enjoyment and self-efficacy when engaging with it.

Turning to the binary outcomes, when we estimate the probability of reporting strong liking for mathematics (i.e., "I like math a lot"), we observe a gender-specific pattern consistent with the MATES results. For boys, parental endorsement of stereotypes is associated with a higher probability of reporting liking for mathematics (0.865 versus 0.802). For girls, the direction reverses: those whose parents endorse stereotypes are less likely to report strong liking (0.662 versus 0.712). However, the differences between stereotype and no-stereotype groups are not statistically significant for either gender, as indicated by confidence intervals in Figure 2. Although the estimated differences are modest in magnitude, their direction mirrors the patterns observed for enjoyment and self-efficacy, although the estimates remain statistically imprecise, lending additional support to the interpretation that parental stereotypes are associated with less favourable mathematical attitudes among girls and more favourable attitudes among boys.

A similar pattern emerges for confidence in mathematics, measured through the binary item

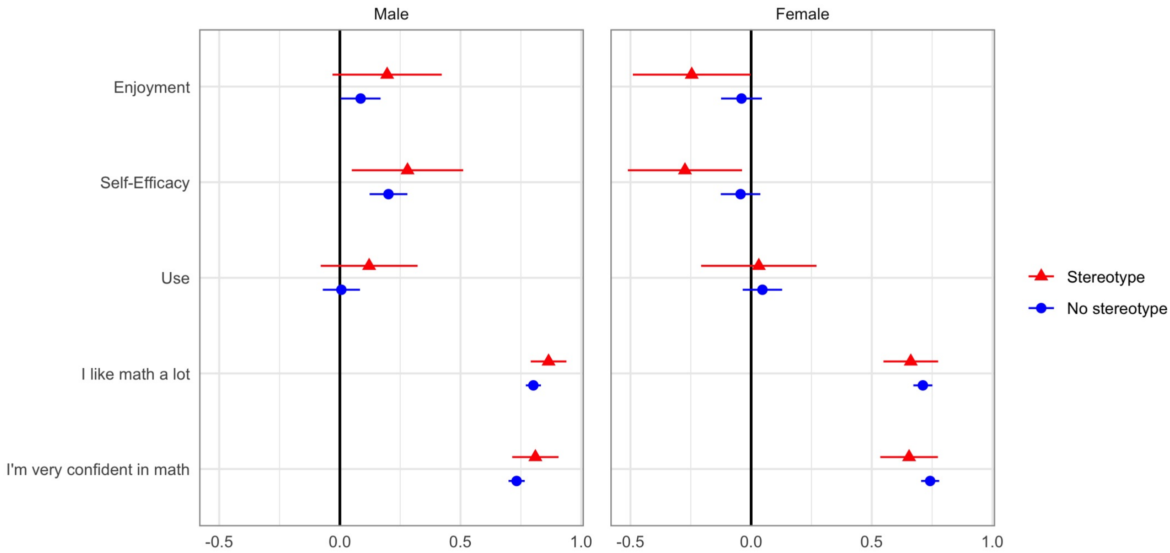

Figure 2. Predicted values and 95% confidence intervals

"I am very confident in math". In the absence of parental stereotypes, girls report a marginally higher probability of expressing confidence than boys (0.742 versus 0.732), a reversal of the direction observed across all other outcomes. When parents endorse gender stereotypes, however, this pattern inverts substantially: boys increase to 0.810 while girls fall to 0.655, producing a gap of 0.155 in favour of boys. This asymmetric pattern is consistent with the hypothesis that parental stereotypes may contribute to gendered differences in children's self-evaluations, although the estimates do not reach conventional levels of statistical significance. Notably, this is the largest gender gap observed among all predicted binary outcomes, and it mirrors closely the results obtained for the continuous self-efficacy scale.

5. Discussion

This study provides evidence that gender differences in mathematical attitudes emerge early in primary school. By combining student and parental data, we contribute to the literature by highlighting the role of family-level mechanisms—particularly parental beliefs—in affecting these early attitudinal gaps. The finding that boys report higher mathematics self-efficacy than girls at age 8 is consistent with the well-documented self-efficacy gap [34, 11]. Such differences in self-beliefs are important because they are predictive of subsequent choices, including effort allocation, persistence, and participation in mathematically intensive activities [32].

From an EVT perspective, parental stereotype endorsement effectively undermines the expectancy component of girls' mathematical motivation—reducing both their self-efficacy and their mathematics enjoyment—while leaving the perceived utility largely unaffected, a pattern fully consistent with the descriptive evidence on the use dimension. This result aligns with evidence that gender differences in perceived utility are generally smaller and less consistent than those observed for affective and self-evaluative dimensions, with some studies reporting similar or even higher perceived usefulness among girls [17, 25].

More broadly, the results suggest that parental stereotypes are associated primarily with children's self-evaluative and affective orientations toward mathematics rather than with their perceptions of its usefulness [29, 38, 22]. These early attitudinal deficits may function as negative inputs into a cumulative developmental process, amplifying over time even in the absence of initial performance gaps [23, 10].

While no significant average effect is detected for parental stereotypes, interaction results show that stereotypes are associated with lower attitudinal scores among girls, while the corresponding estimates for boys are generally positive, although not statistically significant. The most consistent pattern across outcomes is not a uniform effect of stereotype endorsement but an amplification of gender differences: parental stereotypes appear to operate primarily as a mechanism that widens the gap between boys' and girls' attitudes toward mathematics, rather than as a general determinant of children's attitudes. This pattern is consistent with models of belief formation in which biased expectations shape individuals' self-efficacy and preferences differently across groups [38, 22].

These findings suggest that early attitudinal differences may contribute to the persistence of gender gaps in STEM fields. If girls internalise lower self-efficacy in mathematics from an early age, this may influence their future educational trajectories, even in the absence of initial performance differences. The fact that the strongest associations emerge for self-efficacy is particularly noteworthy, given the central role of self-beliefs in educational choices and persistence documented in the literature.

At the same time, the absence of significant gender differences in the use dimension is noteworthy. The use dimension captures routine and concrete experiences with mathematics in everyday life—such as counting, games, or school-related activities—which are likely to be similarly experienced by boys and girls at this early stage of schooling. This shared foundation could be leveraged through pedagogical interventions: strengthening connections between mathematics and real-world applications may help sustain engagement and mitigate the emergence of larger gender gaps in later stages of schooling. In contrast, gender differences tend to emerge more strongly in evaluative and affective dimensions, such as self-efficacy and emotional orientation towards mathematics, which are more directly shaped by stereotypes and social expectations [14, 11, 22].

Some limitations of the paper are worth noting. The analysis is primarily descriptive, and results should be interpreted as associations rather than causal effects. Since the study did not include standardised achievement tests, it is not possible to assess whether the observed attitudinal gaps correspond to differences in actual mathematical performance. The role of teachers and peer relationships in shaping students' attitudes also falls outside the scope of the present analysis and will be explored in future work. Finally, because parental participation was voluntary, some degree of self-selection cannot be ruled out.

Notwithstanding these limitations, the findings offer a valuable contribution to the understanding of how the family environment shapes children's attitudes toward mathematics and suggest that parental stereotypes may operate primarily through children's self-efficacy and broader self-evaluative beliefs rather than through beliefs about the usefulness of mathematics. Although the estimated associations are modest in magnitude, their consistency across multiple outcomes and across both continuous and binary measures strengthens confidence in the substantive interpretation of the results. By highlighting the associations between parental beliefs and students' dispositions, this study provides a meaningful empirical basis for future research and for the design of family-oriented educational interventions.

6. Conclusions

This article has presented evidence from the MATES project on gender differences in mathematical attitudes among 8-year-old Italian primary school students. Three main findings emerge.

First, girls report lower levels of liking for mathematics and confidence in mathematics than boys at the beginning of Grade 3, while at the same time reporting higher levels of overall school enjoyment. This suggests that gender differences are already present at an early stage, particularly in domain-specific attitudes rather than in general attitudes toward schooling.

Second, the use dimension of mathematical attitudes—namely the perceived use of mathematics in everyday life—does not differ significantly by gender at this age. This indicates that boys and girls share a similar perception of the returns to mathematical engagement, suggesting that the use dimension may represent the most stable lever for pedagogical interventions — particularly those aimed at making the practical value of mathematics salient — before self-efficacy gaps translate into differential investment decisions with longer-run consequences for educational and labour market trajectories.

Third, parental characteristics play a significant role. In particular, positive parental attitudes toward mathematics are associated with more favourable attitudes among children, while the endorsement of gender stereotypes is associated with a differentiated pattern: it is associated with lower levels of liking for mathematics and confidence in mathematics among girls and, conversely, with more positive attitudes among boys. This highlights the importance of family-level belief transmission in shaping early gender differences.

These findings, while based on non-randomly selected schools, so still contribute to a growing literature emphasising early childhood as a critical period for the formation—and potentially the prevention—of gendered attitudes toward mathematics.
From a policy perspective, interventions aimed at reducing gender gaps should begin early in the educational process and address not only students but also their social environment.
The findings suggest that interventions aimed at reducing early gender gaps in mathematical attitudes should target the belief formation process within the family. Two broad classes of intervention appear particularly promising.
The first concerns information provision: if parental stereotype endorsement partly reflects inaccurate beliefs about boys' and girls' mathematical abilities—rather than deeply held preferences—then low-cost informational interventions providing parents with evidence on gender similarities in early mathematical performance may help shift beliefs and, through them, children's attitudes. This is consistent with a growing literature in economics showing that information provision can update biased parental expectations and improve children's educational outcomes [8]. The second class of interventions concerns school-family engagement initiatives, such as the MATES web app [2], that create structured opportunities for parents and children to interact around mathematical content, potentially reducing the scope for stereotype-consistent behaviour in everyday family dynamics.
Crucially, both types of intervention operate on the belief formation process rather than requiring changes in deep preferences, making them potentially more cost-effective than broader cultural campaigns. The shared foundation identified in the use dimension further suggests that interventions leveraging the perceived practical returns to mathematics may be particularly well-suited to sustaining girls' engagement before attitudinal gaps consolidate into differential investment decisions — with potentially persistent consequences for human capital accumulation and labour market outcomes that extend well beyond the primary school years.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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