

The formula for success in mathematics: Higher socioeconomic background, lower anxiety, and higher curiosity at the student and school level

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Summary

Students' attitudes, emotions, and socioeconomic background affect their learning and later well-being. Mathematics anxiety, curiosity toward learning, socioeconomic background, and perceived mathematics lesson quality are all important student-level predictors for mathematics test results. Previous studies have shown that mathematics anxiety is moderately negatively related to performance (Caviola et al., 2022), while curiosity fosters deeper engagement and better results (Rach, 2023). An Estonian study found that mathematics competency and interest in mathematics in the 6th grade are positively related to their mathematics national exam results at the end of the 9th grade. Perceived lesson quality also matters. For example, students who perceive higher lesson quality tend to perform better (Arthur et al., 2022) and experience lower mathematics anxiety, especially when supported by their teachers (Aldrup et al., 2020; Q. Li et al., 2021).

Family background further shapes achievement. Studies have shown that students from lower socioeconomic backgrounds may experience fewer educational opportunities (Sirin, 2005) and often score lower in science and mathematics (Rozgonjuk et al., 2023). Overall, mathematics outcomes benefit from higher socioeconomic status, curiosity, and positive perceptions of lessons, but are hindered by higher levels of mathematics anxiety.

Educational achievement depends not only on individual factors (student-level) but also on school-level contexts. Previous research shows that when

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predicting students' achievements (also mathematics achievement), school-level socioeconomic background plays an important role (Rozgonjuk et al., 2023). However, little is known about whether school-level lesson quality differs across schools and how it predicts achievement.

The aim of this study is to find out how students' socioeconomic background, (perceived) lesson quality, mathematics anxiety, and curiosity explain the variability of mathematics test results at both the student- and school-level.

Methology

The current study uses data from the 2022 large-scale Programme for International Student Assessment (PISA) survey. In Estonia, there were 6392 (48.81% girls, 51.19% boys) participants from 196 schools. In our analysis, we used only schools with at least ten participating students, resulting in an effective sample of 6232 students (48.72% girls, 51.28% boys) from 166 schools.

The analysis included descriptive statistics and correlations at both the student and school levels, followed by two-level regression models predicting mathematics test results. Student-level predictors (socioeconomic background, mathematics anxiety, curiosity, and perceived lesson quality) were group-mean-centred, and school-level predictors were defined as school means that were then grand-mean-centred. This centring approach provides a within-between decomposition of each predictor, allowing us to distinguish whether associations arise from differences between students within schools or from differences between schools. The final multilevel model included a random intercept for schools and random slopes for mathematics anxiety and curiosity. Random effects were specified as uncorrelated.

Measures

The current study examines the relationships between mathematics test results, mathematics anxiety, curiosity, perceived lesson quality, and socioeconomic background using PISA 2022 data.

Mathematics test result

During the student assessment, each participant answered a subset of all the questions. For the unanswered questions, imputed values were calculated, which resulted in 10 plausible mathematics test scores for each student. All of those values are standardised, with a mean of 500 and a standard deviation of 100 points (OECD, 2024b).

Mathematics anxiety

The mathematics anxiety value was calculated from six statements, where students had to answer on a 4-point scale from 1, meaning “Completely agree”, to 4, meaning “Completely disagree”. The example statements were “I worry that I will face difficulties in mathematics class” and “I feel helpless when doing a mathematics problem”. All of those statements were reverse-coded and then summed so that the higher score also meant higher anxiety. Internal consistency for the mathematics anxiety scale in the current sample was very good (Cronbach’s $\alpha = 0.92$).

Curiosity

The curiosity value was calculated from 10 statements, where students had to answer on a 5-point scale from 1, meaning “Completely disagree” to 5, meaning “Completely agree”. The example statements were “I like to know how things work,” and “I am more curious than most people I know”. Internal consistency for the curiosity scale in the current sample was very good (Cronbach’s $\alpha = 0.84$).

Perceived lesson quality

Perceived lesson quality was measured using a single-item question: “How would you rate the quality of mathematics teaching during this school year?” Students had to answer this question on a 10-point scale from 1 (meaning “Worst mathematics instruction possible”) to 10 (meaning “Best mathematics instruction possible”).

Socioeconomic background

While calculating students’ socioeconomic background, their parents’ education level and occupation, as well as their home possessions (such as the amount of books and digital devices) (OECD, 2024b), were considered.

Results

From the descriptive statistics, we saw that mathematics test scores vary more within schools than between them ($ICC = 0.17$), while socioeconomic background shows somewhat stronger school-level differences ($ICC = 0.21$). Emotional and motivational factors (mathematics anxiety, curiosity, perceived lesson quality) are largely individual ($ICCs \leq 0.10$).

Next, we conducted correlation analyses among the variables. At the school level, average mathematics achievement is positively correlated to socioeconomic background ($r = .77$, $p < .001$) and negatively to maths anxiety

($r = -.55$, $p < .001$). Curiosity correlates positively with achievement ($r = .53$, $p < .001$), socio-economic background ($r = .55$, $p < .001$), and perceived lesson quality ($r = .25$, $p < .001$), but negatively with anxiety ($r = -.31$, $p < .001$). At the student level, mathematics achievement is positively associated with socioeconomic background ($r = .36$, $p < .001$), curiosity ($r = .24$, $p < .001$), and perceived lesson quality ($r = .27$, $p < .001$), and negatively with maths anxiety ($r = -.36$, $p < .001$). Thus, students with higher socioeconomic backgrounds, lower anxiety, and greater curiosity generally achieve better results.

Lastly, we conducted a multilevel regression model. The results showed that at the student level, socioeconomic background ($\beta = 20.13$, $p < .001$), curiosity ($\beta = 12.67$, $p < .001$), and perceived lesson quality ($\beta = 5.17$, $p < .001$) predicted higher mathematics test results, while mathematics anxiety predicted lower scores ($\beta = -17.76$, $p < .001$). At the school level, average socioeconomic background ($B = 55.04$, $p < .001$) and curiosity ($\beta = 20.24$, $p = .023$) were positive predictors for mathematics test results, while average anxiety was a negative predictor ($\beta = -42.45$, $p < .001$). The perceived lesson quality was not a significant predictor at the school level. Random slope modelling indicated that the effects of both mathematics anxiety and curiosity varied across schools, being stronger in higher-achieving environments. After including predictors, the intraclass correlation indicated that approximately 5.7% of the variance in mathematics test results remains at the student level, though school context still matters.

Conclusion

The study used Estonian PISA 2022 data and a two-level regression approach to examine how socioeconomic background, mathematics anxiety, curiosity, and perceived lesson quality relate to mathematics test results. The results showed that a higher socioeconomic background is one of the strongest predictors of mathematics performance at both the student and school levels. The findings also showed that at the school level, socioeconomic background, mathematics anxiety, and curiosity are significant predictors of mathematics test results; however, perceived lesson quality is not a significant factor. This indicates that while emotional and motivational factors play an important role, their influence varies across schools, especially curiosity, which shows school-level variation and points to the importance of the school environment. The results underscore the need to approach educational inequality more broadly than as a mere knowledge gap and support stronger attention to the development of socio-emotional skills as well as the shaping of the school context.

Keywords: mathematics anxiety, curiosity, socioeconomic background, mathematics, PISA