RELATIONSHIPS BETWEEN SELF-CONCEPT, SELF-EFFICACY, AND GRADE 4 NUMBER ACHIEVEMENT ACROSS GENDERS IN SWEDISH TIMSS 2023

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The present study utilizes data from the Swedish TIMSS 2023 sample to investigate the relationships between Grade 4 students' mathematics self-concept, self-efficacy, and achievement in the Number domain, as well as potential gender differences in these relationships. Structural equation modelling with latent mediation was applied. Boys outperformed girls on the Number achievement and reported higher levels of self-concept and self-efficacy. Results showed that mathematics self-concept, but not self-efficacy, was strongly and similarly associated with Number achievement for both genders. The results further indicate that gender differences in achievement were partially explained by differences in students' self-concept. Mathematics self-concept is identified as a key factor associated with early Number achievement.

INTRODUCTION

By positioning number sense as a foundational resource for generalization and abstraction, such approaches support sustained mathematical development as students engage with increasingly complex mathematical tasks (Nguyen et al., 2016). However, cognitive engagement alone does not fully explain students' success in mathematics. Motivational perspectives including mathematics self-concept, perceptions of self-efficacy, and the value students attribute to mathematics, are critical affective factors influencing mathematical understanding and achievement (Ding 2024; Michaelides et al., 2019). A positive self-concept is suggested to foster deeper engagement and more robust mathematical understanding (Lohbeck, 2018) and is strongly associated with achievement, often more so than motivation alone (Ding et al., 2024; Kania & Juandi, 2023). Ding et al., (2024) further report that self-concept and self-efficacy, while closely related, each exhibit a distinct contribution to mathematics achievement. These relationships emerge early: fourth-grade students with higher math self-concept and motivation tend to perform better on standardized assessments and classroom tasks (Lohbeck, 2018). In addition, potential gender differences in mathematical self-concept and achievement, along with cognitive and affective factors are suggested to interact in early mathematics learning. Prior studies suggest that gendered patterns in students' self-perceptions of mathematical self-concept can develop as early as the primary grades, and in some cases, precede measurable differences in achievement (e.g., Levine & Pantoja, 2021). The Swedish context offers a particularly informative case. In Grade 4, TIMSS 2015 mathematics assessment, no gender differences were

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observed in either self-concept or mathematics achievement (The National Agency of Education, 2015). However, more recent national data suggest a shift in these patterns. Historically Swedish girls have outperformed boys in mathematics, but in recent years boys have outperformed girls for the first time in both final grades and national exams. At the same time, girls express more negative perceptions of mathematics learning compared to boys (The National Agency of Education, 2025). Investigating whether such patterns are evident within students' number sense may provide critical insight into how differences in self-concept, self-efficacy, and achievement emerge and potentially compound over time. In particular, investigating the relationships between students' self-concept, self-efficacy, and number sense achievement can provide valuable insights into early mathematical learning processes. Accordingly, this study addresses the following research questions: What are the relationships between Swedish fourth grade students' mathematics self-concept, self-efficacy and their number achievement as measured in TIMSS 2023? How do the relationships differ by gender?

STUDENT'S SELF-CONCEPT AND SELF-EFFICACY IN MATHEMATICS

Students' success in mathematics is shaped not only by cognitive engagement but also by affective and motivational factors. Research consistently highlights the importance of motivation and self-concept, students' perceptions of their competence and the value they assign to mathematics, as critical determinants of mathematical understanding and achievement (Mejía-Rodríguez et al., 2020; Michaelides et al., 2019). Intrinsic motivation and a positive mathematics self-concept have been shown to foster deeper engagement and more robust conceptual understanding, whereas extrinsic motivation and amotivation are negatively associated with performance.

Research indicates that these relationships emerge early in schooling: fourth-grade students with higher self-concept and intrinsic motivation tend to perform better on standardized assessments and classroom tasks (Lohbeck, 2018). Empirical evidence further suggests that mathematics self-concept is strongly correlated with achievement, often exerting a greater influence than motivation alone (Ding et al., 2024; Kania & Juandi, 2023). Ding (2024) reinforces these findings by demonstrating that both self-concept and self-efficacy are significant predictors of mathematics achievement across diverse educational systems. This work emphasizes that students' perceptions about their mathematical competence interact with motivational orientations to shape engagement and persistence in problem-solving contexts, as evidenced in mathematics assessments from PISA 2003 and 2012. In Ding's conceptualization, mathematics self-concept refers to students' broad perceptions of their competence in mathematics, encompassing general beliefs about their ability in the subject. This construct is distinct from self-efficacy, which denotes confidence in successfully performing specific mathematical tasks. Both self-concept and self-efficacy are highlighted as significant predictors of academic motivation, well-being, resilience, and overall educational experience, situating them within a broader perspective of motivational development.

From this perspective, mathematics self-concept shapes students' expectations of success and their identity as learners of mathematics, while self-efficacy provides the confidence necessary to engage with and persist in challenging mathematical tasks (Ding, 2024). Together, these perceptions form a foundational structure for motivation and sustained engagement in mathematics learning. This interpretation underpins the present study's approach to self-concept and self-efficacy

NUMBER SENSE IN THE EARLY GRADES

Number sense is widely recognized as a foundational component of mathematical proficiency in the early grades and a strong predictor of later mathematical achievement (e.g., Lyons et al., 2014; Nguyen et al., 2016). It encompasses students' understandings of numbers, number relationships, operations, and numerical representations, as well as their ability to reason flexibly and efficiently with numbers (Nguyen et al., 2016; Pittalis et al., 2018). Instructional approaches that engage students in tasks emphasizing properties of operations, patterns, and structural relationships within familiar arithmetic contexts can strengthen number sense while simultaneously preparing learners for more abstract mathematical reasoning in (Blanton et al., 2015). Furthermore, number sense can be viewed as an integral component of generalized arithmetic and a central element in the development of algebraic thinking (Blanton et al., 2015).

METHODS

The present study utilizes data from the Swedish Grade 4 sample of TIMSS 2023 (N= 5139) to investigate the relationships between students' mathematics self-concept, self-efficacy, and achievement in the TIMSS Number domain. The Number domain constitutes up to 50% of the Grade 4 TIMSS assessment and captures competencies that bridge whole-number understanding and introductory algebraic thinking. In the Swedish sample, the mean score on the overall mathematics assessment was 533 points for both boys and girls, while the mean score on the Number domain was 530 points. (The National Agency of Education, 2024). Overall mathematics achievement and Number achievement were strongly correlated (r= 0.87). Descriptive statistics revealed gender differences in Number domain achievement, with girls attaining a mean score of 518 points and boys a mean score of 537 points. Gender was coded dichotomously in all analyses (0= girls and 1= boys). Missing data was handled using multiple imputation, and all analyses employed robust maximum likelihood (MLR) to account for non-normality and incorporated sampling weights (HOUWGT) to ensure population-representative estimates.

Students' motivational perspectives were measured using TIMSS 2023 student questionnaire items. Exploratory factor analysis supported a two-factor latent construct: student self-efficacy and self-concept. In the questionnaire these topics are evaluated by questions (How much do you agree with these statements about mathematics?) which capture how well the student assesses he or she does in

mathematics, if the student feels that he or she is good at mathematics, and mathematics makes him or her confused. These were measured with a 4-point Likert scale ranging from 1= Agree a lot to 4= Disagree a lot (see Table 1). For some of the items the scaling was reversed as a positively phrased question was considered to have a rating 4 as Agree a lot. Achievement in the Number domain served as the outcome variable.

Table 1: Included student indicators of self-efficacy and self-concept

Latent variable	Question	Response options
Self-efficacy	How much do you agree with these statements about mathematics? a) I usually do well in mathematics b) Mathematics is easy for me c) I am good at working out mathematics problems	Reversed Likert scale, ranging from 1) Disagree a lot to 4) Agree a lot
Self-concept	a) Mathematics is harder for me than for many of my classmates b) I am just not good at mathematics c) Mathematics is harder for me than any other subject d) Mathematics makes me confused	Likert scale, ranging from 1) Agree a lot to 4) Disagree a lot

The analytical procedure followed a stepwise modelling strategy designed to examine the measurement properties of the motivational constructs and their relationship with Number achievement, as well as potential gender differences in these associations. First, a two-factor measurement model representing mathematics self-concept and self-efficacy was specified and evaluated using confirmatory factor analysis (CFA). Model fit was assessed using standard fit indices, including the Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA). Upon establishing an acceptable baseline measurement model, multigroup CFA was conducted to assess measurement invariance across gender. Invariance testing proceeded sequentially through configural, metric, and scalar models, with CFI and RMSEA used to evaluate whether increasingly restrictive models resulted in meaningful deterioration in model fit. Establishing scalar invariance permitted valid comparisons of latent means across boys and girls. Following confirmation of scalar invariance, latent mean differences between genders were examined. Structural equation models were then estimated in which Number achievement was regressed on the latent self-concept and self-efficacy factors. Next, to evaluate whether the strength of these associations differed by gender, path coefficients were compared across groups within a multigroup framework.

Finally, a multigroup latent mediation model was specified to assess indirect effects of gender on achievement via the latent constructs.

RESULTS

This study investigated whether gender differences in Number achievement are related to differences in students' self-efficacy and self-concept using a multigroup latent variable approach. The results suggest that mathematics self- efficacy and self-concept were measured equivalently across gender, allowing for meaningful comparisons of latent means and structural relationships between the latent constructs and mathematics achievement across gender.

Boys demonstrated significantly higher levels of both self-efficacy and self-concept than girls, with a moderate gender difference for self-efficacy (Δ= 0.44, SE= .04, p< .001) and a smaller difference for self-concept (Δ= 0.22, SE= .03, p< .001).

In the structural models, only self-concept showed a strong and significant association with Number achievement (girls β= .50, SE= .04, p< .001, and boys β= .51, SE= .04, p< .001). Higher levels of self-concept were associated with higher achievement scores. Constraining the structural paths to equality across gender resulted in negligible changes in model fit, indicating that the strength of the relationships between mathematics self-concept and achievement did not differ significantly for girls and boys.

The latent mediation analysis suggested a significant effect of gender on Number achievement via self-concept, but not via self-efficacy. Boys' higher self-concept partially accounted for their higher Number achievement, corresponding to an estimated difference of approximately 7 points of the overall 19 points difference.

The results suggest that girls in Grade 4 exhibit lower self-concept, self-efficacy, and lower achievement than boys in the Number domain. Yet, the findings highlight that mathematics self-concept is a meaningful factor associated with Number achievement for both girls and boys in fourth grade.

CONCLUSION AND IMPLICATIONS

The results suggest a strong association between students' self-concept and number achievement, for both girls and boys and that gender differences in number achievement are partially mediated by differences in students' self-concept. Boys demonstrated higher levels of self-concept, which was strongly associated with higher achievement. This pattern contrasts with results from the Swedish Grade 4 TIMSS 2015 assessment, which reported no gender differences in either self-concept or mathematics achievement (The National Agency of Education, 2015). However, more recent national data point to a shift in these trends. Whereas Swedish girls have historically outperformed boys in mathematics, boys have in recent years achieved higher in both final grades and national tests, alongside more positive perceptions of mathematics learning (The National Agency of Education, 2025). Viewed in this

context, the present findings suggest that changes in achievement trends may be accompanied by corresponding shifts students' self-concept and self-efficacy reinforcing the importance of motivational factors in understanding emerging gender differences in mathematics achievement (Ding, 2024; Ding et al., 2024; Mejía-Rodríguez et al., 2020; Michaelides et al., 2019). Similar to the findings of this study, Mejía-Rodríguez et al. (2021) report that gender differences in achievement are partially mediated by disparities in self-concept, with boys generally exhibiting higher levels of self-concept, which in turn strongly correlates with superior performance. These insights underscore the necessity of promoting positive self-conceptions alongside conceptual understanding in early mathematics education, especially as number sense is recognized as a foundational component in mathematical proficiency (Lyons et al., 2014; Nguyen et al., 2016). We interpret these findings as suggesting that a positive mathematics self-concept may foster deeper engagement with numerical content and support the development of more robust mathematical understanding from early grades. Lohbeck (2018) suggests that intrinsic motivation and a positive self-concept may foster deeper engagement and more robust mathematical understanding, whereas amotivation is negatively associated with performance. These associations may emerge early in student mathematics development, even at the primary level (Lohbeck, 2016). Although research on early mathematical development has expanded, the relationship between number sense and students' self-concept and motivation within number sense contexts remains insufficiently examined. A well-developed number domain not only provides a foundation for arithmetic generalization and algebra learning but also contributes to the cultivation of enduring positive attitudes toward mathematics (Ding, 2024; Nguyen et al., 2016; Pittalis et al., 2018) while simultaneously supporting students' progression toward more abstract reasoning in mathematics (Blanton et al., 2015).

Although causal conclusions cannot be made from the cross-sectional design, the findings suggest that self-concept constitutes a key affective mechanism through which gender differences in mathematics achievement may develop, with potential implications for later arithmetic generalization and algebra learning. Longitudinal research is needed to clarify these pathways and inform instructional strategies aimed at fostering equitable mathematics outcomes. This approach could then also enable discussions about how teachers can address these differences and strengthen students' self-concept in mathematics.

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