



Not simply a decline: gendered changes in students' intrinsic motivation towards mathematics

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Abstract

This study examines one-year changes in students' intrinsic motivational orientation towards mathematics and whether these changes are gendered. Drawing on Swedish data from the TIMSS 2023 Longitudinal Study, we analysed two student cohorts, followed from Grade 4 to Grade 5 and from Grade 8 to Grade 9. Building on a theoretical recoding of TIMSS affective questionnaire items, intrinsic motivation was analysed as an overarching category, with cognitive and emotional motivation treated as subcategories. Mean change analyses and categorical change analyses were used to examine both average change and the proportions of students who decreased, remained stable, or increased. The younger cohort reported more positive orientations than the older cohort but declined over the year, while the older cohort started lower and showed weak positive change or stabilisation. Emotional motivation showed more variability than cognitive motivation, and the two subcategories did not move in identical ways. Gender differences in change were small: girls in the younger group were more likely to decrease, especially emotionally, but there were no significant differences in the older group. Findings suggest that mathematics-related affective development is uneven and dimension-specific rather than a simple decline, with gender differences more visible in the younger cohort than in the older cohort.

Keywords Emotions · Gender · Intrinsic motivation · Longitudinal study · Mathematics · TIMSS

1 Introduction

Decades of research highlight the importance of affective factors in mathematics education (e.g., Schukajlow et al., 2017), and over the past twenty years emotion has gained focus for its role in managing failure, mistakes, and achievement (e.g., Fredrickson & Joiner, 2018). Emotions appear to influence learning more than previously thought, including through their impact on motivation (e.g., Nelson et al., 2018; Valiente et al., 2012), a relation often described in two directions: a positive attitude can enhance performance, while negative conceptions can hinder it and lead to lower achievement (Capuno et al., 2019). An analysis of the reasons students give for their strategy choices when solving mathematics tasks illustrates how influential affective factors can be, shaping both the strategies chosen and judgements of what

is achievable (Sumpter, 2013). Understanding the roles of emotions and motivation is therefore essential.

Affective states are also rarely static and often culturally bounded, varying not only across cultures but also within the same culture (Niemivirta et al., 2024; Sumpter & Sollerman, 2023). Some patterns are universal and cross-cultural, others are specific to nations or microclimates. Studies from various countries, such as the Philippines (Capuno et al., 2019), show a positive correlation between students' attitudes and their achievement in mathematics, suggesting that certain aspects are consistent across borders, as does the inverse relationship between interest in mathematics and years of schooling (e.g., Blomqvist et al., 2012; Hannula, 2006). One major problem, however, is the dominance of Western research, with much of it originating in four countries: the United States, Italy, France, and Germany (Flore & Wicherts, 2015). While cross-cultural and universal patterns are relatively well documented, intra-cultural and context-specific dynamics remain understudied, leaving an empirical gap around within-culture variation in affect over time.

A further question concerns how gender disparities progress over time, particularly since these differences are

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not inherently linked to biological sex but are open to influence. Greater disparities in participation and performance are observed in competitive nations and environments (Steeh et al., 2019), and France exemplifies such circumstances: following all first- and second-grade students over four years, Martinot et al. (2025) found comparable performance at the start of schooling but a gender gap favouring boys after only four months, which widened over the following year. Australian kindergarten children show a similar pattern, with girls' confidence declining relative to boys' over the first school year alongside a shift towards viewing mathematics as less critical for future careers (Davey et al., 2026), and TIMSS data show a comparable decline in enjoyment (Mullis et al., 2020). Since enjoyment correlates positively with achievement across grades (e.g., Dowker et al., 2019), such declines raise questions about when the decrease in positive emotions and motivation emerges and whether it intensifies as students progress through school. Gender gaps in affect persist even where no gender differences in performance are observed (Mejía-Rodríguez et al., 2021), and may help explain why many girls experience a weaker sense of belonging in mathematics, where dominant images of 'the mathematician' misalign with their own identities (Good et al., 2012). Consequently, a future in mathematics may not seem like an option, despite strong performance.

Two main questions arise from the studies above: when declines in positive emotions and motivation begin and at what rate they develop across grade levels, and whether and how these changes are gendered. Previously, we analysed Swedish TIMSS data from 2015 and 2019 and compared the same national cohort at Grade 4 and Grade 8 (Sumpter & Sollerman, 2023). Girls were more likely than boys to develop negative emotional directions over time, and cognitive motivation differentiated boys and girls already in Grade 4, whereas differences relating to extrinsic motivation were weak at that grade, findings that highlight the so-called *educational-gender-equality paradox* (Stoet & Geary, 2018), a paradox found in Nordic countries, where strong equity policies coexist with persistent gendered differences in mathematics education (e.g., Brandell et al., 2007). Reviews of the field have called for the between-person designs that dominate research on emotions and motivation to be complemented by within-person studies, since between-person data cannot support conclusions about how affect develops within individual students (Schukajlow et al., 2023). The TIMSS 2023 Longitudinal Study allows us to extend these results by following the same students across consecutive school years, using a coding framework carried over from our earlier work rather than being extended. Building on that theoretical recoding of TIMSS affective items, the aim is to analyse intrinsic motivation as an overarching category and distinguish two subcategories within it, cognitive

and emotional motivation, in order to examine which motivational dimensions appear more sensitive to change and how these patterns are gendered. Two research questions guide the study: (1) How does students' intrinsic motivational orientation towards mathematics, including its cognitive and emotional subcategories, change between Grades 4 and 5 and between Grades 8 and 9?; and (2) What gendered patterns can be observed in these changes?

2 Literature review

The literature review is divided into two sections: emotions and motivation, and emotions and gender. For each section, there is an overview of relevant research. Each section closes by stating which parts of that research are carried forward as the theoretical framework of the present study.

2.1 Emotions and motivation

The study of emotions has a long history in research (Prinz, 2005). They are understood to arise from and simultaneously shape human experience, and, as a theoretical construct, emotions are embedded within a range of broader affective concepts, including self-evaluation and motivation (Damasio, 1994; Hannula, 2006). Within emotion research, a fundamental distinction is drawn between feelings, understood as physiological reactions, and emotions, understood as consciously reported experiences (Whiting, 2011). This distinction is noted here to clarify what questionnaire data can capture: the present study operates exclusively at the level of self-report and makes no claim about the physiological level. A contemporary perspective is offered by Prinz (2005), who defines emotions as self-reported conscious experiences that can be broadly categorised into three emotional directions: positive, negative, and neutral. In this framework, an emotion is typically tied to a specific cause or situation and subsequently shapes behaviour in relation to it (Damasio, 1994). In this sense, emotional direction provides one way of understanding how motivation is oriented and maintained. Motivation has been defined in numerous ways, but a recurring element across definitions is its orientation towards a goal (Schukajlow et al., 2023); more specifically, it can be understood as the process through which goal-directed activity is both initiated and maintained (Schunk et al., 2008). Goals themselves are rooted in emotions, whether viewed from a state or a trait perspective (Damasio, 1994; Hannula, 2006). The most widely applied distinction in motivation research is that between extrinsic and intrinsic motivation (Ryan & Deci, 2000), and earlier research has identified finer subscales within each: outward and compensation as subcategories of extrinsic motivation, referring to social and personal gains respectively (Amabile et al., 1994), and

cognitive and emotional dimensions as subscales of intrinsic motivation (Nyman & Sumpter, 2019; Sumpter, 2013). Motivation and emotions are thus intertwined as theoretical constructs: three of these subcategories — outward, compensation, and cognitive — can each be associated with a distinct emotional state, whereas in the fourth, emotional motivation, the emotion is itself the goal, as in “I am doing this because it is fun.”

In this paper, the theoretical framing draws on different traditions: Ryan and Deci (2000) supply the intrinsic–extrinsic distinction that defines the overarching category, and Schunk et al. (2008) the definition of motivation as goal-directed activity that is initiated and sustained. Prinz (2005) supplies the valence coding applied to each item, used for that alone rather than as a theory of motivation, and Damasio (1994) the premise that goals are grounded in emotion, which makes it coherent to treat an emotional subcategory as motivational. The cognitive–emotional distinction, by contrast, was developed inductively from qualitative analyses of students' expressed reasons for engaging with mathematics (Sumpter, 2013), and is used here as an empirically grounded rather than an a priori distinction. Its criterion is the object of the expressed motivation: cognitive, where the stated object is the mathematical content or activity; emotional, where it is the affective state accompanying that activity. Related frameworks offer partly overlapping distinctions: Hidi and Renninger (2006) differentiate between feeling-related and value-related valences of interest, while Pekrun (2006) separates activity-related emotions, such as enjoyment and boredom, from the appraisals that accompany them. Neither maps exactly onto the present subcategories, and the present study examines how the two subcategories shift over time rather than validating the distinction itself.

Positive emotional orientations are consistently associated with enhanced academic behaviour and the development of subject interest (e.g., Fredrickson & Joiner, 2018; Nelson et al., 2018), though findings vary with when and how students are asked: expressed emotions and motivation differ considerably depending on whether students are surveyed in general terms, immediately before a lesson, or while doing mathematics (Takeuchi et al., 2016). Across time, a broader qualitative shift is apparent, with younger students expressing positive intrinsic motivation and older students increasingly emphasising extrinsic motivation alongside negative intrinsic motivation (e.g., Gottfried et al., 2001; Hannula, 2006; Nyman & Sumpter, 2019); in mathematics specifically, both intrinsic and extrinsic motivation appear to decline with age (Mula et al., 2024). A well-established pattern across national contexts is that younger students hold more positive attitudes towards mathematics than their older counterparts (e.g., Hannula, 2006), a trend reflected in TIMSS data, which show that fourth-grade students display more positive orientations towards

learning mathematics than eighth-grade students (Mullis et al., 2020). Understanding this trajectory requires looking beyond broad categories of positive and negative emotion: positive affect not only buffers against negative emotional states but exerts a lasting influence over time, functioning as a mediating mechanism encompassing motivation (Damasio, 1994).

The implications are significant, as students who come to view mathematics as difficult, tedious, and irrelevant are considerably more likely to disengage from the subject at the earliest opportunity (Mula et al., 2024). Much of this evidence is, however, cross-sectional or drawn from small qualitative samples, and reviews of early-years affect note how little is established about development within individual students (Batchelor et al., 2019). Longitudinal work has begun to address this: Nagy et al. (2010) followed mathematics self-concept across adolescence in three countries and found trajectories differing by gender and national context rather than converging on a single downward path, and Niemivirta et al. (2024) report comparable heterogeneity among school beginners. Within-student change, therefore, cannot be inferred from level differences between grades, which is the distinction the present study is designed to make.

2.2 Emotional direction and gender

In this study, gender is treated as a social construct rather than as biological sex: gender is regarded as a system of relationships, with the constructs ‘man’ and ‘woman’ continually negotiated. Previous studies examining mathematics and gender indicate that gendered paths can be established quickly (Davey et al., 2026; Martinot et al., 2025). These could be seen as norms that create trajectories in which acting and thinking are directed by what is considered ‘male’ and ‘female’. Gender then plays a role in the constitution of mathematical self-understanding, meaning that gender is produced. Research examining gender differences shows that male students in mathematics exhibit higher and more positive self-concept, intrinsic motivation, a self-enhancing ego-orientation, and higher performance expectations than female students (Skaalvik & Skaalvik, 2004). However, when the focus was on language, women expressed higher (and more positive) intrinsic motivation. Similar results have been found with Swedish upper secondary school students (Ding et al., 2024). Analysing a large longitudinal sample in the United States, the gender gap in mathematics confidence was larger than the gaps in either interest or achievement, indicating a difference in self-related beliefs rather than in performance (Ganley & Lubienski, 2016). Previous studies have reported gender differences in expressed attitudes and self-beliefs in mathematics (and science) that increase with age (McGeown & Warhurst, 2020), including a gender confidence gap (Zander et al., 2020). How success is explained

matters here too: where achievement is attributed to fixed brilliance rather than effort, women are underrepresented across academic fields (Leslie et al., 2015), and the contrasting figures of the hard-working woman and the gifted man supply unequal accounts of the same result. Such attributional patterns offer one explanation for why self-evaluation and expressed motivation diverge from measured achievement. This is particularly interesting, as studies show that boys/men tend to overestimate their abilities relative to their grades and achievements (e.g., Adamecz et al., 2025). Such patterns have consequences beyond school, and have been used to account for gender segregation in mathematics at doctoral level and beyond (Sumpter & Sumpter, 2021).

As mentioned earlier, Sweden and other Nordic countries have a problematic relationship among participation, motivation, and mathematics, known as the ‘educational-gender-equality paradox’ (Stoet & Geary, 2018): the most gender-equal countries within the OECD also have the largest gender gaps in higher education in STEM fields. Sweden nonetheless has some unique patterns. The boy/girl ratio is within the target range for a balanced group (40–60%) in the Natural Science programme (Skolverket, 2020), the most mathematically intensive upper secondary school programme preparing students for university. Girls are therefore not dropping out of mathematics at school; rather, they are choosing not to pursue it afterwards, despite having the qualifications and the grades.

3 Method

The method section describes the longitudinal data source, the theoretical coding of the retained questionnaire items, and the statistical analyses used to examine change. The analyses focused on one-year changes in students’ intrinsic motivational orientation towards mathematics and on whether these changes differed between girls and boys. Full item-level coding for both cohorts is provided in Online Resource 1 (Tables S1 and S2).

3.1 Data source and participants

Data were drawn from the Swedish TIMSS 2023 Longitudinal Study, in which students who participated in TIMSS 2023 were followed up one year later, from Grade 4 to Grade 5 and from Grade 8 to Grade 9. This design enabled analysis of change in students’ intrinsic motivational orientation towards mathematics over one school year within two cohorts (von Davier et al., 2025). In the younger cohort, the longitudinal file included 5,358 students from 160 schools. Of these students, 2,730 were girls, and 2,628 were boys. In the older cohort, the longitudinal file included 5,303 students from 154 schools. Of these students, 2,574 were girls,

and 2,728 were boys, while one student had missing or omitted gender information. Analytical sample sizes varied because of missing questionnaire responses and are reported for each scale or subcategory in the Results section. Gender is recorded in TIMSS as a binary variable, which is a property of the instrument. The results, however, are interpreted through the lens of the chosen gender theory. Because scale scores required sufficient valid responses at both measurement points, the analytical samples are smaller than the longitudinal files, and roughly a quarter of each cohort is not represented below. Whether these students differ systematically from those retained has not been examined.

3.2 Instruments and coding

Following Sumpter and Sollerman (2023), the present study did not rely on the pre-set TIMSS questionnaire indices. Instead, items were coded according to selected theoretical definitions of emotional direction (e.g., Prinz, 2005), motivation (e.g., Schunk et al., 2008), and their subscales (e.g., Amabile et al., 1994; Sumpter, 2013), which allows nuances within each of these to be examined and girls’ and boys’ responses to be compared across them. The framework is carried over unchanged rather than extended; what is new is its application to the TIMSS 2023 Longitudinal data to track change within students. Items were retained in two stages. First, items had to be administered at both measurement points within a cohort, so that a change score could be computed. Second, items had to be administered with the same wording in both cohorts, so that the Grade 4/5 and Grade 8/9 cohorts could be compared on the same instrument. This yielded 14 items, seven from “Students Like Learning Mathematics” and seven from “Students Confident in Mathematics”. The same coding system was applied to both cohorts; no item was coded differently by age group. Full item-level coding is given in Online Resource 1 (Tables S1 and S2).

The retained longitudinal item set primarily represents intrinsic motivation as defined by Ryan and Deci (2000): 13 of the 14 items were coded as intrinsic, and intrinsic motivation was therefore treated as the overarching motivational category in the longitudinal analyses. Within it, two subcategories were sufficiently represented to be analysed separately: cognitive motivation (8 items) and emotional motivation (7 items). The criterion separating them is the object of the expressed motivation. “I like any schoolwork that involves numbers” is cognitive, since it refers to a specific class of mathematical work, whereas “I like mathematics” is emotional, since it reports an affective stance with no content specified. The emotional subcategory thus encompasses emotions both as goals in themselves and as states associated with engagement in mathematics (e.g., Sumpter, 2013). Two items satisfy both descriptions and were coded to both subcategories: “I enjoy learning mathematics” combines an

emotion with a cognitive goal, and “I like to solve mathematics problems” refers to problem solving rather than routine procedure and so carries a cognitive demand alongside the liking. Because these two enter both subscales, the eight cognitive and seven emotional items together comprise the 13 intrinsic items rather than 15, and the subscales are correlated by construction, a feature taken into account when their change patterns are compared.

Extrinsic motivation was retained in the coding framework but not analysed as a separate outcome, because only two retained items were coded as extrinsic and one of those was also coded as intrinsic. “Mathematics is more difficult for me than for many of my classmates” was coded as extrinsic-outward because it refers to comparison with classmates (e.g., Amabile et al., 1994), while “I usually do well in mathematics” may be read either as a personal reflection on mathematical ability or as referring to grades, test performance, or external evaluation, and was therefore coded as both intrinsic-cognitive and extrinsic-compensation. That so few extrinsic items remain follows from the longitudinal design rather than from the coding: items had to be present at both measurement points, which excluded four items available in Sumpter and Sollerman (2023): two extrinsic-outward (“I wish I did not have to study mathematics”; “My teacher tells me I am good at mathematics”) and two intrinsic-emotional (“Mathematics is boring”; “Mathematics makes me nervous”). The retained set is therefore smaller than in the earlier study, and asymmetrically so. This asymmetry is relevant when the two subcategories are compared.

For transparency, it should be noted that three cognitive items — “I usually do well in mathematics”, “I learn things quickly in mathematics” and “I am good at working out difficult mathematics problems” — are capability judgments from the TIMSS scale Students Confident in Mathematics, and may also be read as indicators of self-efficacy or self-concept (Bandura, 1997), constructs with well-documented gender differences (Ganley & Lubienski, 2016; Zander et al., 2020). Classifying them as cognitive intrinsic motivation follows the criterion set out earlier: their stated object is mathematical activity, and they report an orientation towards it, expressed through perceived capability. Capability judgments and interest are not the same, so this cognitive subcategory should not be interpreted as a pure measure of interest, and results should be interpreted accordingly.

3.3 Data analysis

The analysis examined longitudinal change in students' intrinsic motivational orientation towards mathematics. Because the purpose was to examine student-level change patterns within the Swedish longitudinal sample, the analyses were conducted on unweighted student-level data, and the results should be interpreted as descriptive of the analysed

students rather than as weighted estimates of national population parameters. Although the coding framework distinguishes between positive and negative emotional directions, the four-point response scale was retained to capture the degree of change over time, with all items coded so that higher values indicate a more positive orientation towards mathematics. Scale scores were computed as the mean of the item responses for intrinsic motivation and for the two subcategories sufficiently represented in the longitudinal item set, cognitive and emotional motivation; extrinsic motivation was excluded, since too few extrinsically coded items remained to support a scale-level analysis. To reduce case loss from occasional missing responses, scores were computed for students with valid responses on at least approximately 70% of the relevant items: nine of 13 for intrinsic motivation, six of eight for cognitive motivation, and five of seven for emotional motivation. Because the two subcategories share two double-coded items, they are not independent scales, and comparisons between them are descriptive rather than tests of difference.

Internal consistency was examined using Cronbach's alpha (Cronbach, 1951). Change scores were calculated separately for each scale or subcategory and cohort, as Grade 5 minus Grade 4 and Grade 9 minus Grade 8, so that positive values indicate a more positive orientation at the second time point. Mean change was examined descriptively, both overall and separately for girls and boys, and independent-samples t-tests were used to test whether it differed by gender, with Cohen's *d* as an effect-size measure (Cohen, 1988). Categorical change variables were also created to distinguish students who decreased, remained stable, or increased. Because scale scores are means on a four-point scale, very small numerical differences could occur without indicating a clear shift, so a descriptive threshold of 0.25 scale points — one quarter of a response category — was used to identify more visible directional changes: a decrease below -0.25 , stable between -0.25 and 0.25 , and an increase above 0.25 . Associations between gender and change category were examined using chi-square tests, with Cramer's *V* as a measure of association (Agresti, 2018). Given the large samples and the descriptive purpose of the analyses, statistical significance was interpreted cautiously, with emphasis on effect sizes, proportions, and the consistency of patterns rather than on *p*-values alone.

Two features differ from Sumpter and Sollerman (2023). First, the earlier study dichotomised the four-point scale into positive and negative emotional directions, whereas the present study retains all four points, since collapsing them would discard the information about degree of change that a longitudinal design is meant to capture; results from the two studies are therefore not directly comparable in magnitude. Second, the 0.25 threshold is applied identically to all three outcomes, even though they do not have identical variability,

and a fixed threshold classifies more students as changing on a more variable scale, so mean changes are also reported in standard-deviation units of the change score.

4 Results

The results are presented in three steps. First, we report the reliability, scale levels, and mean changes for intrinsic motivation and its cognitive and emotional subcategories. Second, we examine how students were distributed across three categories of change: decrease, stable, and increase. Third, we analyse whether these change patterns differed between girls and boys.

4.1 Reliability, scale levels, and mean change

The retained TIMSS questionnaire items were used to construct a scale for intrinsic motivation and two subcategory scales within it: cognitive and emotional motivation. Internal consistency was high across both cohorts and both time points. Table 1 presents Cronbach's alpha for each scale or subcategory, together with the mean change scores:

Table 1 shows high internal consistency for intrinsic motivation and subcategories across cohorts and time points.

The two cohorts differed in level and change direction: the younger cohort had higher positive orientations but decreased in intrinsic (-0.197), cognitive (-0.181), and emotional motivation (-0.245), with the largest decline in emotional motivation. The older cohort showed slight positive changes: 0.087 in intrinsic, 0.079 in cognitive, and 0.097 in emotional, indicating weak growth or stabilisation from lower levels. In standard-deviation units, these changes were modest: -0.33 , -0.30 , and -0.35 in the younger cohort, and 0.17, 0.15, and 0.16 in the older cohort, for intrinsic, cognitive, and emotional motivation, respectively. Thus, emotional motivation showed the largest standardised change in the younger cohort, whereas differences between subcategories were small in the older cohort.

4.2 Decrease, stability, and increase

To examine whether the mean changes reflected broad shifts among students or were driven by smaller subgroups, Table 2 presents the distribution of students across the three change categories.

As shown in Table 2, decreases outnumbered increases in the younger group, especially for emotional motivation, where 48.3% of students decreased, and 23.5% increased. Emotional motivation had the smallest stable group, indi-

Table 1 Reliability, scale levels, and mean change in intrinsic motivation and its cognitive and emotional subcategories

Cohort	Scale/subcategory	<i>n</i>	Alpha Grade 4/8	Alpha Grade 5/9	Mean Grade 4/8	Mean Grade 5/9	Mean change	SD
Grade 4 to 5	Intrinsic motivation	4006	0.927	0.938	2.857	2.656	-0.197	0.600
Grade 4 to 5	Cognitive motivation	4002	0.882	0.904	2.912	2.729	-0.181	0.601
Grade 4 to 5	Emotional motivation	4228	0.893	0.892	2.788	2.541	-0.245	0.703
Grade 8 to 9	Intrinsic motivation	3696	0.938	0.948	2.333	2.440	0.087	0.516
Grade 8 to 9	Cognitive motivation	3689	0.909	0.925	2.422	2.524	0.079	0.540
Grade 8 to 9	Emotional motivation	3916	0.897	0.912	2.239	2.351	0.097	0.605

Note: All means and change scores are based on students with valid scale scores at both measurement points. Change was calculated as Grade 5 minus Grade 4 and Grade 9 minus Grade 8.

Table 2 Categorical change in intrinsic motivation and its cognitive and emotional subcategories, percentages

Cohort	Scale/subcategory	<i>n</i>	Decrease (%)	Stable (%)	Increase (%)
Grade 4 to 5	Intrinsic motivation	4006	41.8	38.7	19.5
Grade 4 to 5	Cognitive motivation	4002	37.9	44.2	17.9
Grade 4 to 5	Emotional motivation	4228	48.3	28.2	23.5
Grade 8 to 9	Intrinsic motivation	3696	21.9	45.5	32.5
Grade 8 to 9	Cognitive motivation	3689	20.4	50.6	29.0
Grade 8 to 9	Emotional motivation	3916	27.6	34.7	37.7

Note: Values are valid percentages. Decrease = change score below -0.25 ; Stable = change score between -0.25 and 0.25 ; Increase = change score above 0.25 .

cating more movement across the fixed threshold than cognitive motivation. In the older group, increases were more common across all three outcomes, with emotional motivation again showing the highest number of students increasing. Since the same threshold applies to all outcomes and emotional motivation has the largest change variance, the difference in stable group sizes partly reflects measurement properties, rather than greater shifts. These results suggest that mean changes are due to shifts across many students rather than large movements among a few.

4.3 Gendered patterns of change

To make the level differences and gendered change patterns more visible, Fig. 1 displays mean scores at both time points separately for girls and boys:

Figure 1 highlights differences in mean levels, with boys reporting higher mean scores than girls across cohorts and subcategories. The figure also indicates that the overall cohort pattern was similar for girls and boys: the younger cohort declined, whereas the older cohort showed weak positive change. The following analyses examine whether girls and boys also differed in their patterns of change.

Gender differences were first examined using mean change scores. In the younger cohort, girls showed larger decreases than boys in intrinsic motivation and in both subcategories, with mean differences of -0.099 for intrinsic

motivation, -0.081 for cognitive motivation, and -0.115 for emotional motivation. The differences were statistically significant but small, with absolute Cohen's d values ranging from 0.135 to 0.165. In the older cohort, boys showed slightly larger mean increases than girls, but the differences were very small, with absolute Cohen's d values ranging from 0.051 to 0.053, and were not statistically significant in two-sided t-tests. Because the categorical analysis provides a more interpretable picture of how students moved over time, gender differences were also examined through cross-tabulations of decrease, stability, and increase, see Table 3:

As shown in Table 3, gender differences were most visible in the younger cohort, where girls were more often classified as decreasing across all three outcomes. The largest difference was in emotional motivation: 52.6% of girls decreased, compared with 43.7% of boys. The associations between gender and change category were weak throughout, with Cramer's V ranging from 0.044 to 0.089. The direction of the gender pattern was nonetheless consistent across all three outcomes. In the older cohort, gender patterns were weaker. Boys were somewhat more likely to increase, while girls were more often classified as stable, especially in emotional motivation. The gendered pattern was therefore clearer in the younger cohort than in the older cohort.

Taken together, the analyses show three empirical patterns. The two cohorts differed in both the level and the direction of change. Emotional motivation showed somewhat

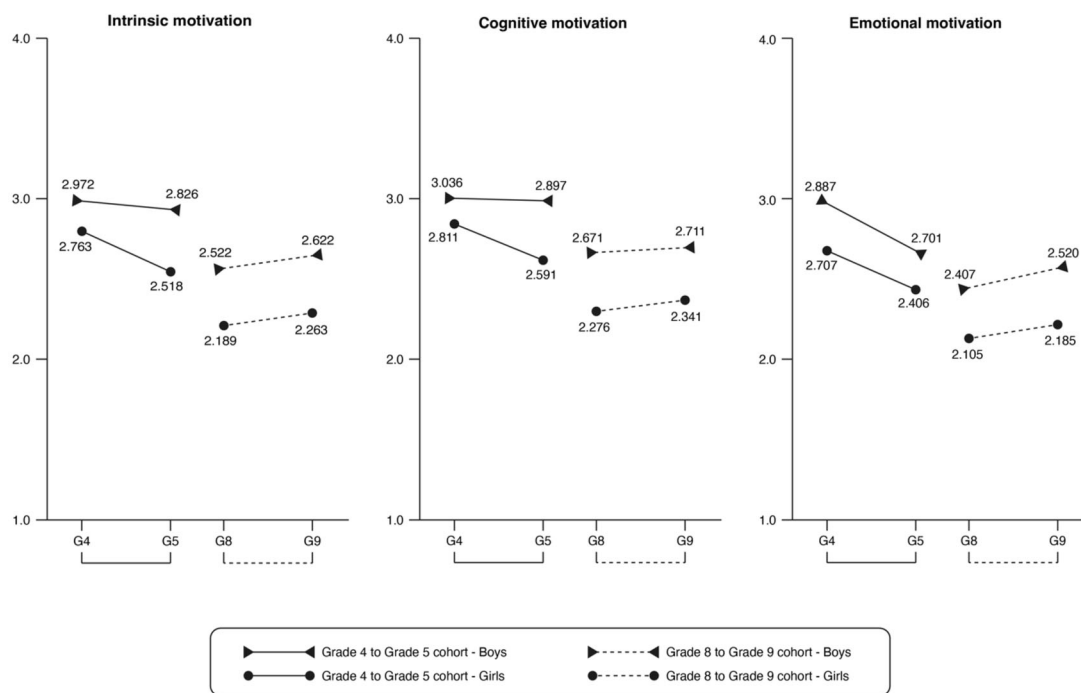


Fig. 1 Mean levels and gendered change in intrinsic motivation and its subcategories. *Note:* Lines show mean scale scores for students with valid scores at both time points. Colour indicates cohort, and line type

indicates gender. Sample sizes vary slightly across scales and gender groups; see Table 3 for corresponding n values

Table 3 Gender differences in categorical change in intrinsic motivation and its cognitive and emotional subcategories, percentages

Cohort	Scale/subcategory	Gender	<i>n</i>	Decrease (%)	Stable (%)	Increase (%)	Cramer's <i>V</i>	<i>p</i>
Grade 4 to 5	Intrinsic motivation	Girls	2063	45.5	36.5	18.1	0.077	<.001
Grade 4 to 5	Intrinsic motivation	Boys	1943	37.9	41.2	20.9		
Grade 4 to 5	Cognitive motivation	Girls	2061	40.7	42.6	16.8	0.060	<.001
Grade 4 to 5	Cognitive motivation	Boys	1941	34.9	46.0	19.2		
Grade 4 to 5	Emotional motivation	Girls	2180	52.6	26.2	21.2	0.089	<.001
Grade 4 to 5	Emotional motivation	Boys	2048	43.7	30.4	25.9		
Grade 8 to 9	Intrinsic motivation	Girls	1865	22.0	47.9	30.1	0.056	.003
Grade 8 to 9	Intrinsic motivation	Boys	1831	21.8	43.1	35.0		
Grade 8 to 9	Cognitive motivation	Girls	1862	20.1	52.6	27.2	0.044	.028
Grade 8 to 9	Cognitive motivation	Boys	1827	20.6	48.6	30.8		
Grade 8 to 9	Emotional motivation	Girls	1959	27.1	37.4	35.5	0.059	.001
Grade 8 to 9	Emotional motivation	Boys	1957	28.1	32.0	40.0		

Note: Values are row percentages within gender. *n* indicates the number of students with valid change scores for each scale/subcategory and gender group. Cramer's *V* and *p* refer to the chi-square test of association between gender and change category within each cohort and scale/subcategory.

more movement than cognitive motivation in both cohorts, although the difference is modest in standardised terms. Gendered differences in change were small throughout and were most visible in the younger cohort, particularly in the emotional subcategory.

5 Discussion

The discussion is organised around three aspects of the findings: how the longitudinal results complicate the common picture of gradual decline, how cognitive and emotional motivation showed different patterns of change, and how these changes were gendered across cohort and motivational subcategory.

5.1 Not simply a decline: level and change across school years

The findings complicate the often-repeated picture of declining affective orientations towards mathematics across school years. The younger cohort reported higher levels of positive intrinsic motivational orientation than the older cohort, partly consistent with earlier research showing that younger students express more positive attitudes, interest, or motivation towards mathematics than older students (e.g., Blomqvist et al., 2012; Hannula, 2006; Mula et al., 2024; Mullis et al., 2020; Sumpter & Sollerman, 2023). That agreement, however, concerns differences in level. The longitudinal results add that lower levels among older students do not mean students continue to decline each school year: the older cohort started lower but showed weak positive change or stabilisation, whereas the younger cohort started

higher but declined across the same measures. This contrast separates affective level across school years from actual change within a school year, a distinction cross-sectional and grade-comparative studies cannot capture (e.g., Gottfried et al., 2001; Niemivirta et al., 2024). Mathematics-related affect therefore does not follow a simple pattern of decline at the group level; average change may differ across school years, with some cohorts declining and others stabilising.

The question thus shifts from whether students become less positive towards mathematics to when decline or stabilisation occurs, and what might explain it. Any such explanation is, at this stage, a conjecture rather than a finding, since the study identifies patterns of change but does not examine the factors that produce them. Possible candidates include teaching practices, assessment contexts, peer relations, or classroom climate, consistent with research showing that expressed emotions and motivation vary by situation, activity, and measurement timing (e.g., Takeuchi et al., 2016). For practice and policy, the findings caution against assuming a uniform downward trajectory and point to the value of monitoring affective orientations over time. One alternative account of the older cohort's upward movement also deserves mention: that cohort began at a lower level, and any measure with less-than-perfect reliability produces some apparent movement towards the mean on re-measurement. With only two measurement points, regression to the mean cannot be ruled out, and the observed changes are small. We therefore describe the older cohort as stable rather than recovering, and treat the contrast between the cohorts — decline in one, absence of decline in the other — as the more stable finding. The study also lacks classroom-level and qualitative data, and future work should examine longer trajectories and

connect longitudinal survey data with contextual and qualitative information.

5.2 Cognitive and emotional change within intrinsic motivation

The second aspect of the findings concerns the emotional subcategory within intrinsic motivation. Previous research has emphasised the close relation between emotion and motivation in mathematics learning (e.g., Hannula, 2006; Nelson et al., 2018; Schukajlow et al. 2017, 2023; Valiente et al., 2012). The present study adds that the two subcategories do not move together: in the younger cohort, emotional motivation declined the most and had the highest decrease rate, while in the older cohort the order was less clear once standardised. The difference is real but small, and we do not suggest that emotional motivation is inherently more changeable. It does indicate, however, that a change in students' intrinsic motivational orientation may not be evenly distributed across its cognitive and emotional aspects, and that treating intrinsic motivation as one undifferentiated scale would conceal this (e.g., Ryan & Deci, 2000). This extends the approach of Sumpter and Sollerman (2023), who analysed expressed emotional directions across grade levels using theoretically recoded TIMSS items, by applying the same logic longitudinally.

Drawing on accounts of emotions as directed, experience-based, and action-oriented (Damasio, 1994; Prinz, 2005), the greater movement in emotional motivation may indicate that a changing relationship to mathematics becomes visible first in items expressing enjoyment, anticipation of lessons, or confusion. If so, a decline there would be not only a symptom of disengagement but part of the affective conditions under which engagement and persistence are sustained, which is an interpretation of the pattern rather than a result, and one that the present design cannot test. The findings nonetheless contribute to calls for fine-grained concepts and methods of analysis tailored to the mathematical domain (Schukajlow et al., 2017): broad composite measures of motivation, interest, and self-related beliefs are widely used (e.g., Schukajlow et al., 2023; Valiente et al., 2012) but may obscure how affective dimensions change over time. For research, this points to longitudinal studies of how different aspects of motivation change over time and under what conditions; for practice, it suggests attending to how students emotionally experience mathematics lessons and tasks, not only to whether they value the subject, experiences shaped by activities, classroom interactions, and students' interpretations of what mathematics is and who they can be in relation to it (e.g., Takeuchi et al., 2016).

These interpretations are limited by reliance on TIMSS items not designed to distinguish the two subcategories, which constrains both. Several cognitive-subcategory items

are capability judgements from Students Confident in Mathematics that could be read as indicators of self-efficacy or self-concept (e.g., Bandura, 1997; Zander et al., 2020), so results depend on the theoretical framing. The emotional subcategory, meanwhile, contains no items on boredom or anxiety, both in Sumpter and Sollerman (2023) and in the usual understanding of that subcategory (Pekrun, 2006), making it narrower here than its name suggests. Purpose-designed instruments, ideally combined with qualitative methods capturing how students articulate enjoyment, confusion, confidence, frustration, and belonging, would address both constraints and permit a test of whether the cognitive-emotional distinction is separable from the self-efficacy-interest distinction, which the present data were not designed to settle.

5.3 Gendered patterns as timing and dimension

The third aspect of the findings concerns gendered patterns in mathematics-related affect. Gender differences in mathematics are often more pronounced in affective and self-related constructs than in achievement itself, as measured at given points in time (e.g., Brandell et al., 2007; Ganley & Lubienski, 2016; Good et al., 2012; McGeown & Warhurst, 2020; Mejía-Rodríguez et al., 2021; Zander et al., 2020). The present study further reports that such patterns are also evident in longitudinal change. In the younger cohort, girls were more likely than boys to show decreases in intrinsic motivation and in both subcategories, most visibly in emotional motivation, although all the differences were small; in the older cohort, they were weaker and less consistent. Gender differences, therefore, do not appear to strengthen progressively across school years; rather, the clearest gendered change appeared early and in the emotional subcategory, consistent with studies showing that gendered mathematics-related patterns emerge early in schooling (Davey et al., 2026; Martinot et al., 2025) and are reinforced through schooling, classroom interaction, and cultural expectations (Adamecz et al., 2025).

This relates to our earlier cross-sectional results: Sumpter and Sollerman (2023) found the gender-emotional association stronger at Grade 8, suggesting that gender differences grow with age, whereas the present study locates the clearest gendered change in the younger cohort. The distinction between level and change reconciles the two: differences in level may widen across schooling while the gendered movement producing them is unevenly distributed, being more evident between Grades 4–5 than 8–9. This is consistent with a gap that opens early and is then maintained rather than continually increasing, a reading our two-wave data can propose but not confirm. Emotional motivation may therefore be an important site for understanding how gendered relationships to mathematics develop, and supporting motivation may need to attend to early emotional changes rather

than only to later course choices or performance outcomes. This matters in a context such as Sweden, where participation in advanced mathematics remains relatively balanced at upper secondary level (Skolverket, 2020) but the growth of women's participation at doctoral level in mathematics has been markedly slower than in almost every other discipline (Sumpter & Sumpter, 2021; see also Stoet & Geary, 2018). These interpretations should be treated with caution: gender was measured as a binary variable, roughly a quarter of each cohort is absent from the analytical samples, and the study cannot identify the classroom practices, peer relations, teacher expectations, or cultural messages contributing to the observed patterns. Future studies should connect longitudinal patterns to students' experiences of mathematics classrooms, examine when gendered affective patterns emerge and how they relate to later educational choices, and test whether findings differ across other student groups.

Taken together, the results indicate that students' intrinsic motivational orientation towards mathematics develops unevenly and in dimension-specific ways, shaped by cohort, subcategory, and gender.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11858-026-01849-6>.

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Data Availability The study is based on Swedish data from the TIMSS 2023 Longitudinal Study. The underlying public-use TIMSS 2023 Longitudinal International Database is available through the TIMSS & PIRLS International Study Center. The analysis variables used in the present study were derived from the retained questionnaire items described in the article.

Declarations

Competing Interests The authors declare no competing interests.

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References

- Adamecz, A., Jerrim, J., Pingault, J.-B., & Shure, N. (2025). Peers, parents, and self-perceptions: The gender gap in mathematics self-assessment. *Journal of Population Economics*, 38, Article 33. <https://doi.org/10.1007/s00148-025-01087-2>
- Agresti, A. (2018). *An introduction to categorical data analysis* (3rd ed.). Wiley.
- Amabile, T. M., Hill, K. G., Hennessey, B. A., & Tighe, E. M. (1994). The work preference inventory: Assessing intrinsic and extrinsic motivational orientations. *Journal of Personality and Social Psychology*, 66(5), 950–967. <https://doi.org/10.1037/0022-3514.66.5.950>
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.
- Batchelor, S., Torbeyns, J., & Verschaffel, L. (2019). Affect and mathematics in young children: An introduction. *Educational Studies in Mathematics*, 100(3), 201–209. <https://doi.org/10.1007/s10649-018-9864-x>
- Blomqvist, A., Elamari, U., & Sumpter, L. (2012). Grade 2 and Grade 5 students' conceptions about mathematics and mathematics education. In G. H. Gunnarsdottir, F. Hreinsdottir, G. Palsdottir, M. Hannula, M. Hannula-Sormunen, E. Jablonka, U. Jankvist, A. Ryve, P. Valero, & K. Wæge (Eds.), *Proceedings of NORMA 11: The sixth Nordic conference on mathematics education* (pp. 187–196). Reykjavik.
- Brandell, G., Leder, G., & Nyström, P. (2007). Gender and mathematics: Recent development from a Swedish perspective. *ZDM – Mathematics Education*, 39(3), 235–250. <https://doi.org/10.1007/s11858-007-0025-4>
- Capuno, R., Necesario, R., Etcuban, J. O., Espina, R., Padillo, G., & Manguilimotan, R. (2019). Attitudes, study habits, and academic performance of junior high school students in mathematics. *International Electronic Journal of Mathematics Education*, 14(3), 547–561. <https://doi.org/10.29333/iejme/5768>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). <https://doi.org/10.4324/9780203771587>
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3), 297–334. <https://doi.org/10.1007/BF02310555>
- Damasio, A. R. (1994). *Descartes' error: Emotion, reason, and the human brain*. G. P. Putnam's Sons.
- Davey, R., Bellen, L., Thai, T., & Kearney, S. (2026). Shifts in children's mathematical identities during the first year of school. *Mathematics Education Research Journal*, 38, 135–159. <https://doi.org/10.1007/s13394-025-00523-6>
- Ding, Y., Klapp, A., & Yang Hansen, K. (2024). The importance of mathematics self-concept and self-efficacy for mathematics achievement: A comparison between public and independent schools in Sweden. *Educational Psychology*, 44(8), 989–1009. <https://doi.org/10.1080/01443410.2024.2410217>
- Dowker, A., Cheriton, O., Horton, R., & Mark, W. (2019). Relationships between attitudes and performance in young children's mathematics. *Educational Studies in Mathematics*, 100(3), 211–230. <https://doi.org/10.1007/s10649-019-9880-5>
- Flore, P. C., & Wicherts, J. M. (2015). Does stereotype threat influence performance of girls in stereotyped domains? A meta-analysis. *Journal of School Psychology*, 53(1), 25–44. <https://doi.org/10.1016/j.jsp.2014.10.002>
- Fredrickson, B. L., & Joiner, T. (2018). Reflections on positive emotions and upward spirals. *Perspectives on Psychological Science*, 13(2), 194–199. <https://doi.org/10.1177/1745691617692106>
- Ganley, C. M., & Lubienski, S. T. (2016). Mathematics confidence, interest, and performance: Examining gender patterns and reciprocal relations. *Learning and Individual Differences*, 47, 182–193. <https://doi.org/10.1016/j.lindif.2016.01.002>

- Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology*, 102(4), 700–717. <https://doi.org/10.1037/a0026659>
- Gottfried, A. E., Fleming, J. S., & Gottfried, A. W. (2001). Continuity of academic intrinsic motivation from childhood through late adolescence: A longitudinal study. *Journal of Educational Psychology*, 93(1), 3–13. <https://doi.org/10.1037/0022-0663.93.1.3>
- Hannula, M. S. (2006). Motivation in mathematics: Goals reflected in emotions. *Educational Studies in Mathematics*, 63, 165–178. <https://doi.org/10.1007/s10649-005-9019-8>
- Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4
- Leslie, S.-J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science*, 347(6219), 262–265. <https://doi.org/10.1126/science.1261375>
- Martinot, P., Colnet, B., Breda, T., Sultan, J., Toutou, L., Huguet, P., Spelke, E., Dehaene-Lambertz, G., Bressoux, P., & Dehaene, S. (2025). Rapid emergence of a maths gender gap in first grade. *Nature*, 643(8073), 1020–1029. <https://doi.org/10.1038/s41586-025-09126-4>
- McGeown, S. P., & Warhurst, A. (2020). Sex differences in education: Exploring children's gender identity. *Educational Psychology*, 40(1), 103–119. <https://doi.org/10.1080/01443410.2019.1640349>
- Mejía-Rodríguez, A. M., Luyten, H., & Meelissen, M. R. (2021). Gender differences in mathematics self-concept across the world: An exploration of student and parent data of TIMSS 2015. *International Journal of Science and Mathematics Education*, 19(6), 1229–1250. <https://doi.org/10.1007/s10763-020-10100-x>
- Mula, M., Naka, L., & Sylhasi, F. (2024). Intrinsic and extrinsic motivation of primary school students for mathematics and English as a foreign language. *International Electronic Journal of Elementary Education*, 17(1), 191–202. <https://doi.org/10.26822/iejee.2024.372>
- Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 International Results in Mathematics and Science*. Retrieved from Boston College, TIMSS & PIRLS International Study Center. <https://timssandpirls.bc.edu/timss2019/international-results/>
- Nagy, G., Watt, H. M. G., Eccles, J. S., Trautwein, U., Lüdtke, O., & Baumert, J. (2010). The development of students' mathematics self-concept in relation to gender: Different countries, different trajectories? *Journal of Research on Adolescence*, 20(2), 482–506. <https://doi.org/10.1111/j.1532-7795.2010.00644.x>
- Nelson, N., Malkoc, S. A., & Shiv, B. (2018). Emotions know best: The advantage of emotional versus cognitive responses to failure. *Journal of Behavioral Decision Making*, 31(1), 40–51. <https://doi.org/10.1002/bdm.2042>
- Niemivirta, M., Tapola, A., Tuominen, H., & Viljaranta, J. (2024). Developmental trajectories of school-beginners' ability self-concept, intrinsic value and performance in mathematics. *British Journal of Educational Psychology*, 94(2), 441–459. <https://doi.org/10.1111/bjep.12655>
- Nyman, M., & Sumpter, L. (2019). The issue of 'proudliness': Primary students' motivation towards mathematics. *Lumat: International Journal of Math, Science and Technology Education*, 7(2), 80–96. <https://doi.org/10.31129/LUMAT.7.2.331>
- Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, 18(4), 315–341. <https://doi.org/10.1007/s10648-006-9029-9>
- Prinz, J. J. (2005). Are emotions feelings? *Journal of Consciousness Studies*, 12(8–10), 9–25.
- Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25(1), 54–67. <https://doi.org/10.1006/ceps.1999.1020>
- Schukajlow, S., Rakoczy, K., & Pekrun, R. (2017). Emotions and motivation in mathematics education: Theoretical considerations and empirical contributions. *ZDM – Mathematics Education*, 49(3), 307–322. <https://doi.org/10.1007/s11858-017-0864-6>
- Schukajlow, S., Rakoczy, K., & Pekrun, R. (2023). Emotions and motivation in mathematics education: Where we are today and where we need to go. *ZDM – Mathematics Education*, 55(2), 249–267. <https://doi.org/10.1007/s11858-022-01463-2>
- Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education: Theory, research, and applications* (3rd ed.). Pearson/Merrill Prentice Hall.
- Skaalvik, S., & Skaalvik, E. M. (2004). Gender differences in math and verbal self-concept, performance expectations, and motivation. *Sex Roles*, 50(3), 241–252. <https://doi.org/10.1023/B:SERS.0000015555.40976.e6>
- Skolverket (2020). *Elever i gymnasieskolan läsåret 2019/2020* [Students in upper secondary school, school year 2019/2020] (Dnr 2019:00860). Skolverket.
- Steeh, A. M., Höffler, T. N., Keller, M. M., & Parchmann, I. (2019). Gender differences in mathematics and science competitions: A systematic review. *Journal of Research in Science Teaching*, 56(10), 1431–1460. <https://doi.org/10.1002/tea.21580>
- Stoet, G., & Geary, D. C. (2018). The gender-equality paradox in science, technology, engineering, and mathematics education. *Psychological Science*, 29(4), 581–593. <https://doi.org/10.1177/0956797617741719>
- Sumpter, L. (2013). Themes and interplay of beliefs in mathematical reasoning. *International Journal of Science and Mathematics Education*, 11(5), 1115–1135. <https://doi.org/10.1007/s10763-012-9392-6>
- Sumpter, L., & Sollerman, S. (2023). Changes in affect: Patterns in Grade 4 and Grade 8 students' expressed emotional directions. *International Journal of Mathematical Education in Science and Technology*, 54(8), 1598–1613. <https://doi.org/10.1080/0020739X.2023.2184279>
- Sumpter, L., & Sumpter, D. J. T. (2021). Modelling gender differences in participation in PhD studies in mathematics. *SN Social Sciences*, 1(4), 90. <https://doi.org/10.1007/s43545-021-00098-6>
- Takeuchi, M. A., Towers, J., & Plosz, J. (2016). Early years students' relationships with mathematics. *Alberta Journal of Educational Research*, 62(2), 168–183. <https://doi.org/10.55016/ojs/ajer.v6i2i.56197>
- Valiente, C., Swanson, J., & Eisenberg, N. (2012). Linking students' emotions and academic achievement: When and why emotions matter. *Child Development Perspectives*, 6(2), 129–135. <https://doi.org/10.1111/j.1750-8606.2011.00192.x>
- von Davier, M., Kennedy, A. M., Reynolds, K. A., Gonzalez, E., & Khorramdel, L. (2025). *TIMSS 2023 Longitudinal International Results in Mathematics and Science*. Boston College, TIMSS & PIRLS International Study Center. <https://doi.org/10.6017/lse.tpisc.timss.dn2487>
- Whiting, D. (2011). The feeling theory of emotion and the object-directed emotions. *European Journal of Philosophy*, 19(2), 281–303. <https://doi.org/10.1111/j.1468-0378.2009.00384.x>
- Zander, L., Höhne, E., Harms, S., Pfost, M., & Hornsey, M. J. (2020). When grades are high but self-efficacy is low: Unpacking the confidence gap between girls and boys in mathematics. *Frontiers in Psychology*, 11, 552355. <https://doi.org/10.3389/fpsyg.2020.552355>