Who and How Matters

Using situated expectancy value theory to explore the mathematics performance of Grade 9 learners in South Africa

Mukovhe Glen Takalani & Debra L. Shepherd
(13 December 2023)

Teacher Demographic Dividend.

RESEP
Research on Socio-Economic Policy

Acknowledgements

This document was written as part of the Teacher Demographic Dividend project, which is supported by Allan & Gill Gray Philanthropies and the FEM Education Foundation. The project is managed by the Research on Socioeconomic Policy unit (Resep) at Stellenbosch University.

Executive Summary

Since 2006, a revision to the basic education curriculum has made mathematics compulsory for all South African students during the Further Education and Training (FET) phase. This served to both rectify historical inadequacies in mathematical literacy, as well as meet demands of contemporary economy and the Fourth Industrial Revolution (4IR). Cross-time trends in the Trends in Mathematics and Sciences Study (TIMSS) have indicated substantial improvements in mathematics achievement of Grade 9 South African learners between 1995 and 2019. Nevertheless, **South African students, on average, continue to lag internationally, and there exist significant gaps in mathematical proficiency across socioeconomics groups, as well as by gender (albeit to a lesser degree).**

The empirical analysis presented in this working paper aimed to examine the complex relationship between learner academic self-efficacy, engagement, and expectancy value, and the association of these with mathematics achievement. The Situated Expectancy-Value Theory (S-EVT) of Eccles and Wigfield (2020) contends that a learner's motivational and competency beliefs dynamically evolve with each learning situation. Central to this evolution are the experiences and perceptions of the behaviour of key socializers (i.e., teachers and peers) and sociocultural attitudes such as gender stereotyping. The TIMSS data for South African Grade 9 learners collected in 2019 was used together with Structural Equation Modelling (SEM) using Maximum Likelihood Missing Value (MLMV) estimation. SEM analyses performed by school socio-economic classification and gender aimed to emphasize the role of perceptions of socializer behaviour, affective reactions, self-schemas, and task values on mathematics achievement.

The main findings of the paper can be summarized as follows:

1. **Successful outcomes in mathematics are nurtured within an emotional ecosystem where students — through an instilled sense of competence and interest — forge a genuine bond with the subject, leading to enhanced mathematical proficiency.** However, this account is not uniform, but entwined with gender- and class-based nuances.
2. **Boys, more than girls, necessitate an augmented level of effort, interaction, and support from their educators to stimulate their interest in and utility value from mathematics.** While the social cognitive processes of both boys and girls were

influenced by perceptions of teacher social support and instructive engagement (TSSE), the effect sizes estimated for boys were more pronounced, supporting existing research (e.g., Watt et al., 2019). This is, perhaps, because TSSE serves as a countervailing force against prevailing negative expectations.

3. **Teachers play an important role in fostering girls' confidence in their mathematical capabilities.** For girls, TSSE emerged as a significant determinant of interest in mathematics, a subject traditionally perceived as aligning with masculine attributes. This pathway emerged predominantly through the mechanism of mathematics self-efficacy (MSE).
4. **Goal orientations are rooted in socioeconomic context**. Differential paths from MSE to mathematics achievement were found for boys and girls: For girls — and particularly those in more affluent schools — the total effect of MSE on performance operated predominantly through intrinsic task value. For boys in less-affluent settings, the total effect of MSE on performance operated through utility task value.
5. **Teacher quality — both objectively measured and subjectively perceived by learners — plays a crucial role in academic outcomes, particularly for students from vulnerable backgrounds.** The role of teacher quality factors (i.e., education and experience) in mathematics learning are more pronounced and significant for learners in the poorest 60% of schools. Learners taught by teachers that are recent university graduates or teachers with more experience are predicted to perceive significantly more supportive and engaging learning environments. Moreover, we find that being taught by a recent graduate has significant positive direct effects on the affective responses and self-efficacy of learners in poorer school contexts, as well as a positive direct effect on mathematics performance. Similarly, being taught by an experienced teacher is related to significantly higher mathematics self-efficacy — contributing to more pronounced intrinsic and utility task values, particularly for boys — and mathematics performance. **We hypothesise this to be capturing the superior self-regulation skills and pedagogical confidence of experienced teachers, and better content knowledge and assessment training of recent graduates.**

1. Introduction

Since the introduction of a fresh national curriculum in 2006, it has become compulsory for all South African students to take mathematics during the Further Education and Training (FET) phase (Grades 10 – 12) of basic education (Department of Basic Education, 2014). This revision in curriculum served to rectify the historical inadequacy in mathematical literacy and achievement, while meeting contemporary demands (Jojo, 2019). Drawing on the successes of countries like Singapore and South Korea — as pointed out by Feza (2014) — reforms in education and changes in teaching policies have been used to improve performance in mathematics, as evidenced by cross-time trends in the Trends in Mathematics and Sciences Study (TIMSS) standardised assessment. Nevertheless, despite several revisions in policy and curriculum since 1994, South African students, on average, continue to lag their international counterparts. This, however, doesn't negate noteworthy improvements such as a more than 100-point increase in average TIMSS performance between 1995 and 2019 (Reddy, 2021).

Despite these strides, a significant disparity in mathematical proficiency still exists across different socioeconomics groups in South Africa, as well as by gender (albeit to a lesser degree). The 2014 Grade 9 Annual National Assessment (ANA), for instance, revealed that students from non-fee-paying schools (quintiles 1 to 3)[1] underperformed in mathematics compared to their counterparts in quintiles 4 and 5 (Department of Basic Education, 2014). A similar trend was evident in the 2019 TIMSS data (HSRC, 2019), with little difference between the performance of quintile 5 and independent schools. Spaull and Makaluza (2019) find a pro-girl gap in Intermediate phase (Grades 4 – 6) mathematics performance using the SACMEQ[2] 2007 and TIMSS-Numeracy 2015 data, respectively. At the Senior phase (Grades 7 – 9), the pro-boy achievement gap that was observed in the TIMSS mathematics and science assessments in 1995 and 1999 has reversed to a small (yet statistically insignificant) pro-girl gap in 2011 and 2015. More significantly, Spaull and Makaluza (2019) show that male outperformance in the school-leaving (matric) examinations is partly a function of dropout that is notably higher amongst boys, and that there is an over-representation of males at both the upper and lower ends of the distribution of Grade 12 mathematics performance.

[1] School quintiles refer to the division of schools in each province which are classified according to their wealth status. The schools are split into five sub-groups from school quintile 1 to school quintile 5, with the lowest sub-group (school quintile 1) catering for 20% of the poorest schools in the province and the highest quintile being school quintile 5 catering to 20% of the least poor schools.

[2] Southern and Eastern African Consortium for Monitoring Educational Quality.

Overall, the importance of mathematics extends beyond the classroom: mathematics is essential for advancing human reasoning and logic — empowering us to make sense of the world and life's problems (Gates & Vistro-Yu, 2011). Understanding the determinants of mathematics performance is crucial in developing contexts such as South Africa where there is an increasing pressure to meet the growing demands of the Fourth Industrial Revolution (4IR). And although it is not definitive that mathematics enhances higher cognitive functioning, it is indispensable for understanding the content of other school subjects (Mwakapenda, 2008; Cresswell & Speelman, 2020). Furthermore, placing emphasis on Grade 9 mathematics performance may prove critical as successful completion of this grade marks a pivotal transition from the Senior into the FET[3] phase of the South African basic education system. Identifying the learning gaps that students have at this stage and in earlier grades is crucial, as these shortcomings may eventually undermine the student's ability to benefit from further educational training.

STEM careers are gaining popularity and are in high demand in the South African labour market. Many higher education institutions require advanced mathematics for STEM studies, or at least a subminimum performance in the school-leaving examinations. However, aside from academic performance, the career choices of learners are influenced by social-contextual factors, as previous research indicates (Howie, 2005; Abe & Chikoko, 2020). Parental influence significantly impacts a learner's decision to pursue a STEM career. This influence encompasses the parents' own educational level, their attitudes toward STEM subjects, and the gender labels they associate with different careers, which can potentially steer learners towards gender-stereotyped choices (Jacobs, et al., 2017). Limited parental education — often linked to lower socioeconomic status — can leave parents in vulnerable social situations ill-equipped to guide their children toward STEM qualifications (Taylor & Yu, 2009; Gutfleisch & Kogan, 2022). This exacerbates the disparity between social classes in the labour market: those from privileged backgrounds secure STEM roles, while others with weaker academic records compete for less skilled occupation.

Parental gender biases also shape learners' career decisions, particularly concerning STEM fields. Girls are more affected than boys by how their parents perceive STEM subjects (Eccles & Jacobs, 1986; Eccles, Jacobs, & Harold, 1990; Cheng, Kopotic, & Zamorro, 2017). These careers still carry masculine stereotypes and are often seen as less suitable for future

[3] Further Education and Training.

professions for females (Struyf, et al., 2017). According to Spaull and van Broekhuizen (2017), males are 62% more likely than females to enroll in tertiary studies focused on Engineering, and male students are 52% more likely to complete an Engineering degree in four years. Conversely, while females are 45% less likely to enroll in Mathematical Sciences, they are 53% more likely than males to graduate, a difference that is partly explained by males' greater probability of dropout. Therefore, understanding the factors influencing mathematics performance is critical not only for equipping learners with skills and knowledge necessary for their future studies and careers, but also for addressing barriers to social progress and social inclusion.

A substantial portion of the underperformance in developing countries' education systems, like South Africa's, can be attributed to teacher-related factors — such as inadequate professional training and insufficient knowledge of subject and pedagogical content — and resource-limited school environments, including overcrowding and high teacher-to-learner ratios (du Plessis & Mestry, 2019; Mabena et al., 2021). Shepherd (2015), for example, points out that the influence of a teacher's knowledge is not evenly distributed across all South African schools: teachers deemed high-quality, with greater content knowledge and higher levels of education, are concentrated in the top two school quintiles. On the other hand, an expanding body of research in education and psychology considers learner-level factors such as goal setting, self-monitoring, self-instruction, and self-reinforcement, indicating that students themselves play a significant role in managing their learning and progress (Harris & Graham, 1999; Schunk & Ertmer, 2000; Schraw, et al., 2006).

Affective engagement plays a key role in fostering self-regulatory strategies and student cognitive engagement and motivation within and outside the classroom (Gerber, et al., 2019). Notably, affective engagement reflects the quality of the relationship students form with their learning and how they process academic information (Barlow, et al., 2020). These behaviours and attitudes towards learning promote interactive classroom relationships where active and constructive task completion contributes to cognitive engagement (Pieterinen, et al., 2014). Moreover, when combined with strategic and supportive teaching styles, students gain confidence in various learning methods, allowing them to reflect on and adapt these methodologies across different learning tasks.

A positive learning environment — whether social or academic — has also been shown to greatly influence students' sense of academic self-efficacy (Raufelder & Kulakow, 2021).

Often referred to as academic self-concept, this pertains to a student's belief in their capability to learn and achieve academic activities to a certain standard. Since academic self-efficacy mirrors a student's confidence in their abilities and demands conscious effort, it directly impacts a student's affective and cognitive engagement (Barlow, et al., 2020). More specifically, self-efficacy is recognized as a key variable that fosters cognitive and affective functions, thereby enhancing the ability to learn and perform well at school (Mohamad & Osman, 2017).

It is evident that several elements impact the performance of students in the realm of mathematics. These include teacher factors, school resources, and the students' socio-economic backgrounds, but also learners' self-efficacy, affective and cognitive engagement, and expectations and valuations of task success. However, the context of learning is "a changing system that includes all of the participants" (Eccles & Wigfield, 2020), and so cognisance needs to be taken of the environment in which learning occurs, and the role of experiences and perceptions of social interactions in these contexts. It is through understanding the interplay between these psychological determinants of performance we can make targeted interventions to enhance mathematics performance, particularly for those in lower socio-economic quintiles, and promote more equitable educational outcomes in South Africa.

This process is best summarised in Expectancy-Value Theory (EVT; Eccles & Wigfield, 2020) that predicts learning outcomes and goals to stem from learners' self-efficacy beliefs — or expectancies of success — and learners' interest in and sense of worthwhileness of learning tasks. In fact, EVT was first conceived to understand the educational choices of women, in particular self-selection out of STEM majors and careers. The most up-to-date version of EVT has been termed the Situated Expectancy-Value Theory (S-EVT; Eccles and Wigfield, 2020), and specifies learner self-efficacy, engagement, and task values to be situation-specific and culturally bound. Mathematics is notorious as a school subject that evokes a lack of confidence and strong feelings of incompetence and anxiety (Gellert, et al., 2001). Additionally, beliefs around mathematical ability, and subsequently interest in mathematics, tend to be based on prejudices associated with gender, ethnicity, and class. This makes the S-EVT framework most suited to an empirical analysis of differences between learners based on social identity factors of gender and socioeconomic class.

In this paper, we empirically explore how learners' personal and proximal motivational characteristics, as well as distal contextual factors — most notably students' experiences and perceptions of their teacher, learning environments and peers — interrelate to determine patterns of engagement and, subsequently, academic performance. A secondary aim is to examine differences in these relationships by gender group and school socio-economic status (SES). Data for grade 9 South African learners from the most recent (2019) wave of the Trends in Mathematics and Science Study (TIMSS) is employed together with structural equation modelling.

2. Conceptual Framework and Literature Review

2.1 Expectancy-Value Theory

One approach to the investigation of academic motivation, and how learners perceptions are intertemporally formed by personal and social factors, is the Eccles (1983) and Wigfield and Eccles (2000) Expectancy-Value Theory (EVT) of learner motivation, persistence, and achievement in learning. Here, expectancy refers to a learners perceived compentence within a particular domain — as it relates to their ability to successfully complete tasks with great skill and mastery — and value refers to an assessment of the task as worthwhile and/or interesting. In this sense, EVT assumes that the strength of a learner's belief about their own abilities is related to the objective they are trying to achieve, and also the value that they put on the task at hand (Meyer et al., 2019; Olivier, et al., 2019). In other words, a learner perceiving a positive outcome as a result of a particular task engagement would only be motivated to make the necessary efforts if they see a good reason to do so. Wigfield and Eccles (2000) describe this as having intrinstic value towards tasks, which overlaps with affective engagement that also include feelings of enjoyment and interest. EVT, therefore, draws a link between affective engagment and academic self-efficacy. Simply put, high expectancy beliefs that are accomodated by high task value, will reward the learner with positive emotional outcomes in the classroom.

The second assumption of EVT is that learners that are motivated to learn more, they put in more effort to learn and master the necessary skills. High motivation is only as strong as a learner's expectancy beliefs — their academic self-efficacy — and the task value leads to enhanced behavioural engagement as a result of a combined self-belief system and affect for learning (Meyer et al., 2019; Olivier, et al., 2019). EVT hypothesizes that if a learner places positive value in their learning, as well as find interest in completing tasks and feel confident that they can achieve the outcome required for the task, they are more likely to perform well in that task (Eccles, 1983; Wigfield & Eccles, 2000). This performance will not only be reflected in their achievement scores, but in an increased level of understanding of the work, and improved skill and knowledge of the content.

EVT further reasons that the components of expectancy and value most proximal to achievement and other learning goals emerge from an individual's interpretations of task settings, socialisation processes and situational experiences and influences (Wigfield & Eccles, 1992). Emanating from the work of Festinger (1954), theories of social cognitive processes — such as The-Big-Fish-Little-Pond effects (Marsh, 1986) — have shown processes of intra- and inter-personal comparison to be key determinants of competency beliefs, and that these are influenced by social contextual characteristics of classrooms and schools. The EVT model has, then, been recently adapted to measure the effect of task values and expectancy beliefs in the situations and moments in which these occur (Eccles & Wigfield, 2020).

The intention behind the extension of the EVT model to a situational EVT (S-EVT) model is to push researchers to start thinking about intra-individual motivational experiences, and how these differ between situations (Dietrich, et al., 2017; Eccles & Wigfield, 2020). S-EVT, for example, offers some insight into how teachers can create an environment where different types of learners are motivated to exert effort in a specific learning task (Dietrich, et al., 2017). In this way, S-EVT makes links between, for example, teacher engagement and learner affect towards learning, and how these reinforce a learner's subjective task value and expectancy for success. An interesting development model by Knogler et al. (2015) showed that environmental events had the effect of generating situational interest, and therefore it is possible that it can turn into long-term interest through the learners personal interest going beyond just task value, but also including stored knowledge of the subject area.

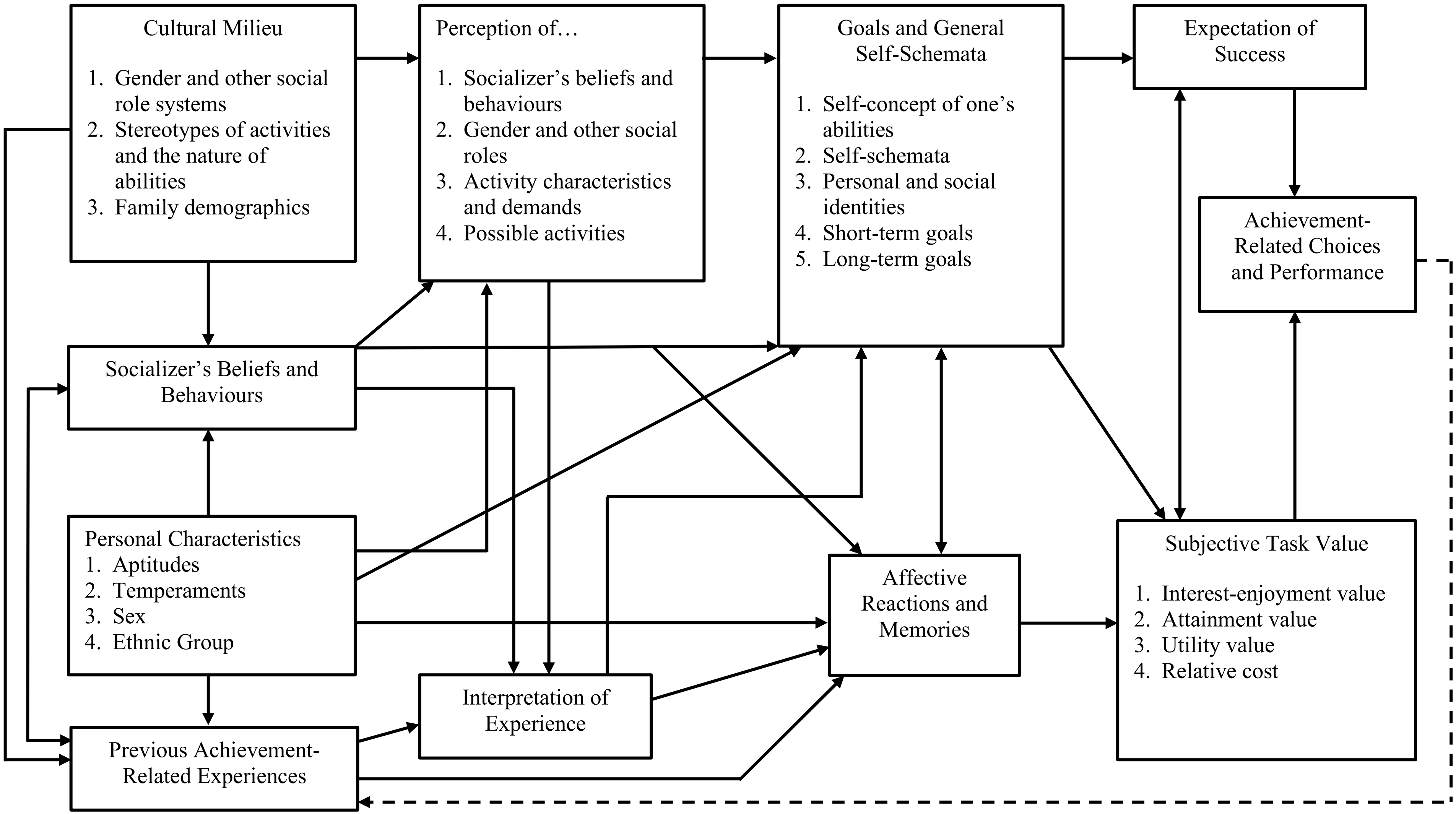
The most general version of the S-EVT model is represented in Figure 1. The right-hand side of the model deals with the conventional EVT cognitive processes proximal to achievement and achievement-related decisions — notably expectancies, self-schemas and affective responses. The 'situated' part of the model is informed by the far left and middle parts. Authors such as Dietrich et al. (2017) and Eccles and Wigfield (2020) describe, for example, the situational intrinsitive value in learning, where environmental factors including teacher-learner associations and social cognition processes affect the anticipated enjoyment in completing a task. The middle part of the model represents the social cognition processes — such as the perceptions and interpretations of others — and draws from, amongst others, Social Cognitive Theory (Bandura, 1977) and Attribution Theory (Weiner, 1985). These cognition processes are represented as the mediators of learners' experiences on self-concepts and task perceptions (Eccles, 1983), including the social contextual characteristics of schools, classrooms and family backgrounds. As stated by Eccles and Wigfield (2020), the development of this framework is meant to be as general as possible; that is, the examples included are not meant to be exhaustive, nor is it implied that they would be necessarily relevant in all contexts and at all time points. Furthermore, the relative influence of each construct in the model is expected to depend on contextual, individual differences, and by contextual processes. The remainder of this chapter focuses on unpacking the literature — and existing evidence— of the various parts of the model that will be incorporated in the present study.

2.2 Academic Self-Efficacy

At the offset, it is important to note that the interchangable use of academic self-efficacy and academic self-concept in the literature often makes their conceptual distinctness unclear. Academic self-efficacy refers to the beliefs that a learner holds about their abilities to learn and perform tasks with mastery and skill (Schunk & Mullen, 2012). This represents one part of academic self-concept, which also incorporates an affective component alongside self-evaluated competence, specifically feelings of self-worth (Pajares & Schunk, 2006).

The literature has shown self-efficacy to be a crucial determinant of learning and, subsequently, academic achievement. As described by Deci and Ryan (2000) and Connell (1990), the conceptualisation of self-efficacy requires that the learner also has the knowledge to perform the task with a regulated strategy of their own to reach an outcome. The process of developing self-efficacy is extended by the work of Möller et al. (2020) and Wolff et al. (2021) that states that learners can build confidence in their academic abilities in a three-step comparison process. Firstly, learners develop self-efficacy through a dimensional comparison process, where they compare their own individual achievements across different subject areas. The second comparison process is a social comparison process, where learners reaffirm their abilities by comparing how well they are doing in a social context by comparing themselves to their peers. Finally, learners check how far they have come in their learning, understanding and mastery of the work content over time, which Möller et al. (2020) and Wolff et al. (2021) refer to as a temporal comparison. These comparisons not only develop a learners academic self-efficacy, but also reinforce it through enhanced academic achievement (Wolff et al., 2021).

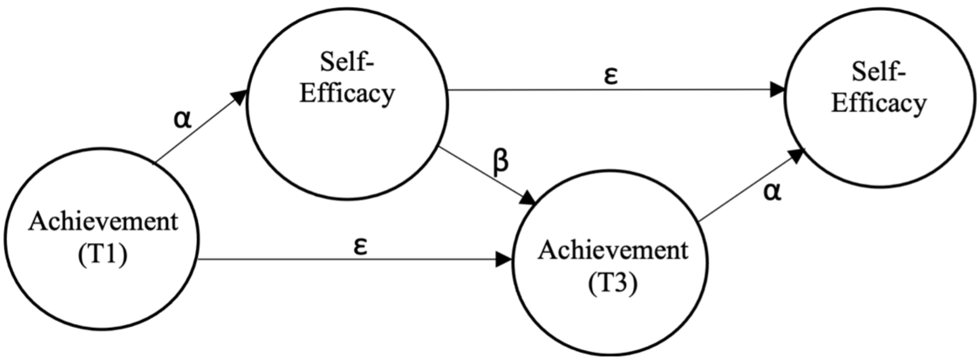
Figure 1: Eccles Situated Expectancy Value Model of Achievement Choices



Source: Eccles and Wigfield (2020)

This process is summarised in Figure 2, which illustrates the mutually reinforcing nature of academic self-efficacy and academic achievement. Specifically, the skills development effect represented by path coefficient α indicated the positive effect of academic achievement on academic self-efficacy. The reverse is also true through the self-enhancement effect, represented by path coefficient β, whereby academic self-efficacy allows for enhanced learning outcomes. A learner is also able to rebuild their own self-efficacy in a continual cycle, by re-affirming their own beliefs about their capabilities in school. This, according to Wolff et al. (2021), occurs through the autoregressive effects, ε, and the within-subject autoregressive effects are typically found to be stronger than the self-enhancement effects. This result helps to explain, for example, the paradoxical finding that learners from vulnerable contexts tend to rate their self-efficacy quite high in spite of relatively low levels of achievement.

Figure 2: The Reciprocal Effects Model



Source: Marsh and Craven (2006)

Notes: Path labels refer to: α = skill-development effects; β = self-enhancement effect; and ε = autoregressive effects. T = Time.

Socio-economic imbalances and access to learning resources influence the educational outcomes of learners, particularly in low and middle income countries such as South Africa (Visser et al., 2015; Juan, et al., 2018). Schunk and Pajares (2002) and Fan and Williams (2010), for example, found the association between parental involvement and academic self-efficacy to vary with socioeconomic status. Parents from higher SES households were found to be better equipped to be involved in their children's school activities, as well as provided their children with an environment that encourage mastery skills that help learners cope with learning challenges and develop persistence in tasks. Learners that attend schools with peers from higher SES families also outperform their peers from schools with a lower concentration of wealth, primarily because of improved access to resources (Özdemir et al., 2014; Sun, et al., 2012), include books, social capital — in the form of supportive relationships from parents and the school — and computers. In the case of South Africa, Juan et al. (2018) found higher levels of SES among grade 9 learners to be associated with positive attitudes about science. The authors argue that parents who were more educated, and from higher SES backgrounds, were more involved in their children's learning, and the interaction of these factors was — next to classroom experiences and skills development — the third largest positive predictor of learners' self-efficacy.

Girls generally show greater anxiety about their abilities to do well in STEM subjects, yet report higher levels of confidence in their abilities to manage their learning (Britner & Pajares, 2006; Gor et al., 2020; Zander et al., 2020). This could be one of the reasons why the gender gap in performance in STEM subjects has narrowed in recent times. Girls show better mastery in their confidence to persist in tasks and complete them, while boys only possess a higher sense of confidence to do well in the tasks. Gor et al. (2020) find evidence pointing to this among secondary school students in Migori County, Kenya, in a science class. In a qualitative research study by Motsa (2018) on vulnerable feminities, the authors argue that the socioeconomic contexts of Swaziland's schooling sector deprived girls from vulnerable contexts of their self-efficacy. This leads to poor school performance, and subjects girls to gender stereotyped roles through access to particular types of post-secondary education. A similar situation is observed by Juan et al. (2018) in South African schools, where girls were less likely to have confidence in their ability to learn science when controlling for socioeconomic status, the skills development effect and classroom experience.

2.3 Affective Engagement

Social Cognitive Theory (SCT, Bandura, 1986) argues that a learner's judgements about their competencies are important determinants of their persistence, efforts, and emotional reactions. Specifically, SCT is based on three reciprocally interacting domains: the individual, their behaviour, and the environment. In this framework, self-efficacy — discussed in the previous section — is a key factor influencing emotional and behavioural engagement (Lam, et al., 2012). Emotions play a significant role in how learners engage, perform, and respond to learning instructions — both inside and outside of the classroom. Emotions highlight a learner's level of interest in and enjoyment of tasks, and can explain the type of value (i.e., positive or negative) a learner places on their own learning (Cardwell, 2011; Wara et al., 2018; Nazamud-din, et al., 2020).

To increase learners' affective engagement in the classroom and at school, it is essential that the learning environment encourages positive situational interest that could develop into longer-term interest (Eccles & Wigfield, 2020). This, as described by the self-determination theoretical framework, encourages a greater sense of belonging (Wang & Holcombe, 2010). It is hypothesised that affective engagement, higher functioning, and greater academic performance is achieved when perceptions and experiences of the school environment encourage feelings of competence, autonomy, and relatedness with others (Deci & Ryan, 1985; Wang & Holcombe, 2010; Eccles & Wigfield, 2020). Learner autonomy in this regard refers to a feeling that they are included in the decision-making process of what is taught and the preferred method of instruction, making them feel valued in the school community (Wang & Holcombe, 2010; Han, 2021). Therefore, meeting the autonomous psychological needs of learners and enhancing their sense of competency encourages relatedness, participation, and school identification.

Additionally, if affect is not foundational to a learner's academic goals, then disengagement from learning will challenge their functioning and self-regulations skills: it becomes difficult for them to plan, remember, or focus in areas in which they need to learn and equip themselves with important skills. Mastery goal orientation as a measure of higher functioning has received much attention in the empirical literature. Pathway analyses of the effects of competency and mastery goals promotion on academic achievement by Yeung et al. (2014) and Wang and Holcombe (2010), for example, have found a significant effect of participation and school identification on achievement mediated through mastery orientation.

In a developing country context, Wara et al. (2018) found a sense of safety and autonomy, as well as a positive classroom environment, to enhance academic achievement through the pathway of affective egnagement. Empirical research has also indicated a role for teacher engagement in determining learners' affective engagement (Cardwell, 2011; Olasehinde-Williams et al., 2018; Wang, et al., 2022). Encouraging peer-to-peer discussions, for example, allows learners to satisfy their social needs, and boost relatedness with peers in the classroom (Hughes & Chen, 2011; Henderson, 2019). Moreover, classroom discussions can promote metacognitive reflection in learning through allowing learners to collaborate, share ideas, and challenge one another's views on subject content. Moving from passive to active learning, and providing the space for autonomy and emotional regulation, contributes to learners' enhanced identification with their school (Wang & Holcombe, 2010; Han, 2021).

One of the main findings in global research about girls socialisation process in school shows that girls engage in more relational practices in school than boys, and that they have higher interest in finding meaningful and nurturing relationships than do boys (Nichols & Good, 1998; Galambos, 2004). Girls are more likely to form healthy relationships with and attitudes towards their teachers, which enhances their sense of school belonging. This is illustrated by Arends and Visser (2019) in their study of the contribution of South African teachers to student' sense of belonging and mathematics achievement. Another interesting study by Sanchez et al. (2005) researching the role of sense of school belonging and gender in the academic adjustment of Latino adolescents found no significant differences between boys' and girls' sense of belonging across different socioeconomic scales. The authors make an argument of how the Latino culture encapsulates collectivist ideals, even across different social classes. It may appear that a sense of relatedness is important for the success of the Latino culture (Sanchez, et al., 2005). However, in South Africa where some cultures may share similar values as those in the Latino case, the social inequalities have a parallel effect on learners affective engagement in school, and subsequently their performance at school. Taylor and Yu (2009) and Isdale et al. (2019) demonstrate that home SES plays a significant role in learners' sense of belonging in South African schools. Specifically, learners that score high on mathematics or language assessments are likely to come from more affluent households, and attend schools with adequate resources where learners feel safe, collaboration among peers and teachers is encouraged, and a greater sense of school belonging emerges.

2.4 Expectancy and Task Value

Eccles (1983) hypothesised that the most proximal psychological determinants of academic performance are a learner's self-efficacy, expectancies for success, and subjective task values. These variables were originally entered into regression analyses as a single construct of self-concept, which arguably may have limited the attention given to the interrelationships and influence of each on learning outcomes in earlier empirical work. It is since held that the development of a learner's self-regulation strategies can be encouraged through a mediated effect vis-à-vis academic self-efficacy. Specifically, academic self-efficacy is a reinforcement tool for a learner that encourages goal setting, and the development of further strategies to achieve those goals. Eccles (1986) defined these ability beliefs as a learner's expectations for achievement — or expectancies of success — and have been found to be directly linked to achievement choices and performance (Eccles, 1983; Eccles, 2007; Eccles & Wigfield, 2020).

Galungu (2019) suggests that these expectancies are also linked to increased learner engagement in the learning process, especially at the school level: through self-regulated strategies, learners with higher levels of academic self-concept can link their performance to effort, rather than to confidence in their ability. Furthermore, these learners can identify their weaknesses and strengths, and subsequently strategise how to improve their skills and engagement in the classroom.

Based on the original expectancy-value achievement motivation model of Atkinson (1957), EVT recognises the interaction between self-efficacy and task value constructs, but further develops the latter as subjective and divided into the different components of intrinsic value, attainment value, utility value, and cost (Eccles, 1984). Intrinsic subjective task value is defined as the enjoyment that a learner benefits from doing in a task, which is similar to intrinsic motivation referred to by Ryan and Deci (2016). Utility subjective task value is conceptualised as the perceived usefulness that a task holds for a learner's present and/or future plans. Ryan and Deci (2016) argue that if a learners subjective task value in a learning area is directly linked to its utility value for them, then learning is a means to an end rather than an end in itself. There is an overlap between the utility and the attainment value of a task, as utility value can correspond to personal and social identity-based goals. Finally, task costs include things like the cost of effort, the opportunity cost of choosing one task over another, and the emotional cost of, for example, task-induced anxiety and the social cost of failure (Eccles & Wigfield, 2020). Many authors describe the absence of utility and intrinsic task values in learners as indicating a perception of a high cost of engagement (e.g. Wigfield et al., 2017; Eccles and Wigfield, 2020).

Multiple studies support the global validity of EVT, specifically those by Gaspard et al. (2015) and Song et al. (2015) that examined the longitundinal effects of learners' expectancies and value beliefs on their mathematics achievement. The latter study found constructs describing expectancy beliefs and value systems to significantly predict performance in mathematics, while the former study showed that the development of expectancy and task value beliefs in earlier grades significantly impact performance in later grades. These studies, among others, provide empirical support for the core postulates of EVT, suggesting that students' beliefs about their capabilities (expectancies) and the importance they attach to tasks (values) are significant predictors of their academic achievement.

In addition to the above findings, EVT has been well illustrated in path analyses showing the effect of academic self-efficacy on performance, and how it is meditated through other engagement constructs, specifically cognitive engagement. For example, the study of Hayat et al. (2020) adopted path analysis to show that academic self-efficacy has a direct effect on academic performance and other meta-constructs such as emotional engagement and metacognitive learning strategies, and that the latter were significant mediators of the relationship between academic self-efficacy and performance. The path-model estimated that 30 percent of the variation in academic success was explained by emotional engagement, metacognitive learning, and affective engagement, and that 40 percent and 43 percent of the variation in metacognitive learning strategies and positive emotional engagement, respectively, were explained by academic self-efficacy.

Research that has investigated the learning strategies adopted by learners has been linked to intrinsic and utility subjective task value. Learning strategies involve cognitive and metacognitive strategies (Bircan & Sungur, 2016), where cognitive learning strategies are those that allow learners to better process information and think deeply about it, while at the same time building a capacity of retained knowledge (Chi & Wylie, 2014; Wiggins, et al., 2017; Henderson, 2019; Lim, et al., 2019), and metacognitive strategies involve strategies that make learners aware of their thinking process and allows them to take control of their learning (Akyol et al., 2010; Hayat et al., 2020). The study by Akyol et al. (2010) researching the direct link between cognitive engagement and achievement found that cognitive and, to a larger extent, metacognitive strategy use significantly predicted seventh-graders performance in science classes. According to Bircan and Sungur (2016), metacognitive strategies involve elements of monitoring (i.e, continuously updating one's level of understanding during task completion), planning (i.e. preparing for the subject content that the learner is going to engage with), and regulation (i.e. re-attempting content that were not well understood). Both cognitive and metacognitive strategies require that a learner applies a deep learning approach as opposed to a shallow one, where the former signals that a learner can critically evaluate their learning and successfully identify connections across different learning areas (Csikszentmihalyi, 1997; Sedaghat et al., 2011).

Learners that can implement cognitive and metacognitive strategies during their learning process show signs of having a higher investment in their education, which is a consequence of having greater task value for learning (Goto, 2023). These learners are more likely to be able to relish any challenges that come with learning, by applying greater effort and persistence through the learning process. EVT, then, posits that a learner with high intrinsic and utility task value is likely to be applying a deep approach learning strategy (Eccles & Wigfield, 2020; Goto, 2023). Conversely, learners that display shallow levels of cognitive engagement are mostly concerned with not repeating a grade and avoiding failure in an assessment. However, it is worth noting that although shallow learning strategies tend to be associated with rote memory engagement, it does not imply that the learners do not understand the work (Sedaghat et al., 2011; Sani & Hashim, 2016).

According to Goto (2023), although learners are highly motivated at the initial stages of learning, this motivation slowly declines. However, it can be sustained through related motivational goals and being able to self-regulate during the learning process. Having academic goals allows learners to expand their effort and spend time to understand and deeply process the subject content to further master any difficult skills that the learner may be struggling with (Fredricks et al., 2004; Ravindran et al., 2005; Rotgans & Schmidt, 2010). Academic goals are defined by the learner's subjective task value for learning, including intrinsic and utility value. Additionally, learners can improve their cognitive skills through self-regulation by managing and organising their thought processing and transforming those thoughts into skills that they would need to use during learning (Zimmerman, 1990). Qualitative research by Gamage et al. (2021) on the effect of personal values on learning approaches found a deep learning approach to learning to be associated with alturistic life goals. Learners with these types of goals and self-direction are concerned with how their effort and engagement impacts society and others, and points to having interest and finding usefulness of engagement. Gamage et al. (2021) further argued that a shallow learning approach is linked to more hedonistic life goals, and any knowledge gained tends to be only temporarily retained. Numerous empirical evidence has reported deep learning strategies to be associated with higher academic achievement (Sedaghat et al., 2011; Gašević et al,, 2017; Gamage et al., 2021). Related to this are differences in individuals' hierarchies of academic self-concept and task values that explain why learners might choose certain tasks (Eccles, 2005). These hierarchies will be informed not only by previous task successes and/or failures, but also on socializer (i.e., teachers and peers) behaviours and opinions around, for example, the social identity groups they belong to.

2.5 Situated and Culturally Based EVT

The relationship between academic self-efficacy and learner engagement was initially thought to be disconnected from situational experiences (Linnenbrink & Pintrich, 2003). However, it is now accepted that learners motivational and competency beliefs can change with each learning situation (Dietrich et al., 2017; Trautwein et al., 2009; Malmberg et al., 2013). According to Dietrich et al. (2017) and Eccles and Wigfield (2020), motivation is associated with the extent to which a task in a classroom is structured by the teacher and whether it involves social interaction with other peers, vis-à-vis learning situation. For example, instrumental assistance seeking from peers and teachers, as well as task persistence can be indicators of subjective task value (Meyer et al., 2019). Heller et al. (2003) and Akey (2006) report that teachers who are able to link the information taught to real life situations — such as personal concerns and interests of learner — can enhance engagement in the classroom, and subsequently positively influence the learning outcomes of learners.

Although teacher engagement can account for the improvement in learner academic achievement, Wang et al. (2022) shows that teacher engagement alone cannot directly account for greater achievement but rather, it is mediated by development of psychological factors from the learner's side. Chong et al. (2018), for example, shows how a learner's interaction with different levels of support in their primal environments of learning can configure their development process and reinforce their beliefs about their learning capabilities. The work of Wang and Eccles (2013) on school context has also focused on the school and classroom characteristics that support learner self-efficacy and relatedness, and augmented task engagement, and shown that learners who can establish a link between positive learning-related emotions, utility task value and improved academic achievement are more likely to have a higher sense of academic self-concept.

Critical to the development of learning trajectories and self-belief construction is how teachers influence learner's self-efficacy by adapting and adjusting their classroom environment and mode of instruction, and how they encourage and reinforce learners' educational goals (Shunk & Mullen, 2012). Incorporated into a situated EVT model, then, is the role that the teacher plays at a social level — encouraging learner goals and aspirations — but also at the student level by way of understanding the learning needs of different students (Ding et al., 2013; Dietrich et al., 2017). A positive teacher-learner relationship can be accomplished by allowing sufficient time and opportunity for learners to engage within the classroom environment actively and socially, as well as allowing learners to respond and query instructed material during classroom instruction. Providing opportunities for peer collaboration can also make learners feel seen at school and enhance their competency beliefs (Al-Bashir et al., 2016).

Reeve (2013) and Lei et al. (2018) have suggested that augmented educational outcomes are a consequence of peer-to-peer and teacher-to-learner interactions in the classroom. Specifically, learners can gauge how well they have mastered the learning outcomes of the subject through responding to questions in the class, being able to ask questions of clarification, and collaborating with peers. Classroom-based relationships satisfy the learners need for peer relatedness — sometimes referred to as social connectedness in school — which has been shown to have positive effects on emotional engagement and building stable expectancy beliefs (Wentzel, 2003; Wang & Eccles, 2013). It is also likely that learners receive some form of assurance in their capabilities and grow to enjoy school when other learners acknowledge their academic performance (Edwards & Taasoobshirazi, 2022).

Learners' subjective views on a teacher's role in the classroom can also influence their motivation, engagement and academic success (Rosenzweig et al., 2019). Learners perceive an engaged and supportive teacher as one showing an expression of warmth towards the learners in the classroom, easy to understand and also providing resources over and above those provided at the school level (see, Marchand & Gutierrez, 2017; Ayllon et al., 2019; Valdes et al., 2021). Perceptions of an emotionally supportive and caring teacher leads to higher intrinsic task value, as learners are able to demonstrate interest and enjoyment towards their learning if they are able to express themselves (Wang & Eccles, 2013). Learners are also able to feel a sense of independence and find usefulness in task engagement if they are made to feel that fulfilling tasks at school allows them to satisfy their personal goals and provides them with the chance for self-exploration (Finn & Voelkl, 1993; Roeser et al., 1998). Wang et al. (2022), for example, showed that percieved teacher engagement had a significant indirect effect on English achievement through autonomous motivation and enjoyment. Wang and Eccles (2013) similarly found teacher involvement to be a significant predictor of expectancy beliefs and subjective task values for 7th and 8th grade learners in a public middle school in Washington D.C.

The impact of task values on cognitive functioning and academic achievement was explored in a study by Sani and Hashim (2016). Their research highlights that learners expressing higher task values tend to exhibit deeper cognitive processing, leading to better academic performance. The authors further found that this phenomenon is particularly pronounced among male students in Grades 9 and 10 when compared to female students, and students in Grade 8. The study findings suggest that male learners engage more intensely with the subject material at hand, as is evidenced in their active participation through questioning, collaboration with peers, and independent analysis. In England, the Department for Education (2019) found that girls on average scored higher average A-Level grades, while a higher proportion of boys achieved top grades.

As argued by Kessels et al. (2014), learners appear to align their interests and perceived usefulness of school and learning in accordance with their identity, including gender. It appears that, for boys, identity clashes with elements of subjective task value — such as showing effort and commitment to school and learning — because they may perceive the whole process of learning as feminine. Although evidence for this phenomenon remains scarce, Heyder and Kessels (2017) developed a test that revealed an implicit bias amongst learners that school is more associated with girls than with boys. Additionally, there is a masculine aspect to boys' self-concept that is associated with learning; specifically, the higher boys scored on negative masculinity (.i.e., not seeking help, not following school rules, and showing 'laddish behaviour'), the more it affected their academic engagement (Kessels et al., 2014). Engaging in school for boys, then, comes as an opportunity cost, which could explain the low levels of academic success when compared to girls.

Stereotype threat emerges when individuals from specific social categories — such as gender, ethnic or race groups — face the anxiety of knowing one is a potential target of prejudice and stereotypes experience, leading to social pressure and apprehension of validating detrimental stereotypes associated with these groups (Steele & Aronson, 1995; Steele, 1997). For example, there may be a widely held belief that black students exhibit inferior academic capabilities when compared to their white and Asian counterparts, and similarly for gender where it is often asserted that boys outperform girls in STEM subjects (Jacobs et al., 2006; Evans et al., 2011). Research additionally indicates that society often links notions of limited aptitude with black boys when compared to other genders and ethnicities (Cunningham, 1999; Hudley & Graham, 2001). These students are frequently (and unfairly) perceived to be underachievers (Kessels et al., 2014).

Being conscious of and succumbing to these stereotypes can be detrimental for learners' academic performance and their involvement in school activities. In contrast to 'high status' groups that aren't subjected to these negative stereotypes, those who face these challenges are compelled to invest greater effort to surmount these obstacles and excel in academics. Steele (1990) finds that a lifetime of exposure to negative ability perceptions in society, can lead learners belonging to so-called 'low status' and stigmatised groups to internalize these perceptions, contributing to a higher probability of poor life success. Boys from low socioeconomic backgrounds, for example, may consign themselves to low-skilled employment, perpetuating stereotypes that diminish the academic potential of male students in the classroom, and consequentially hampering their engagement.

Effective communication of subject knowledge by teachers can mediate self-efficacy and enhance learning outcomes, as indicated by Sharp et al. (2016). This relationship is shown in the context of elementary education, where teachers' expertise in their subjects positively influences students with a strong academic self-efficacy. Olasehinde-Williams et al. (2018) further underscore the pivotal role of teachers' qualifications in learner performance, demonstrating that those with subject-specific qualifications demonstrate superior instructional skills and engagement in the classroom. This, in turn, yields markedly improved academic performance among students, as evidenced by a 26 percentage point difference compared to teachers with a teaching degree lacking subject speciality.

Shepherd (2015) makes a case for South African schools, where there exists a strong association between high quality teaching and teaching in the wealthier subset of schools (quintile 4 and 5). Darling-Hammond (2001), from her chapter on the inequalities of teaching and schooling for students of colour in America, draws several inferences on the effect of teacher certification on learners' mathematics scores, and where high quality teachers are likely to be found in the American school system. The author finds that teachers certified in teaching algebra as opposed to general mathematics, had a larger positive impact on the learning outcomes of their learners. Furthermore, high quality teachers — considered those teachers that go through a pre-service training — are more likely to be found in high-income communities in American schools.

Research has shown that teacher engagement and support can help bridge the educational divide between students grappling with intrinsic and extrinsic learning challenges, and those who already holding an advantage. By creating an inclusive learning environment, teachers are able to continuously identify and minimise the barriers to learning that emerge from the diversity of learner experience within a classroom (Ntombela, 2011). One strategy that teachers can employ to accommodate the diverse learning needs of their learners is to identify and develop interventions and remedial tools that meet the diverse learning requirements of their learners without straying too far from the formal learning schedule (Skae, et al., 2020). A report by the Center for Teaching Quality (CTQ) found that collaborative teaching networks where teachers add value to one anothers knowledge base, can improve teaching and learning effectiveness in the classroom (Berry et al., 2009). Surveys of teachers from high-needs schools in North Carolina found that over three quarters of teachers who were part of these networks reported being able to improve their teaching and gain knowledge and skills to accommodate the different needs of learners in their classroom in the face of increasing class sizes (Berry, et al., 2009).

Situational influences can exert a considerable impact on academic motivation and performance, as set forth by Midgley et al. (2001), Turner et al. (2002), Rimm-Kaufman et al. (2009), and Pekrun and Stephens (2010). These authors contend that contextual factors, including classroom environment and task significance, play an important role in shaping learners' motivation and engagement. Notably, a classroom environment that emphasises mastery-oriented learning and understanding fosters higher levels of engagement and academic motivation when compared to environments that prioritise performance. The latter can inadvertently intimidate learners, leading to a loss of interest in learnng. An implication of this could be poor performance when it comes to application of content knowledge in tasks. However, certain school subjects may be reflected in a learners personal goals that they have come to hold very deeply. This is most likely relevant for learners from socio-economically vulnerable contexts, who are seeking to complete school and see achievements in certain subjects as part of the goal towards attaining a certain occupation in the future. This can be referred to as situational utility value, where the benefits of task completion or doing well in a subject is linked to a learner's personal goals and sense of self. Forming ties with attainment value can, then, either reinforce expectancy beliefs — proxied by academic self-concept in many studies — or damage a learner's capability beliefs.

2.6 Existing evidence for South Africa

Using the TIMSS 2015 and 2019 data for South Africa, Juan et al. (2018) and Fadiji and Reddy (2021, 2023) explore the interplay of self-efficacy and academic performance in science and mathematics, making use of the TIMSS dataset. Accounting for contextual variables — such as home resources, school climate, parental involvement, instructional clarity, and gender —

the findings of these studies underscore a significant positive association between self-efficacy and academic achievement. Notably, higher levels of socioeconomic status (SES) augment the role of learner self-efficacy. Juan et al. (2018) stress the significance of fostering positive classroom interactions and parental involvement, particularly for learners from lower SES backgrounds given their majority representation amongst learners in the South African context.

A positive school climate further emerges as a significant predictor of educational aspirations among grade nine South African learners. Fadiji and Reddy (2021) argue that this connection stems from the positive psychological impact of social interactions and a robust sense of school belonging, motivating learners to aspire to higher educational achievements. Alongside a positive school climate, the quality of the teacher-learner engagement in the classroom also surfaces as a significant predictor of learners' self-efficacy. Teachers wield the influence to instill positive attitudes and learning behaviors in students, recognizing the substantial time learners spend in school and the reliance on external judgments to shape their perceptions of their abilities and self-worth (Juan et al., 2018; Fadiji & Reddy, 2023).

Despite recent strides in narrowing the gender gap in mathematics achievement at secondary school level[4] — even across all school quintiles with negligible differences in quintile 5 schools – Shepherd (2017) and Rühle (2022) observe a persistent pro-male gender gap in students' confidence in mathematics. The study of Juan et al. (2018) similarly identifies girls to report lower levels of self-efficacy than boys even in science learning, controlling for home SES and classroom experiences. Although there has been much emphasis paid to whether a gender gap in mathematics performance exists in South Africa, investigations of the influence of self-schemata — as determined by social experiences and behaviors — and the subsequent effects on confidence-building in the learning process have been largely missing. This gap is addressed in this study through the utilization of the Situated Expectancy Value framework (S-EVT), as discussed earlier.

2.7 The Present Study

We propose filling the gap in existing empirical literature in the South African context regarding gender and socio-economic differences in the influence of cognitive and psychological influences on mathematics performance. Specifically, we use the Situated

[4] A pro-girl gap emerges for samples of primary school-aged learners in South Africa (see, for example, Spaull & Makaluza, 2019).

Expectancy Value framework to examine the structural relations among the learning situation variables, motivation-for-learning dimensions of self-efficacy, engagement and task-value, and mathematics achievement. The conceptual model for testing the relationships between situational context, self-efficacy and engagement on mathematics achievement is summarised in Figure 3.

In general, we expect higher student motivation as measured by positive self-efficacy, affective engagement, and intrinsic and utility task values to be associated with higher mathematics scores. However, in recognising the complex nature of self-belief formation and the influence of social and contextual factors on self-efficacy beliefs and subjective task-values, the model will be estimated separately by learner gender and school socioeconomic groups. This will assist in answering questions of the type:

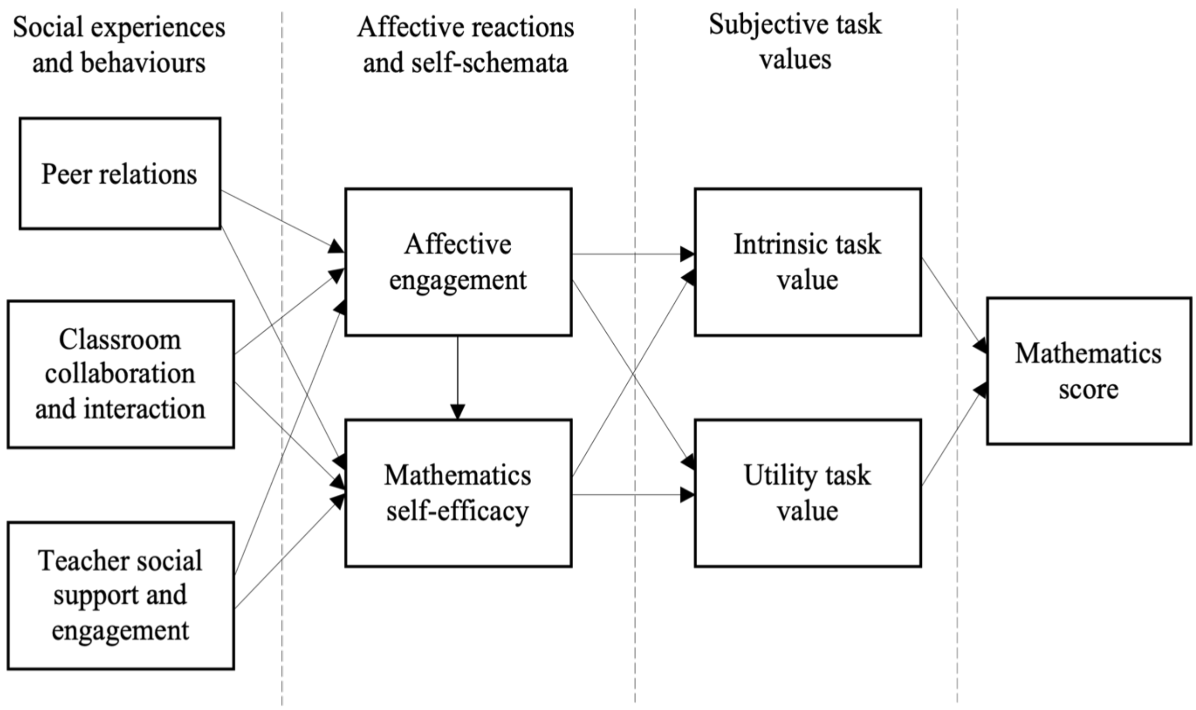
1. How do self-efficacy and affective engagement mediate between the learning environment and students' subjective task values, and how does this differ by learner gender, controlling for socioeconomic context?
2. How do self-efficacy and affective engagement mediate between the learning environment and students' subjective task values, and how does this differ by socioeconomic context, controlling for gender?
3. How do subjective task values mediate between student self-efficacy, affective engagement, and mathematics performance, and how does this differ by learner gender, controlling for socioeconomic context?
4. How do subjective task values mediate between student self-efficacy, affective engagement, and mathematics performance, and how does this differ by socioeconomic context, controlling for gender?

3. Data and Method

3.1 Data

Conducted every four years since 1995, the Trends in International Mathematics and Science Study (TIMSS) is an international study developed by the International Association for the Evaluation of Educational Achievement (IEA) and managed by the TIMSS and PIRLS International Study Centre. TIMSS aims to provide a detailed picture of performance in mathematics and science across countries and over time, using nationally representative samples of grade four and grade eight learners and their schools. This study makes use of the most recent (seventh) wave of TIMSS conducted in 2019.

Figure 3: Conceptual model



Note: Gender and socioeconomic status (SES) are not shown, but enter the model as antecedents to peer relations, classroom collaboration and interaction, and teacher social support and engagement.

The full TIMSS assessment comprises a large set of test items that are packaged into clusters and alternated across 14 assessment booklets that are then distributed amongst learners. This means that each learner writes one of 14 possible tests. Cross-time comparisons are made possible through the inclusion of trend items. Item Response Theory (IRT) scaling it used to obtain accurate measures of proficiency in mathematics that are comparable over time, and five plausible values are estimated for each student.

Sampling is conducted using a two-stage stratified cluster design: first, schools are randomly selected using probability-proportional-to-size sampling, following which a single intact grade 9 class is randomly selected from all possible grade 9 classes in a selected school. In the 2019 wave of TIMSS, achievement and contextual data in South Africa were collected from 20 829 grade nine learners taught in 519 schools by 543 mathematics and science teachers. This represents a larger sample compared to previous rounds, as the Gauteng and Western Cape provinces participated as 'benchmarking participants'. This meant that whilst the usual 30 schools were sampled from the remaining seven provinces, 150 schools each were sampled from Gauteng and the Western Cape. Sample weights are provided in the TIMSS data so that data from each province makes an appropriately sized contribution to the overall national performance.

Contextual and background data is collected through questionnaires administered to teachers, learners, and schools. Responses to these questionnaires provide detailed information about the learning and teaching contexts that learners are exposed to and, therefore, the determinants of mathematics and science achievement. Nationally adapted versions of these contextual questionnaires are provided. Most important for this study are questions referring to the school and classroom climate for learning, and learner perceptions and attitudes towards mathematics and science.

3.2 Measures and Constructs

3.2.1 Expectancy-value and situational constructs

The situational expectancy-value constructs were selected from the learner questionnaire. All items — aside from peer relations — were coded on a four-point Likert scale, with 1 indicating "Agree a lot" and 4 indicating "Disagree a lot". For the purposes of this study, reverse-scoring was adopted so that higher values represent more favourable perceptions and attitudes. Items referring to interactions with other learners at the school were coded on a four-point Likert scale with 1 indicating "At least once a week", 2 indicating "Once or twice a month", 3 indicating "A few times a year", and 4 indicating "Never". See Table A1 of Appendix for more detail regarding the items used.

The reliability of each construct is determined by observing the Cronbach's alpha value that measures the internal consistency of respondents' answers. For example, a learner agreeing that they know what is expected of them in the classroom by their teacher is expected to also agree that their teacher is easy to understand. An alpha value of 0.7 or greater is taken as suitable. Table 1 indicates the Cronbach alpha values for each construct determined from the full sample of learners, and separately by school socio-economic quintile.

Mathematics Self-Efficacy (**MSE**) refers to the learner's general beliefs and perceptions about their capabilities in mathematics (e.g., "I usually do well in mathematics"), as it corresponds to expectancy of success. It is measured using seven items (see Table A1 of the Appendix). Three of the seven items were reverse scored (contra-positive statements, e.g. "Mathematics is not one of my strengths"). Internal consistency between items was suitably high at $\alpha = 0.771$.

Affective Engagement (**AE**) refers to the learner's experiences and perceptions of belonging and relationships at the school (e.g., "I like being in school"). It is measured using five items (see Table A1 of the Appendix). All items were reverse scored prior to analysis. Internal consistency between items was suitably high at $\alpha = 0.704$.

Intrinsic Task Value (**IV**) refers to interest in and the enjoyment of engaging in an activity (e.g., "I learn many interesting things in mathematics") and holds some overlap with affective engagement. It is measured using nine items (see Table A1 of the Appendix). Two of the items were reverse scored (contra-positive statements, e.g. "Mathematics is boring"). Internal consistency between items was suitably high at $\alpha = 0.897$.

Utility Task Value (**UV**) refers to how an activity fits within a learner's future plans and objectives (e.g., "I need mathematics to learn other school subjects"). This overlaps with cognitive engagement, as a learner who reasons that their engagement with a task will lead to some positive outcome that brings value and is of importance to them, will make more effort in that task. It is measured using nine items, none of which were reverse scored (see Table A1 of the Appendix). Internal consistency between items was suitably high at $\alpha = 0.835$.

Teacher social support and engagement (**TSSE**) are measured using statements relating to a student's perceptions of the supportive and engaging practices adopted by their teacher in the mathematics lessons (e.g., "I know what my teacher expects me to do" and "My teacher does a variety of things to help us learn"). All seven items were reverse scored (see Table A1 of the Appendix). Internal consistency between items was suitably high at $\alpha = 0.837$.

Classroom collaboration and interaction (**CCI**) is measured using statements relating to a student's perceptions of the level and quality of cooperation in the classroom (e.g., "Students don't listen to what the teacher says"; see Table A1 of the Appendix). Internal consistency between items was suitably high at $\alpha = 0.822$.

Peer relations (PR) in the context of school learners refer to the interactions and relationships that students have with their classmates or peers within the school setting. It encompasses the social interactions, friendships, and group dynamics that develop among students as they interact with one another on a regular basis (e.g., "other learners have excluded me from their group"). The internal consistency between the items was also suitably high at $\alpha = 0.844$.

All measures above are z-scored to have a mean of zero and a standard deviation of 1.

3.2.2 Dependent variable and other controls

The outcome of interest for this study is mathematics achievement as measured by a learner's score on the TIMSS standardised mathematics assessment. Given known issues with taking the average of the plausible values (Martin et al., 2020), all five plausible values are used in the analysis. Considering the theoretical and empirical evidence, the analysis also includes controls for learner gender and socio-economic status, as well as school socioeconomic quintile. See Table A2 of the Appendix for more detail regarding these variables.

Gender (**GIRL**) is coded as a binary variable (1 = female, 0 = male).

Socio-economic status (**SES**) at the learner level is measured using responses to nine items that refer to access to possessions and services at home: computer/tablet; study desk; own bedroom; internet; own mobile phone; electricity; running tap water; flushing toilets; and hot water from a geyser. Responses to these items were recorded as a "yes" or "no". Internal consistency was indicated to fall just short of the benchmark value ($\alpha = 0.666$).

School socioeconomic quintile (**SSES_Q**) is computed taking the average learner SES within a school and grouping schools into five equally sized groups (n = 103 schools per quintile) ranked from the poorest 20 percent (SSES_Q = 1) to the wealthiest 20 percent (SSES_Q = 5) of schools.

Table 1: Reliability estimates (Cronbach's Alpha) of EVT model measures, by school quintiles

	School SES quintile					
Measure	1	2	3	4	5	All
MSE	0.696	0.725	0.727	0.773	0.873	0.771
AE	0.650	0.648	0.693	0.747	0.768	0.704
IV	0.871	0.881	0.886	0.900	0.929	0.897
UV	0.837	0.817	0.817	0.836	0.867	0.835
TSSE	0.796	0.803	0.824	0.869	0.890	0.837
CCI	0.762	0.767	0.816	0.865	0.902	0.822
PR	0.834	0.828	0.825	0.856	0.857	0.844

Source: Authors' calculations from TIMSS (2019).

3.3 Empirical Strategy

The development of the measures described in section 3.2 begins with confirmatory factor analysis (CFA) to determine the items suitable for constructing the common underlying dimensions of engagement and expectancy-value. CFA is termed a measurement model because it focuses on the link between the underlying factors and the measured variables (Byrne, 2010). Polychoric Principal Component Analysis (PCA) — suitable for Likert scale items — is used both for the CFA and to generate continuous measures. Unlike Pearson correlations that assume all variables are normally distributed — and upon which conventional PCA is based — polychoric correlations do not assume normality. The user-written 'polychoric' and 'polychoricpca' commands in Stata17 (StataCorp, 2021) were used for this purpose. Field's (2005) rule-of-thumb is adopted that considers a factor to be reliable if it has four or more loadings of at least 0.6,[5] regardless of sample size.

We adopt a structural equation modelling (SEM) approach — or pathway analysis — to answer the research questions and hypotheses posed by this study. Specifically, the structural relations among the learning situation variables (i.e., perceived relationships with and behaviours of teachers and other learners, and the teaching and learning environment), dimensions of engagement and expectancy-value, and mathematics achievement are estimated. Path analysis expands on multivariate regression models conventionally used in education production function analyses, as it allows for the specification of direct, indirect, and correlated effects among variables, and solves several regression equations simultaneously (Kline, 2015; Schumacker & Lomax, 2016). Model estimation was performed using the SEM builder tool in Stata17 (Statacorp, 2021), and the "pv" command was used to arrive at unbiased direct effect coefficients. This same model was estimated separately for the sample of learners attending schools of different socio-economic status, and separately by gender.

Examination of the data revealed that approximately 5-10% of the responses on the items incorporated into the measures summarised in section 3.3 were missing. Therefore, the SEM was estimated using maximum likelihood missing value (MLMV) estimation, otherwise known as full information maximum likelihood (FIML, Lee & Shi, 2021). Goodness of fit of individual models was determined using methods that are tolerant to large samples, such as the Root Mean Square Error of Approximation (RMSEA), the Standardised Root Mean Squared

[5] Factor loadings represent the strength of the underlying latent factors to the variables, and thus a factor loading of 0.6 and higher indicates that the factor extracts sufficient variance from the observed variable.

Residual (SRMR) and the Tucker-Lewis (TLI) and Comparative Fit (CFI) indices (Kline, 2015). The RMSEA assesses the gap between the hypothesized model and the perfect model and the SRMR looks at the difference between the observed correlation and the model implied correlation matrix (Kline, 2015; Xia & Yang, 2019). The TLI and CFI are incremental fit indices that make a comparison between possibly the worst fit model and the hypothesized model (Xia & Yang, 2019). As is standard in the literature, RMSEA and SRMR values of less than 0.05 and TLI and CFI values greater than 0.90 and 0.95, respectively, are indicative of good fits to the data (Kline, 2015). RMSEA and SRMR values of less than 0.08 are considered to reflect suitable fits to the data. Finally, estimation considers the complex sampling design using sampling weights — represented by the *totwgt* variable provided in the TIMSS data — and clustering at the class level.

4. Results

4.1 Preliminary analyses

Table A2 of the Appendix reports the CFA results for each of the measures detailed in section 3.2. All measures indicated at least four factor loadings of 0.6 and higher. Comparisons across the school quintiles indicate very similar factor loadings by construct. Table 2 presents the inter-construct and achievement correlations. Most of the correlations are significant at the 5% level of significance and are in the expected direction.

Intrinsic task value has the strongest positive correlation with a learner's mathematics self-concept (r = 0.654, p <0.05). Learners are also able to find the usefulness of a subject if they are interested in it, as indicated by a significant positive correlation between intrinsic task value and utility task value (r = 0.484, p <0.05). Another expected observation is the significant positive correlations between teacher social support and engagement and learner intrinsic task value (r = 0.448, p <0.05), learner utility task value (r = 0.383, p <0.05), and learner mathematics self-concept (r = 0.339, p <0.05), Learning disruptions from disorderly classroom behaviour and a teacher having to focus more on conduct than actual teaching (CCI) and peer relations are weakly correlated with the measures of learner engagement, self-efficacy and task value. Meanwhile, peer relations are significantly positively correlated with a collaborative classroom environment (r = 0.243, p <0.05). Mathematics achievement is most strongly positively correlated with mathematics self-concept (r = 0.203, p <0.05) and peer relations (r = 0.262, p <0.1). The negative correlation between mathematics achievement and feelings of affective engagement (r = -0.055, p <0.10) may be indicative of mathematics anxiety.

Table 2: Correlations across S-EVT constructs

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) MSE							
(2) AE	0.214*						
(3) IV	0.654**	0.372*					
(4) UV	0.301*	0.271*	0.484**				
(5) TSSE	0.339**	0.383**	0.448**	0.365**			
(6) CCI	0.082*	0.033*	0.019*	-.057**	0.052*		
(7) PR	0.003	0.093*	-0.001	0.089*	0.080*	0.243**	
(8) MS	0.203**	-0.055*	0.061*	0.163**	0.036*	0.143*	0.262*

Source: Authors' calculations from TIMSS (2019).

*Note: *** p<0.01, ** p<0.05, * p<0.1;* MS = mathematics score (achievement); MSC = mathematics self-concept; AE = affective engagement; IV = intrinsic task value; UV = utility task value; TSSE = teacher social support and engagement; CCI = classroom collaboration and interaction; PR = peer relations.

4.2 Main analyses

Comparison of the hypothesized model by groups of interest showed that the model was non-invariant across learner gender ($\Delta\chi^2_{(29)}$ = 662.02, p < 0.001) and school socioeconomic context ($\Delta\chi^2_{(59)}$ = 4217.37, p < 0.001), suggesting that the pattern of results differed for these groups. Accordingly, models were examined separately by gender and school socioeconomic context. Estimation of the hypothesized model for boys indicated generally acceptable model fit, and similarly for the model for girls (see Table 3). The goodness of fit indicators for the models estimated for the poorest 60% of schools, quintile 4 (60-80th percentile of wealth) schools, and wealthiest 20% of schools also indicated acceptable model fit, apart from the RMSEA. The higher than acceptable RMSEA is likely being driven by the simplicity of the model (Chaffee & Plante, 2021). Increasing the model complexity through including latent measurement for AE, MSE, IV, and UV — which increases the degrees of freedom ten-fold —indicated *RMSEA* values of 0.063 and 0.067 for models for boys and girls, respectively, and *CFI* and *SRMR* values similar to those noted above. However, these results would be based on Pearson correlation matrices, as the polychoric correlation matrix is not easily incorporated into the "sem" function in Stata17. The fact that the SRMR and CFI show acceptable fit, we continue with the original model that uses EVT measures constructed using polychoric PCA.

Table 3: Summary of fit indices of structural models.

Model	**CFI**	**RMSEA**	**SRMR**
Boys	0.863	0.153	0.060
Girls	0.862	0.151	0.061
Quintile 1 – 3 schools	0.872	0.136	0.058
Quintile 4 schools	0.858	0.145	0.057
Quintile 5 schools	0.865	0.159	0.060

Source: Authors' calculations from TIMSS (2019).

Note: CFI = comparative fit index; RMSEA = root mean squared error of approximation; SRMR = standardised root mean squared residual.

The final structural equation models estimated by gender and school socioeconomic group are presented in Figures 4 to 8. The path coefficients (single arrows) indicate the direct effects of each exogenous variable on the subsequent endogenous variable.[6] Standardised (beta) coefficients that allow for direct comparisons between the various constructs to determine which has the largest influence ("effect size") are indicated. The double-sided arrows represent a covariance between variables. For ease of representation, error terms are omitted. The conceptual model represents a multiple mediator model, where $k = 1, \dots, m$ is the number of mediators. This means that the specific indirect effect through M_k that quantifies that part of the total indirect effect unique to M_k can be distinguished from the total indirect effect through all mediators represented on the paths connecting an exogenous variable X and endogenous variable Y (Montoya, 2021). Assuming $k = 2$, and the coefficient linking X to M_k and M_k to Y are denoted by a_k and b_k, respectively, then the specific indirect effect through M_k is computed as $a_k.b_k$, and the total indirect effect as $\sum_k^m a_k.b_k$. The specific indirect effect through M_k is estimated controlling for all other mediators, M_{-k}. It is possible for the sum of all specific indirect effects — the total indirect effect — to not be statistically significantly different from zero, even if specific indirect effects are.

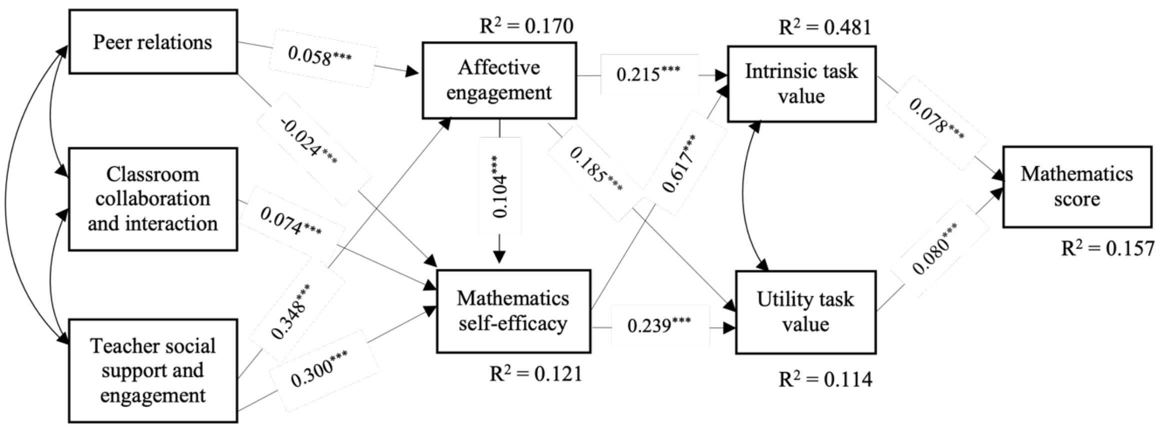
[6] Endogenous variables are those constructs that have single arrows pointing towards them, while endogenous variables are those constructs having single arrows pointing away from them. A construct is not exclusively either an endogenous variable or exogenous variable.

4.2.1 Direct and indirect relations between studied variables, by gender

As seen in Figure 4, positive experiences with the teacher and classroom environment predicted augmented self-efficacy beliefs (MSE) and affective engagement (AE) of girls, with perceptions that the teacher is supportive and engaged in learning having the largest effect ($\beta_{TSSE \rightarrow AE} = 0.348$, $\beta_{TSSE \rightarrow MSE} = 0.300$). Affective engagement is estimated to have a significant positive influence on self-efficacy ($\beta_{AE \rightarrow MSE} = 0.104$, $p < 0.001$). The positive direct effects of the distal cognitive constructs of AE and MSE on the proximal utility task value (UV) and intrinsic task value (IV) constructs are of a moderate to large size and statistically significant ($\beta_{AE \rightarrow IV} = 0.215$; $\beta_{AE \rightarrow UV} = 0.185$; $\beta_{MSE \rightarrow IV} = 0.617$; $\beta_{MSE \rightarrow UV} = 0.239$).

Taken together, then, the indirect effect of girls' perceptions of a supportive and engaged teacher (TSSE) on their IV mediated through the cognitive constructs MSE and AE is moderately sized and highly significant ($\beta_{indirect} = 0.282$, $p < 0.001$; see Table 4). Approximately 75% of this total effect is accounted for by the path through MSE. The estimated indirect effect of TSSE on girls' UV mediated through MSE and AE is less impactful ($\beta_{indirect} = 0.145$, $p < 0.001$), and is not dominated by either of the specific indirect effects. No significant direct path from classroom collaboration and interaction (CCI) to AE is estimated. Positive peer relations are estimated to be positively related to AE ($\beta_{PR \rightarrow AE} = 0.060$, $p < 0.001$) but negatively related to MSE, although the effect size is small ($\beta_{PR \rightarrow MSE} = -0.017$, $p = 0.013$).

Figure 4: Full conceptual model (girls, *n* = 11 033)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at p < 0.001. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

Table 4: Standardized decomposed path coefficients (girls, n = 11 033)

Exogenous variable	Endogenous variable	Direct effect	Specific indirect effect	Total indirect effect	Total effect
SES	Intrinsic task value (IV)	-0.096***	*via AE:* -0.030** *via MSE:* 0.027**	0.003	-0.096***
TSSE			*via AE:* 0.075*** *via MSE:* 0.207***	0.280***	0.280***
CCI			*via AE:* 0.001* *via MSE:* 0.046***	0.045***	0.045***
PR			*via AE:* 0.013*** *via MSE:* -0.010**	0.003	0.003
AE		0.215***			0.215***
MSE		0.617***	*via AE:* 0.020***	0.020***	0.637***
SES	Utility task value (UV)	0.005	*via AE:* -0.026** *via MSE:* 0.011*	-0.012*	-0.006
TSSE			*via AE:* 0.064*** *via MSE:* 0.080***	0.149***	0.149***
CCI			*via AE:* 0.001 *via MSE:* 0.017***	0.018***	0.018***
PR			*via AE:* 0.011*** *via MSE:* -0.004*	0.012**	0.012**
AE		0.185***			0.185***
MSE		0.239***	*via AE:* 0.017***	0.018***	0.257***
SES	Mathematics score (MS)	0.376***	*via IV:* -0.007 *via UV:* 0.005	-0.007	0.375***
TSSE			*via AE+ IV:* 0.006* *via MSE + IV:* 0.016*** *via AE + UV:* 0.005* *via MSE + UV:* 0.006*	0.031***	0.031***
CCI			*via AE+ IV:* 0.000 *via MSE + IV:* 0.004** *via AE + UV:* 0.000 *via MSE + UV:* 0.001**	0.004***	0.004***
PR			*via AE+ IV:* 0.001 *via MSE + IV:* -0.001 *via AE + UV:* 0.001 *via MSE + UV:* -0.000	0.001	0.001
AE			*IV:* 0.017*** *UV:* 0.015***	0.029***	0.029***
MSE			*IV:* 0.048*** *UV:* 0.019***	0.063***	0.063***
IV		0.078***			0.078***
UV		0.080***			0.080***

Source: Authors' calculations from TIMSS (2019).

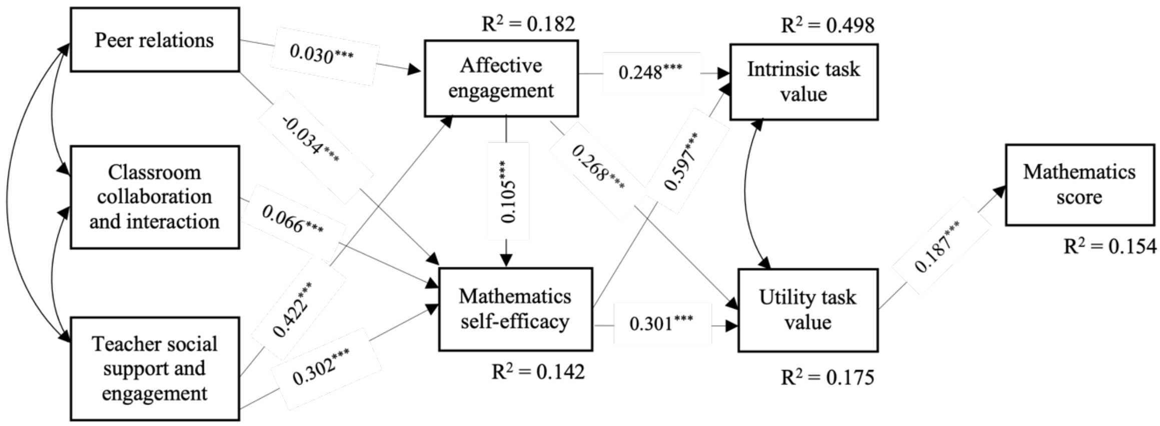
Notes: The specific indirect effects do not add up to the total indirect effect because the latter includes the influence of learner socioeconomic status. TSSE = teacher social support and engagement, CCI = class collaboration and interaction, PR = peer relations, AE = affective engagement, MSE = mathematics self-efficacy.

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

The results presented for boys (Figure 5) are qualitatively similar, although significant differences in the effect sizes of the direct and indirect paths emerge. As with girls, boys' perception of TSSE has the strongest direct association with AE and MSE amongst all situational variables. The estimated direct effect of TSSE on boys' AE is approximately 20% larger than that estimated for girls (girls: $\beta_{TSSE \rightarrow AE} = 0.348$, $p < 0.001$; boys: $\beta_{TSSE \rightarrow AE} = 0.422$, $p < 0.001$), and similarly for the direct effect of AE on boys' MSE ($\beta_{AE \rightarrow MSE} = 0.105$, $p < 0.001$). The direct effects of the distal cognitive constructs on the proximal utility task value construct are in the magnitude of 25-40% larger for boys ($\beta_{AE \rightarrow UV} = 0.268$; $\beta_{MSE \rightarrow UV} = 0.301$). In the case of intrinsic value, the direct effects are of a similar magnitude to that estimated for girls ($\beta_{AE \rightarrow IV} = 0.248$; $\beta_{MSE \rightarrow IV} = 0.597$).

These differences in path coefficients implies that the combined indirect effect (see Table 5) of TSSE on boys' UV mediated through MSE and AE is 50% larger than that estimated for girls ($\beta_{indirect} = 0.217$, $p < 0.001$), and the specific indirect effects are of equal magnitude ($\beta_{indirect, AE} = 0.113$, $p < 0.001$; $\beta_{indirect, MSE} = 0.104$, $p < 0.001$). As with the model for girls, no significant direct path from CCI to AE is estimated, and the negative coefficient on the path from PR to MSE is larger (girls: $\beta_{PR \rightarrow MSE} = -0.024$, $p < 0.001$; boys: $\beta_{PR \rightarrow MSE} = -0.034$, $p < 0.001$). Conversely, the positive direct effect of PR on AE is smaller for boys (girls: $\beta_{PR \rightarrow AE} = 0.058$, $p < 0.001$; boys: $\beta_{PR \rightarrow AE} = 0.030$, $p < 0.001$).

Figure 5*:* Full conceptual model (boys, *n* = 9 689)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at p < 0.001. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

Moving to the far righthand side of the models, the direct effects of the subjective task value constructs, IV and UV, on girls' mathematics achievement (MS) are, as expected, positive and statistically significant ($\beta_{IV \rightarrow MS}$ = 0.078, $p < 0.001$; $\beta_{UV \rightarrow MS}$ = 0.080, $p < 0.001$). In the case of boys, no significant path is observed from IV to achievement, but UV positively determines achievement, and the path coefficient is more than twice the magnitude of that observed for girls ($\beta_{UV \rightarrow MS}$ = 0.187, $p < 0.001$). The specific total effects of subjective task values on performance are, therefore, estimated to be larger for boys. Most notably, the specific indirect effect of affective engagement mediated through UV ($\beta_{AE \rightarrow UV \rightarrow MS}$ = 0.050, $p < 0.001$) which is more than three times larger than the same specific indirect effect estimated for girls ($\beta_{AE \rightarrow UV \rightarrow MS}$ = 0.015, $p < 0.001$).

4.2.2 Direct and indirect relations between studied variables, by school socioeconomic context

There are notable differences in the pathway coefficients estimated for the poorest 60% of schools (Figure 6), quintile 4 schools (Figure 7), and quintile 5 schools (Figure 8). In quintile 5 schools, intrinsic task value emerges as a strong positive predictor of mathematics achievement when compared to the other school SES groups. In fact, the effect size of IV increases with school socioeconomic status (β_{Q5} = 0.252, β_{Q4} = 0.160, β_{Q1toQ3} = 0.095). Conversely, utility task value is a stronger positive predictor of mathematics achievement in poorer school contexts (β_{Q4} = 0.084, β_{Q1toQ3} = 0.173), and its effect size is statistically indistinguishable from zero in quintile 5 schools ((β_{Q5} = -0.029, p = 0.202).

The direct effects of the distal cognitive constructs — AE and MSE — also differ by socioeconomic context. The direct path coefficients between AE and the subjective task value constructs are estimated to be almost twice as large for the poorest 60% of schools ($\beta_{Q1to3:\,AE \rightarrow IV}$ = 0.256, $\beta_{Q1to3:\,AE \rightarrow UV}$ = 0.270) than for the wealthiest 20% of schools ($\beta_{Q5:\,AE \rightarrow IV}$ = 0.122, $\beta_{Q5:\,AE \rightarrow UV}$ = 0.150). With regards to MSE, the coefficient on the direct path to IV and UV is approximately 10% and 25% larger, respectively, in quintile 5 schools ($\beta_{Q5:\,MSE \rightarrow IV}$ = 0.648, $\beta_{Q5:\,MSE \rightarrow UV}$ = 0.337; $\beta_{Q1toQ3:\,MSE \rightarrow IV}$ = 0.586, $\beta_{Q1to3:\,MSE \rightarrow UV}$ = 0.247), whereas the direct effect of AE on MSE is not significantly different between the poorest and wealthiest school contexts.

Table 5: Standardized decomposed path coefficients (boys, *n* = 9 689)

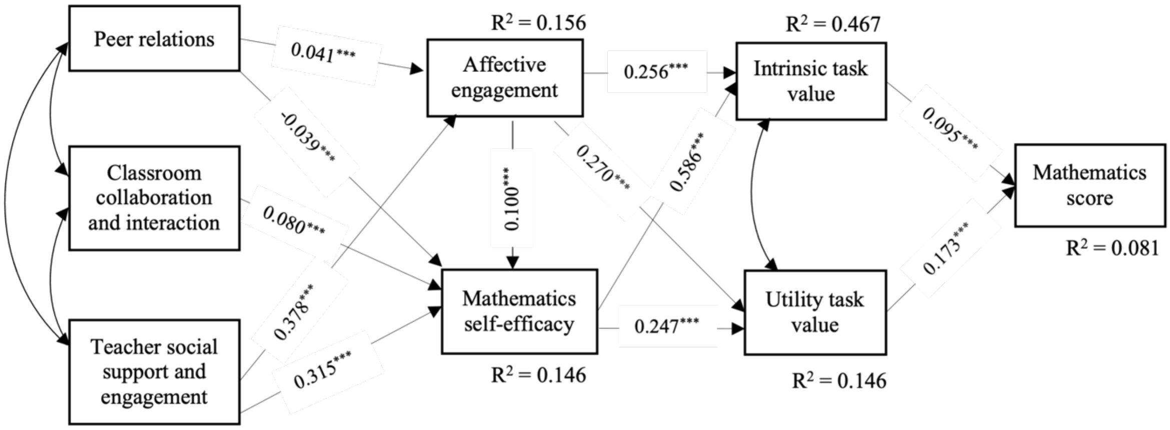
Exogenous variable	Endogenous variable	Direct effect	Specific indirect effect	Total indirect effect	Total effect
SES	Intrinsic task value (IV)	-0.073***	*via AE:* -0.030** *via MSE:* 0.027**	-0.014	-0.087***
TSSE			*via AE:* 0.105*** *via MSE:* 0.206***	0.316***	0.316***
CCI			*via AE:* 0.002** *via MSE:* 0.039***	0.037***	0.037***
PR			*via AE:* 0.007* *via MSE:* -0.019**	-0.023*	-0.023*
AE		0.248***			0.248***
MSE		0.597***	*via AE:* 0.020***	0.028***	0.627***
SES	Utility task value (UV)	0.087***	*via AE:* -0.026** *via MSE:* 0.011*	-0.021***	0.066***
TSSE			*via AE:* 0.113*** *via MSE:* 0.104***	0.201***	0.201***
CCI			*via AE:* 0.021** *via MSE:* 0.020**	0.016**	0.016**
PR			*via AE:* 0.008* *via MSE:* -0.009*	-0.003	-0.003
AE		0.268***			0.268***
MSE		0.301***	*via AE:* 0.030***	0.027***	0.328***
SES	Mathematics score (MS)	0.336***	*via UV:*	0.012***	0.347***
TSSE			*via AE + UV:* 0.021** *via MSE + UV:* 0.020**	0.039***	0.039***
CCI			*via AE + UV:* 0.000 *via MSE + UV:* 0.004**	0.003**	0.003**
PR			*via AE + UV:* 0.001 *via MSE + UV:* -0.000	-0.001	-0.001
AE			*via UV:* 0.050***	0.051***	0.051***
MSE			*via UV:* 0.056***	0.058***	0.058***
UV		0.187***			0.187***

Source: Authors' calculations from TIMSS (2019).

Notes: The specific indirect effects do not add up to the total indirect effect because the latter includes the influence of learner socioeconomic status. TSSE = teacher social support and engagement, CCI = class collaboration and interaction, PR = peer relations, AE = affective engagement, MSE = mathematics self-efficacy.

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

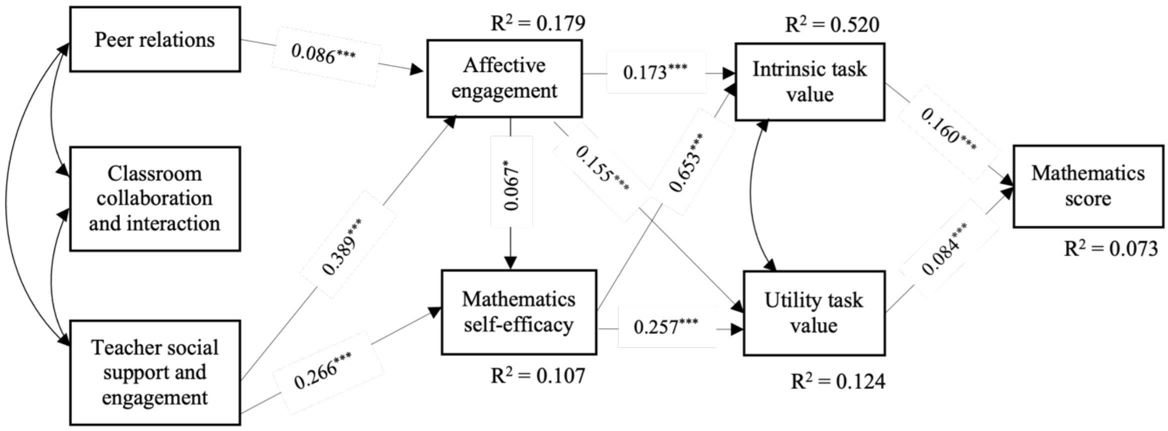
Figure 6: Full conceptual model (poorest 60% of schools, n = 13 806)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at p < 0.001. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

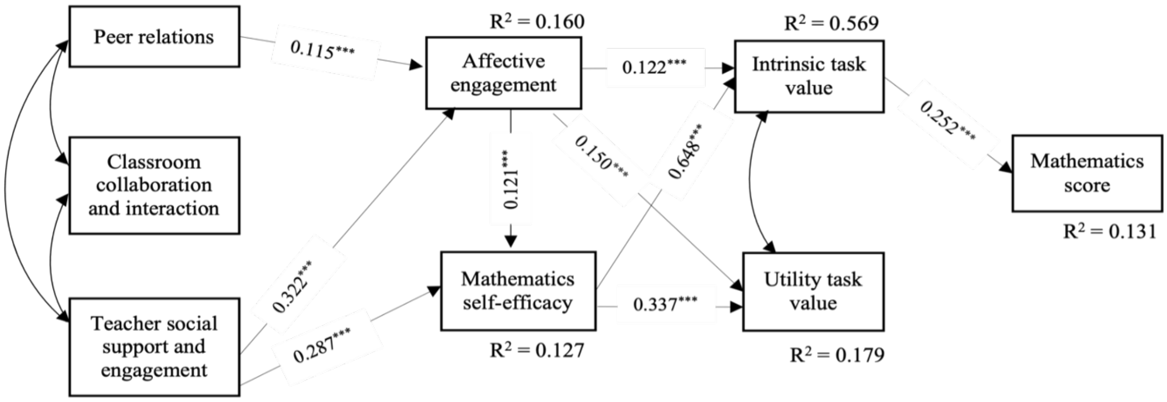
Figure 7: Full conceptual model (quintile 4 schools, n = 2 931)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at p < 0.001. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

Figure 8: Full conceptual model (quintile 5 schools, n = 3 985)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at p < 0.001. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

Turning attention to the indirect effects of the variables on the far left of the model (see Tables 6, 7 and 8), learner perceptions of key socializer behaviours and classroom experiences differentially determine the subjective task values of learners — mediated through AE and MSE — across school socioeconomic context. The positive total indirect effect of TSSE on learners' IV is significantly (p <0.05) higher in the poorest 60% of schools than in the wealthiest 20% of schools ($\beta_{Q1to3} = 0.306$; $\beta_{Q5} = 0.157$), but not significantly different from what is observed for quintile 4 schools. In the case of UV, the positive total indirect effect of TSSE is higher in the poorest 60% of schools than what is observed for quintile 4 and quintile 5 schools, but the difference is not statistically significantly different from zero. The total indirect effect of CCI on learner IV and UV is also not estimated to be significantly different across school socioeconomic contexts, but CCI does have a significantly larger (roughly double) positive indirect effect on IV than on UV.

With regards to PR, the indirect effect of PR on learner IV and UV is estimated to be positive and significantly larger in quintile 5 schools ($\beta_{PR \to IV} = 0.034$, $\beta_{PR \to UV} = 0.028$), and PR is associated with *lower* learner IV in the poorest 60% of schools through the channel of MSE specifically ($\beta_{PR \to IV} = -0.019$, p <0.05). Comparing the total indirect effect of PR with the specific indirect effect through AE, it is evident that learner home background plays a strong role in driving this effect in quintile 4 and quintile 5 schools; that is, learners in these schools with a higher measured socioeconomic status report higher positive peer behaviour and affective engagement, which corresponds with higher intrinsic mathematics task value.

The information contained in the bottom third of Tables 6, 7 and 8 indicates that MSE — compared to AE and learning environment factors — plays a larger role in determining mathematics achievement through the proximal subjective task value constructs. The total indirect effect of MSE on mathematics scores is largest in quintile 5 schools ($\beta_{\text{MSE}\rightarrow\text{MS}} = 0.194$, $p < 0.001$), as is dominated (85%) by the specific indirect effect through IV. Similarly, two-thirds of the total indirect effect of MSE on mathematics scores in quintile 4 schools occurs through IV ($\beta_{\text{MSE}\rightarrow\text{IV}\rightarrow\text{MS}} = 0.104$, $p < 0.001$). In the case of the poorest 60% of schools, the total indirect effect of MSE is accounted for almost equally by the specific indirect effects via IV and UV ($\beta_{\text{MSE}\rightarrow\text{IV}\rightarrow\text{MS}} = 0.056$, $\beta_{\text{MSE}\rightarrow\text{UV}\rightarrow\text{MS}} = 0.043$). AE has the strongest effect on mathematics performance in the poorest 60% of schools, channeled mostly through UV ($\beta_{\text{AE}\rightarrow\text{UV}\rightarrow\text{MS}} = 0.047$, $p < 0.001$). Of the learning environment constructs, TSSE has the strongest indirect effect on performance, which is of a similar size across all socioeconomics contexts ($\beta_{\text{Q1to3: TSSE}\rightarrow\text{MS}} = 0.068$, $\beta_{\text{Q4: TSSE}\rightarrow\text{MS}} = 0.067$, $\beta_{\text{Q5: TSSE}\rightarrow\text{MS}} = 0.063$). However, and like MSE, the indirect effect of TSSE on mathematics performance in the poorest 60% of schools is channeled quite equally through IV and UV, whereas in the wealthier school contexts it is channeled predominantly through IV.

The effects of learner socioeconomic status (SES) on the proximal cognitive constructs and mathematics performance are largely accounted for by direct effects, irrespective of school socioeconomic context. However, it is worth noting that the indirect effect of SES on IV and UV specifically mediated through AE is *negative*, whereas the indirect effect specifically mediated through MSE is positive. Furthermore, the estimated direct effect of SES on learner UV is positive ($p < 0.01$) in poorer school settings, but negative in the wealthiest school quintile ($p < 0.001$). Similarly, the direct effect of SES on learner IV is negative ($p < 0.001$) in quintile 4 and 5 schools. Across all school socioeconomic contexts, SES has a positive and significant direct effect on mathematics performance, and the magnitude of this effect increases with school relative wealth.

Table 6: Standardized decomposed path coefficients (poorest 60% of schools, n = 13 806)

Exogenous variable	Endogenous variable	Direct effect	Specific indirect effect	Total indirect effect	Total effect
SES	Intrinsic task value (IV)	0.002	*via AE:* -0.019** *via MSE:* 0.029***	0.029***	0.030*
TSSE			*via AE:* 0.097*** *via MSE:* 0.207***	0.304***	0.304***
CCI			*via AE:* 0.002 *via MSE:* 0.047***	0.043***	0.043***
PR			*via AE:* 0.010** *via MSE:* -0.021***	-0.010**	-0.010**
AE		0.256***	*via MSE:* 0.059***	0.058***	0.315***
MSE		0.586***			0.586***
SES	Utility task value (UV)	0.066***	*via AE:* -0.015** *via MSE:* 0.012**	0.006	0.072***
TSSE			*via AE:* 0.102*** *via MSE:* 0.087***	0.189***	0.189***
CCI			*via AE:* 0.002 *via MSE:* 0.020***	0.016***	0.016***
PR			*via AE:* 0.011* *via MSE:* 0.002	0.002	0.002
AE		0.270***	*via MSE:* 0.025***	0.025***	0.295***
MSE		0.247***			0.247***
SES	Mathematics score (MS)	0.059**	*via IV:* 0.000 *via UV:* 0.011**	0.015***	0.063***
TSSE			*via AE + IV:* 0.009* *via MSE + IV:* 0.020*** *via AE + UV:* 0.018** *via MSE + UV:* 0.015**	0.057***	0.057***
CCI			*via AE + IV:* 0.000 *via MSE + IV:* 0.004* *via AE + UV:* 0.000 *via MSE + UV:* 0.003*	0.006**	0.006**
PR			*via AE + IV:* 0.001 *via MSE + IV:* -0.002 *via AE + UV:* 0.002 *via MSE + UV:* -0.001	-0.000	-0.000
AE			*via IV:* 0.024** *via UV:* 0.047***	0.076***	0.076***
MSE			*via IV:* 0.056*** *via UV:* 0.043***	0.090***	0.090***
IV		0.095***			0.095***
UV		0.173***			0.173***

Source: Authors' calculations from TIMSS (2019).

Notes: The specific indirect effects do not add up to the total indirect effect because the latter includes the influence of learner socioeconomic status. TSSE = teacher social support and engagement, CCI = class collaboration and interaction, PR = peer relations, AE = affective engagement, MSE = mathematics self-efficacy. *** p<0.001, ** p<0.01, * p<0.05

Table 7: Standardized decomposed path coefficients (quintile 4 schools, n = 3 985)

Exogenous variable	Endogenous variable	Direct effect	Specific indirect effect	Total indirect effect	Total effect
SES	Intrinsic task value (IV)	-0.066***	*via AE:* -0.013** *via MSE:* 0.032***	0.037	-0.029
TSSE			*via AE:* 0.067*** *via MSE:* 0.191***	0.258***	0.258***
PR			*via AE:* 0.015 *via MSE:* 0.004	0.016	0.016
AE		0.173***	*via MSE:* 0.044**	0.044**	0.217***
MSE		0.653***			0.653***
SES	Utility task value (UV)	0.025	*via AE:* -0.012** *via MSE:* 0.013**	0.009	0.037
TSSE			*via AE:* 0.060*** *via MSE:* 0.075***	0.135***	0.135***
CCI				0.017**	0.017**
PR			*via AE:* 0.013** *via MSE:* 0.001	0.014***	0.014***
AE		0.155***	*via MSE:* 0.017**	0.172***	0.155***
MSE		0.257***			0.257***
SES	Mathematics score (MS)	0.102***	*via IV:* -0.011** *via UV:* 0.002	-0.002	0.112***
TSSE			*via AE + IV:* 0.011** *via MSE + IV:* 0.031*** *via AE + UV:* 0.005 *via MSE + UV:* 0.006	0.052***	0.052***
PR			*via AE + IV:* 0.002* *via MSE + IV:* 0.001 *via AE + UV:* 0.001 *via MSE + UV:* 0.000	0.004*	0.004*
AE			*via IV:* 0.028*** *via UV:* 0.013**	0.049***	0.049***
MSE			*via IV:* 0.104*** *via UV:* 0.022***	0.126***	0.126***
IV		0.160***			0.160***
UV		0.084***			0.084***

Source: Authors' calculations from TIMSS (2019).

Notes: The specific indirect effects do not add up to the total indirect effect because the latter includes the influence of learner socioeconomic status. TSSE = teacher social support and engagement, CCI = class collaboration and interaction, PR = peer relations, AE = affective engagement, MSE = mathematics self-efficacy.

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

Table 8: Standardized decomposed path coefficients (quintile 5 schools, *n* = 2 931)

Exogenous variable	Endogenous variable	Direct effect	Specific indirect effect	Total indirect effect	Total effect
SES	Intrinsic task value (IV)	-0.216***	*via AE:* -0.013** *via MSE:* 0.032***	0.139**	-0.076
TSSE			*via AE:* 0.039*** *via MSE:* 0.211***	0.251***	0.251***
CCI			*via MSE:* 0.038**	0.041*	0.041*
PR			*via AE:* 0.014** *via MSE:* 0.009*	0.034**	0.034**
AE		0.122***	*via MSE:* 0.078***	0.078***	0.201***
MSE		0.648***			0.648***
SES	Utility task value (UV)	-0.241***	*via AE:* -0.012** *via MSE:* 0.013**	0.074***	-0.164***
TSSE			*via AE:* 0.048*** *via MSE:* 0.110***	0.158***	0.158***
CCI			*via MSE:* 0.020**	0.023*	0.023*
PR			*via AE:* 0.017*** *via MSE:* 0.005*	0.028***	0.028***
AE		0.150***	*via MSE:* 0.041***	0.041***	0.191***
MSE		0.337***			0.337***
SES	Mathematics score (MS)	0.453***	*via IV:* -0.011** *via UV:* 0.002	-0.014	0.421***
TSSE			*via AE + IV:* 0.010* *via MSE + IV:* 0.053***	0.057***	0.057***
CCI			*via MSE + IV:* 0.009*	0.009*	0.009*
PR			*via AE + IV:* 0.004** *via MSE + IV:* 0.003*	0.008**	0.008**
AE			*via IV:* 0.031***	0.044***	0.044***
MSE			*via IV:* 0.163***	0.149***	0.149***
IV		0.252***			0.252***
UV		-0.029			-0.029

Source: Authors' calculations from TIMSS (2019).

Notes: The specific indirect effects do not add up to the total indirect effect because the latter includes the influence of learner socioeconomic status. TSSE = teacher social support and engagement, CCI = class collaboration and interaction, PR = peer relations, AE = affective engagement, MSE = mathematics self-efficacy.

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

4.2.3 Relations between studied variables, by gender and socio-economic context

Models estimated for each gender-by-school-wealth sample (see Figures A1 to A6 of the Appendix) indicates qualitatively similarly models for boys and girls in the poorest 60% of schools. Differences in path coefficients emerge for TSSE, which has a stronger positive effect on the AE of boys ($\beta_{TSSE \rightarrow AE}$ = 0.427, p < .001) than girls ($\beta_{TSSE \rightarrow AE}$ = 0.333, p < .001). The direct path coefficients from TSSE to AE in quintile 4 and quintile 5 schools are similar to that estimated for quintile 1-3 schools. The AE of girls in wealthier contexts ($\beta_{Q4:\ PR \rightarrow AE}$ = 0.110, $\beta_{Q5:\ PR \rightarrow AE}$ = 0.14) are more dependent on peer relations when compared to their male peers ($\beta_{Q4:\ PR \rightarrow AE}$ = 0.059, $\beta_{Q5:\ PR \rightarrow AE}$ = 0.077), and the estimated effect size is more than double that estimated for girls in the poorest 60% of schools.

In the case of TSSE's influence on MSE, only in quintile 5 schools is the effect size estimated to be significantly larger for boys ($\beta_{TSSE \rightarrow MSE}$ = 0.303) than it is for girls ($\beta_{TSSE \rightarrow MSE}$ = 0.233). In terms of AE's association with MSE, it is estimated to have a slightly stronger effect on the MSE of boys in the poorest 80% of schools. The AE of girl's attending quintile 4 schools is unrelated to competency beliefs, and similarly for boys attending quintile 5 schools. Perceptions of collaboration and positive interactions in the classroom are only predictive of MSE in the poorest 60% of schools. Furthermore, only in the poorest 60% of schools are perceptions of positive peer relations associated with *lower* MSE of both boys and girls.

AE and MSE are estimated to have positive direct effects on the subjective task values for both gender groups. The direct effects of AE and MSE on UV are estimated to be approximately 30-45% larger for boys than girls in the poorest 80% of schools; for the wealthiest 20% of schools, only the effect of AE on UV is larger for boys, and to the order of threefold. The direct effects of MSE on IV is similar for boys and girls in all school wealth contexts, whilst the effect of AE on IV only differs significantly across genders in quintile 4 schools.

Regarding the associations between task values and performance, IV and UV are estimated to have positive effect sizes on the mathematics scores of both boys and girls in the poorest 60% of schools, with a stronger effect of UV than IV. The mathematics performance of girls in quintile 4 schools is not significantly determined by UV (e.g., $\beta_{Q4:\ girls:\ UV \rightarrow MS}$ = 0.034, p > 0.10), which is in opposition to their male peers whose mathematics scores are determined by both IV ($\beta_{\text{Q4: boys: TE IV→MS}} = 0.143$, $p < 0.001$) and UV ($\beta_{\text{Q4: boys: TE UV→MS}} = 0.149$, $p < 0.001$).

Taken together, the estimated path effects described above result in larger total effects of AE and TSSE on the IV, UV and mathematics performance of boys relative to girls (see Table 9). It is worth noting that the total effect of AE and TSSE on the subjective task value constructs in general get smaller from the poorest schools to the most affluent schools. The opposite is true for the total effect of MSE on subjective task values, where the effect size increases with school quintile. For both boys and girls in the poorest 60% of schools, UV is estimated to have the largest total effect on mathematics performance out of all EVT dimension factors.

The total effects of MSE and IV on mathematics performance increases with school wealth context. The most significant determinants of girls' mathematics performance in wealthier schools are IV ($\beta_{\text{Q4: IV→MS}} = 0.191$, $\beta_{\text{Q5: IV→MS}} = 0.268$) and MSE ($\beta_{\text{Q4: MSE→MS}} = 0.132$, $\beta_{\text{Q5: MSE→MS}} = 0.121$). Similar effects are observed for boys in quintile 5 schools ($\beta_{\text{Q5: MSE→MS}} = 0.152$, $\beta_{\text{Q5: IV→MS}} = 0.221$). The total effects of MSE, IV and UV are of a similar magnitude for boys in quintile 4 schools. The mathematics performance of girls attending quintile 5 schools is *negatively* determined by UV ($\beta_{\text{UV→MS}} = -0.080$).

4.3 Secondary analysis

In this secondary analysis, we added conventional measures of teacher quality — namely, teacher education and experience — to the first level of our SEM to determine their relationship with learner perceptions of the class environment, as well as their affective responses, self-efficacy beliefs, subjective task values and mathematics performance. Similar to the analysis of section 5.2. 3, we determine the total effects from our estimated path effects for models estimated for each gender-by-school-wealth sample, which are summarized in Table 10. In our models, we distinguish between teachers that received a university degree and entered teaching in the last five years, and those that received a degree and entered teaching six or more years ago.

In the case of learners in the poorest 60% of schools, being taught by degreed teachers with fewer than six years of experience is related to significantly higher perceptions of a supportive and engaged learning environment. The total effect of recently graduated teachers on TSSE is estimated to be similar for both girls ($\beta_{\text{Recently graduated→TSSE}} = 0.140$, $p < .01$) and boys (β_{Recently}

$_{\text{graduated}\rightarrow\text{TSSE}} = 0.147$, $p < .01$). Similarly, teacher experience, irrespective of degree status, is also estimated to have a positive direct effect on learner perceptions of a supportive and engaged learning environment and is similar for girls ($\beta_{\text{experience}\rightarrow\text{TSSE}} = 0.152$, $p < .01$) and boys ($\beta_{\text{experience}\rightarrow\text{TSSE}} = 0.147$, $p < .01$). No significant path effects of teacher education and experience on TSSE are found for quintile 4 and quintile 5 schools.

Table 9: Standardized total effects, by gender and school socioeconomic context

Exogenous variable	Endogenous variable	Girls (1) Poorest 60%	Girls (2) Quintile 4	Girls (3) Quintile 5	Boys (4) Poorest 60%	Boys (5) Quintile 4	Boys (6) Quintile 5
SES	Intrinsic task value (IV)	0.027	-0.022	-0.051	0.031	-0.047	-0.019
TSSE		0.291***	0.253***	0.227***	0.317***	0.264***	0.278***
CCI		0.054***	0.039	0.027	0.031*	0.031	0.064*
PR		-0.011	0.054*	0.083**	-0.022*	0.004	0.040
AE		0.297***	0.188***	0.214***	0.334***	0.255***	0.186***
MSE		0.600***	0.658***	0.647***	0.569***	0.646***	0.650***
SES	Utility task value (UV)	0.071***	0.016	-0.133***	0.096***	0.078	-0.002
TSSE		0.150***	0.113***	0.127***	0.234***	0.161***	0.196***
CCI		0.019***	0.016*	0.015	0.013	0.019	0.032*
PR		0.007	0.033**	0.049**	-0.002	0.010	0.044*
AE		0.239***	0.113***	0.131***	0.338***	0.202***	0.265***
MSE		0.220***	0.225***	0.348***	0.293***	0.320***	0.325***
SES	Mathematics score (MS)	0.078***	0.118***	0.279***	0.056**	0.109*	0.198***
TSSE		0.048***	0.052***	0.051***	0.067***	0.053***	0.067***
CCI		0.008***	0.008	0.006	0.005	0.006	0.015*
PR		0.000	0.011**	0.018**	-0.002	0.002	0.010
AE		0.063***	0.040***	0.047***	0.087***	0.057***	0.048***
MSE		0.086***	0.132***	0.146***	0.097***	0.121***	0.152***
IV		0.087***	0.191***	0.268***	0.076***	0.126***	0.221***
UV		0.153***	0.032	-0.080*	0.184***	0.124***	0.026

Source: Authors' calculations from TIMSS (2019).

Notes: The total effects indicated are computed as the sum of the total indirect effects and direct effect. TSSE = teacher social support and engagement, CCI = class collaboration and interaction, PR = peer relations, AE = affective engagement, MSE = mathematics self-efficacy. *** p<0.001, ** p<0.01, * p<0.05

At the level of affective reactions and self-schemata, teacher education is not found to be a significant determinant of affective engagement, but recent graduates are found to have a significant positive total effect on the mathematics self-efficacy (MSE) of learners in the poorest 60% of schools that is similar for girls ($\beta_{\text{Recently graduated}\rightarrow\text{MSE}} = 0.081$, $p < .05$) and boy ($\beta_{\text{Recently graduated}\rightarrow\text{MSE}} = 0.080$, $p < .05$). Teacher experience is estimated to be related to significantly higher affective engagement (AE) for boys in the poorest 60% of schools ($\beta_{\text{Experience}\rightarrow\text{AE}} = 0.071$, $p < .05$) and significantly lower AE for boys in quintile 4 schools ($\beta_{\text{Experience}\rightarrow\text{AE}} = -0.095$, $p < .05$). In the case of MSE, teacher experience is related to significant positive direct effects for girls ($\beta_{\text{Experience}\rightarrow\text{MSE}} = 0.107$, $p < .01$) and boys ($\beta_{\text{Experience}\rightarrow\text{MSE}} = 0.097$, $p < .01$) in the poorest 60% of schools only.

Teacher education has no significant links to learners' subjective task values, across all socioeconomic contexts and by gender. Teacher experience is estimated to have a significant positive total effect on the subjective task values of learners in the poorest 60% of schools, and the total effect sizes are estimated to be larger and more significant for boys when compared to those of girls in similar contexts. The mathematics performance of learners from the poorest 60% of schools is significantly and positively determined by being taught by a recent graduate, and the total effect is of the same magnitude for boys ($\beta_{\text{Recently graduated}\rightarrow\text{MS}} = 0.116$, $p < 0.01$) and girls ($\beta_{\text{Recent graduated}\rightarrow\text{MS}} = 0.116$, $p < 0.05$). Moreover, teacher experience is estimated to have a significant total effect on the mathematics performance of boys in the poorest school contexts ($\beta_{\text{Experience}\rightarrow\text{MS}} = 0.103$, $p < 0.01$). Learners attending quintile 5 schools taught by degreed teachers perform significantly better, with a similar total effect estimated for boys ($\beta_{\text{Degree}\rightarrow\text{MS}} = 0.149$, $p < 0.01$) and girls ($\beta_{\text{Degree}\rightarrow\text{MS}} = 0.134$, $p < 0.01$).

Table 10: Standardized total effects, by gender and school socioeconomic context

Exogenous variable	Endogenous variable	Poorest 60% (1) Girls	(2) Boys	Quintile 4 (3) Girls	(4) Boys	Quintile 5 (5) Girls	(6) Boys
Degree	Teacher social support and engagement (TSSE)	-0.001	-0.047+	-0.030	-0.073	0.017	0.022
Recently graduated		0.140**	0.147**	-0.091	-0.102	-0.063	-0.026
Experience		0.152**	0.147**	0.029	0.020	-0.079	-0.015
TSSE	Affective engagement (AE)	0.353***	0.413***	0.373***	0.386***	0.318***	0.343***
Degree		-0.015	0.014	-0.009	-0.056	0.044	0.135*
Recently graduated		0.001	0.028	-0.041	-0.014	-0.000	0.028
Experience		0.011	0.071*	-0.047	-0.095*	0.115	0.107
TSSE	Mathematics Self-efficacy (MSE)	0.091***	0.119***	0.303***	0.322***	0.272***	0.329***
Degree		0.011	-0.037	-0.009	0.046	-0.023	0.004
Recently graduated		0.081*	0.080*	-0.034	0.046	-0.057	0.035
Experience		0.097**	0.107**	-0.041	0.020	0.041	0.017
TSSE	Intrinsic task value (IV)	0.290***	0.322***	0.262***	0.295***	0.231***	0.283***
Degree		0.003	-0.017	-0.024	0.016	-0.012	0.020
Recently graduated		0.048+	0.053+	-0.012	0.026	-0.041	0.029
Experience		0.060*	0.081**	-0.035	-0.009	0.043	0.026
TSSE	Utility task value (UV)	0.153***	0.207***	0.134***	0.170***	0.126***	0.191***
Degree		-0.001	-0.005	-0.010	0.003	-0.005	0.032
Recently graduated		0.018	0.028	-0.008	0.011	-0.021	0.018
Experience		0.024+	0.047**	-0.018	-0.012	0.024	0.030
TSSE	Mathematics score (MS)	0.053***	0.076***	0.062***	0.068***	0.061***	0.076***
Degree		-0.001	0.050	-0.067	-0.039	0.134**	0.149**
Recently graduated		0.116*	0.116**	-0.080	0.039	0.012	0.067
Experience		0.086	0.103*	-0.055	0.066	0.098	0.088

Source: Authors' calculations from TIMSS (2019).

Notes: The total (standardized) effects indicated are computed as the sum of the total indirect effects and direct effect. *** p<0.001, ** p<0.01, * p<0.05

5. Discussion

The analysis conducted in this study aimed to examine the relationship between learning context, the distal and proximal social cognitive features of expectancy and value, and mathematics performance. It was further hypothesised that these relationships would be linked with sociocultural attitudes such as gender stereotyping. The analysis presented has shown teachers to play a key role not only in students' mathematics achievement, but also in fostering self-efficacy beliefs, emotional engagement, and finding value in learning. Specifically, it is argued that successful learning outcomes stem from students being able to form an emotional connection to, interest in and value from a subject, which impacts their dedication and time investment. The pathway analysis provided insight into the possible mechanisms by which perceptions of teacher support and peer behaviour influence the social cognitive processes of expectancy-value and achievement, and how these differ by gender and school socioeconomic context. A secondary analysis then looked specifically at the role of the standard teacher quality indicators of education level and experience.

5.1 Gender

The gender-based variance in the observed relationships are particularly interesting: while the social cognitive processes of both boys and girls are influenced by perceptions of teacher support and instructive engagement, the effect sizes estimated for boys are more pronounced. For example, the direct effect of teacher social support and engagement on boys' sense of school belonging (affective engagement) is 25% larger when compared to the effect size for girls. The empirical evidence further suggests that boys, more than girls, necessitate an augmented level of effort, interaction, and support from their educators to stimulate their interest in and utility value from mathematics (see, for example, Watt, et al., 2019).

These findings suggest that a supportive and engaging learning environment can serve as a countervailing force against prevailing negative expectations; for example, boys being dubbed as 'scholastic failures' or being expected to conform to negative masculine traits, as seen in Kessels et al. (2014). The stereotype threat literature of, for example, Steele (1997) and Spencer et al. (1999), has noted how boys experience social-psychological threat in academic domains when they are encouraged to conform to stereotypical masculine behaviours and norms that can exert a negative influence on their engagement and interest in activities considered to be more feminine, such as engaging in learning (Kessels, et al., 2014). Indeed, the 2019 TIMSS data indicates grade 9 boys in South Africa to report significantly lower average levels of affective engagement at school than do girls, irrespective of the socioeconomic context of the school (Takalani, 2023).

For girls, the efficacy of teachers in seamlessly connecting lessons and investing additional effort emerges as a significant determinant of interest in mathematics, a subject traditionally perceived as aligning with masculine attributes. The most significant mechanism shaping girls' intrinsic task value in response to teacher support is self-efficacy: approximately 75% of the total effect of teacher social support and engagement on girls' interest in mathematics is channeled through this cognitive construct. This underscores the important role that teachers can play in fostering girls' confidence in their mathematical capabilities (Gunderson et al., 2012; Shapiro & Williams, 2012). A further factor found to influence girls' engagement, and subsequently subjective task values, is peer relations: the positive direct effect of peer relations on a girl's sense of belonging is estimated to be about 50% larger than that estimated for boys. This provides further evidence that girls' sense of belonging, more than boys, rely on the nurturing relationships they build at school with their peers and teachers (Eriksson, 2020).

Perhaps counterintuitively, girls' and boys' perceived relationships with other learners was estimated to have a negative influence on their competency beliefs. Disaggregation by school socioeconomic context reveals this association to only present itself in the poorest 60% of schools. In the case of girls, this could stem from feeling undervalued in their efforts to do well and excel in mathematics, possibly due to prevailing stereotypes about girls' performance in masculine subjects as perceived by their peers (Kessels, et al., 2014; Määttä & Uusiautti, 2020). The study by Wolff (2021) on gender stereotypes and math self-concepts amongst secondary school learners in Germany found substantial independent impacts of the gender stereotypes beliefs of classmates on math self-concepts. Several studies have indicated that girls who believe gender stereotypes that favour boys in mathematics, tend to report lower self-efficacy beliefs (Kurtz-Costes et al., 2008; Evans et al., 2011; Passolunghi et al., 2014). The negative association between peer relations and mathematics self-efficacy for boys aligns with evidence of negative race stereotypes in academics that are more strongly associated with black males than black females (Chavous et al., 2004; Evans, et al., 2011).

Gender differences also emerged in the relationship between self-efficacy (MSE) and mathematics performance. For girls, more than 70% of the total effect of MSE on performance operates specifically through intrinsic task value. For boys, the total effect of MSE on performance operates fully through utility task value. Gaspard et al. (2015) found that boys utility value depended on the specific facet of value; for example, boys reported more utility value for learning mathematics for future life and employment, whereas showed similar utility value of mathematics for school (e.g., learning other subjects) as did girls. Two institutions of higher learning in South Africa — Rhodes University[7] and the University of Pretoria — have reported a growing interest amongst girls to pursue STEM subjects. Education initiatives such as "Girls in STEM"[8] and the "African Institute for Mathematical Sciences"[9] may be playing a pivotal role in enhancing girls' involvement and motivation in STEM fields, including mathematics.

The literature has found that whilst both genders start with comparable levels of interest, motivation, and self-efficacy in mathematics during their younger years, girls tend to experience a sharper decline in their interest in mathematics compared to boys as they progress through school (Lee & Anderson, 2015). The data used by this study similarly found higher average intrinsic task value amongst Grade 9 boys, and higher average utility task value amongst Grade 9 girls. This trend challenges the recent narrative in South Africa that the gender gap in performance in STEM subjects is narrowing (Taylor et al., 2013; HSRC, 2019). The empirical results here indicated girls' intrinsic value to have a significantly larger influence on their mathematics performance, whilst the influence of boys' perception of the utility and relevance of mathematics emerged as notably stronger. This latter result is accounted for by the poorer school subsamples, whereas the finding for girls emerges most prominently in the wealthier school subsamples. In fact, utility value was found to have negligible if any influence on the mathematics performances of either boys or girls in quintile 5 schools. Conversely, the positive effect size of utility value on the mathematics performance of girls and boys in the poorest 60% of schools was estimated to approximately twice the effect size of intrinsic value.

[7] Partnership between UNICEF's Global Innovation Centre (GIC) and the Biotechnology Innovation Centre at Rhodes University.

[8] UP EBIT Week shows increasing number of female learners interested in STEM subjects**.** EBIT Week is a four-day holiday programme presented bi-annually giving Grade 10, 11, and 12 learners exposure to the Engineering faculty course offers.

[9] AIMS launched a gender-responsive Teacher Training Program to improve learning in STEM for secondary school learners, especially girls.

5.2 Socioeconomic context

These findings suggest that the factors influencing learners' performance in mathematics are deeply rooted in their socioeconomic contextual circumstances. Students from under-resourced schools tend to not only report deriving higher utility value from mathematics than their counterparts in more affluent schools but recognising the utility of mathematics for achieving future goals positively influences performance, bringing students closer to attaining those goals. Ryan and Deci (2016) assert that if a learner's personal valuation of a subject is closely tied to its utility value, it could potentially transform the act of learning into a means to an end, rather than an intrinsically motivated pursuit. Drawing on this premise and the empirical findings here — particularly those that distinguish across school socioeconomic context — it could be concluded that learners in more affluent schools possess a surplus of social capital, role models, and capabilities (Brown & Putwain, 2022), which makes them less inclined to approach mathematics learning as a means for achieving certain ends, which is more characteristic of their less privileged counterparts.

Specific school subjects tend to reflect learners deeply ingrained personal ambitions. This phenomenon is especially pertinent for learners in socioeconomically disadvantaged contexts, where the pursuit of completing their education and excelling in certain subjects serves as a steppingstone toward realising future aspirations. This notion finds resonance in the work of Fadiji and Reddy (2020) on educational aspirations among South African students, and the interplay of home and school environments in shaping these aspirations. Utility conceptions tend to highlight usefulness for the individual and independent goals (e.g., getting into university). Students from lower socioeconomic and working-class backgrounds typically identify with interdependent norms that center community connectedness and the needs of others (Grossman & Varnum, 2011).

The usefulness of mathematics for achieving *interdependent* goals — such as lifting a family out of poverty — can be particularly motivating for learners attending no-fee schools. Harackiewicz et al. (2016), for example, found first-generation students in tertiary education to emphasise their family when prompted to write essays about the relevance of mathematics for their own lives. According to the National Senior Certificate (NSC) data for 2016,[10] a significantly higher percentage of learners in quintile 1 schools enrolled to write mathematics

[10] This is the most recent data that is publicly available through the datafirst.uct.ac.za data repository.

(as opposed to mathematical literacy) in Grade 12 than did in quintile 5 schools (46.6% compared with 43.3%). Fewer than 40% of learners in quintile 3 and 4 schools enrolled for mathematics. Just two years later, the percentage of learners enrolled in mathematics in quintile 1 schools had risen to 48.1% but remained relatively constant in quintile 5 schools at 43.7% (Shepherd & Van der Berg, 2020).[11] However, fewer than 1% of girls in quintile 1 schools that enrolled in mathematics end up achieving a 70% or higher in the NSC examinations. This is compared to 3.5% of their male peers. Similar gaps are found in quintile 2 and 3 schools, where the proportion of boys achieving a 70% and higher in mathematics is threefold the proportion of girls scoring at a similar level. And although only 25% of learners in quintile 1-3 schools managed to achieve a final mark of at least 40% in the 2018 NSC, it is encouraging to note that the pass rates in these schools increased 30% (roughly 12 percentage points) between 2010 and 2018 (Shepherd & Van der Berg, 2020).

An additional factor influencing mathematics performance — and differing across socioeconomic contexts — is mathematics self-efficacy. While the effect of self-efficacy on mathematics achievement in less privileged schools is positively mediated through subjective task values, the cumulative indirect effect remains smaller — by approximately 60-70% — than that estimated for quintile 4 and quintile 5 schools. This trend emerges for both boys and girls. Yet learners — boys in particular — in the poorest school contexts report higher expectancy beliefs of success than learners in quintile 4 schools.This confidence in ability does not align with actual performance. This may signify a deficiency in adequate signalling of learners' abilities within contexts characterized by lower socioeconomic backgrounds. Drawing from the work of Dai and Rinn (2008) that hypothesizes self-efficacy to be constructed through a process of social comparison, learners in under-resourced schools might have their perceptions of ability reinforced by inadequate signaling provided in learner-teacher interactions. Alternatively, it could be a protective identity strategy whereby boys align their notions of self with explicit gender norms (Kurtz-Costes et al., 2008; McGuire et al., 2022).

The positive influence of peer relations on subjective task values and mathematics performance holds relatively greater importance for more affluent schools. It is well established that schools positioned in the upper two quintiles of the South African education system typically maintain class sizes that range from decent to average (Köhler, 2022). These smaller class sizes afford learners the opportunity to develop a sense of community and engage in more meaningful

[11] Similar proportions of the grade 12 learners enrolled for mathematics across school quintiles are female.

classroom discussions. This could expose learners to a diversity of viewpoints, including positive peer attitudes towards mathematics (Breton, 2014; Li & Konstantopoulos, 2016). The descriptive analyses presented here indicated learners attending quintile 5 schools to report significantly more favorable perceptions of their learning environments. The path analysis uncovered a small positive but statistically significant total effect of peer relations — via the mechanisms of intrinsic and utility taks values — on mathematics performance in quintile 4 and 5 schools. This result was, however, shown to exist for girls only. The total effect of classroom climate on mathematics performance was estimated to be of a greater magnitude in affluent school contexts, and indicated to only emerge significantly for boys. These discrepancies further underscore the role of cooperative spaces — characterised by reduced disorder, diminished friction, and cohesive relationships among learners and teachers (Fraser, 1994) — in enhancing student engagement and motivation for learning. These learning settings are more likely to manifest in wealthier schools as opposed to poorer schools (Bayat et al., 2017; Wills & Hofmeyr, 2019). This is supported by the work of Mupa and Chinooneka (2015) that finds schools with better resources to be better equipped to foster student engagement and sustain interest.

5.3 Teacher factors

The direct effects of perceived teacher support and engagement on affective engagement and self-efficacy were estimated to be relatively consistent in magnitude across school quintiles and gender groups. Similarly, the total effect of perceptions of teacher behaviour on mathematics performance was estimated to be of a similar magnitude across socioeconomic contexts. It is worth nothing, however, that the specific indirect effects of teacher engagement — operating through affective engagement and utility task value— were pronounced within the poorest 60% of schools, and more so for boys.

For schools serving more vulnerable communities, teacher quality indicators were found to be significantly positively related to learning cognitive processes and outcomes. The perceptions of a supportive and engaging learning environment, subjective task values and mathematics performance of learners from socioecnomically vulnerable backgrounds — and boys in particular — were estimated to be positively determined by teacher experience. In order to deliver insightful instruction, teachers must — over and above content area knowledge — possess the ability to self-regulate and activate their own beliefs to effectively fulfill their professional duties (Dembo, 2001). Ghonsooly and Ghanizadeh (2011) find self-regulation strategies to be positively correlated with age and experience, and self-regulatory skills have been shown to be closely linked to students' learning and achievement (Zimmerman & Schunk, 2001).

Learners in the poorest 60% of schools taught by recent graduates with less than six years of teaching experience were shown to perceive significantly more supportive and accommodating learning environments than their peers taught by older teachers. Younger teachers may possess a disposition that produces positive interpersonal interactions with adolescents and encourages a culturally responsive pedadogy (Gay, 2010; Warren-Grice, 2017). Moreover, exposure to younger degreed teachers in the poorest 60% of schools was also indicated to predict higher mathematics performance. This is in line with the findings of a large body of empirical research that show productivity gains of teachers to be greatest during their first few years of teaching (Rice, 2013), and supports existing findings for SA that younger teachers yield superior mathematics performance amongst grade 6 South African learners (Armstrong, 2015). The effect size of 11.6% of a standard deviation is in line with Atteberry et al. (2012) who estimated teachers in their fifth year of teaching to realise learner performance that was between 5-15% of a standard deviation higher than the performance levels of more experienced teachers and teachers in their first year of teaching.

One explanation for the better mathematics performance of learners taught by younger teachers is the superior mathematics content knowledge, as has been found by Venkat and Spaull (2015) using the SACMEQ 2007 data and Spaull and Courtney (2022) using the SACMEQ 2013 data. Other research has pointed toward the role of teacher training, particularly as it relates to assessment procedures and academic preparation (Reynolds-Keefers, 2010; Xu & Brown, 2016). Teacher pre-service and development training programmes need to emphasise the process of learning and how learning can be assessed, as a lack of appropriate training can result in teachers designing and developing assessment tasks that are too focused on learning outcomes, and are misaligned with national curriculum (Kanjee & Sayed, 2013). Advancements in pre-service training may provide younger teachers with better-prepared classroom skills. It is, however, important to consider the confounding effect of teacher attrition related to teacher equality; that is, teachers who leave teaching a few years into starting may be differentially effective than those who remain. The decision to leave teaching may also be differently motivated across socioeconomic contexts.

According to Shalem and De Clerq (2019), initial post-1994 curriculum and assessment policies in SA underspecified subject content matter, pacing and progression. This left much of the work of the design and implementation of learning programmes and lessons plans to teachers, many of whom had been disadvantaged by weak pedagogical training during the apartheid era (Taylor & Vinjevold, 1999). From 1998, training focussed predominantly on conveying an outcomes-based curriculum philosophy, with content knowledge, teaching modes and curriculum sequencing/pacing taking less precidence (De Clercq and Shalem, 2014). This approach left teachers feeling unsupported and overwhelmed, and increased demand for practical competences and guidance on content and assessment (Council on Higher Education 2010). The move away from Outcomes-Based Education to the Curriculum and Assessment Policy Statement (CAPS) centred teacher develoent around "deep knowledge structures embodied in instructional knowledge" (Taylor 2002). Since 2010, large-scale school-based systemic change programmes — specifically targeted at teachers from poorly performing, worse resourced schools — have provided teachers with scripted and standardized lesson plans, coaching to regulate teaching practices, and frameworks of accountability and support. These programmes have been shown to lead to some improvement in learner performance (Fleisch & Schöer 2014; Fleisch 2016).

5.4 Limitations and Generalisability

Some of the item response scales used in the TIMSS 2019 contextual questionnaires are revisions on the 2011 and 2015 questionnaires. Although the questions have largely remained the same, the change in response types creates some challenges for cross-time analyses of social cognitive constructs on academic performance. The construction of the measures used in this study were, although informed by theory, partially based on the author's intuition of factors that would load onto certain psychological and cognitive processes. The batteries of questions used in TIMSS are not necessarily designed to be psychological evaluations, but merely a survey to determine the context under which learners are taught mathematics and science, and their perceptions of, for example, the instructional ability of the teachers.

The measure of socioeconomic status constructed in this study was narrowly defined (i.e., included household assets and access to learning aides at home), and could have been expanded to include parental education and occupation. However, a large proportion of learners in the South African sample for TIMSS 2019 did not provide complete parent education and occupation information. In addition to missing information on parental education and occupation, the inclusion of other important confounding variables — such as the race and/or ethnicity of the learners, province of origin, and a host of other teacher-specific variables — may potentially refine the current results. This should be considered for future research.

The correlational nature of the of the datasets should raise some questions about the external validity of the results (Eriksson et al., 2019); that is, whether the results can be generalised irrespective of the time and place of the questionnaire was conducted. However, the advantage of the TIMSS dataset is that an entire class within a randomly selected school is sampled (based on stratified random sampling), and learners' beliefs, perceptions and experiences can be linked to features of the teacher and classroom. This partially addresses issues of confoundedness in analysing relationships between classroom factors and academic performance (Eriksson et al., 2019).

Finally, the study at hand does not address the causal ordering of the expectancy and value constructs in relation to short-term outcomes (e.g., test performance) and longer-term outcomes (e.g., future career aspirations). This type of analysis would require longitudinal data — preferably collected at different phases of basic education. Future studies could observe a cohort of learners over time to determine the causal nature of the relationships posited by this working paper.

6. Conclusion

Concerted efforts to bridge racial, class and gender gaps within the South African education system has leaned towards physical and financial resources. This inadvertently sidelines the vital intangible resources that learners from vulnerable contexts — irrespective of gender — require to transcend the challenges and stereotypes associated with academic engagement, expectations of success, and subjective task value. Utilizing the S-EVT framework, this study aimed to address important gaps in the South African literature on the cognitive processes and learning outcomes in mathematics. Specifically, the study aimed to investigate the relationships between contextual factors in the classroom, learners' motivation, and mathematics performance, with cognizance given to the social and cultural boundedness of these relationships. The findings of this study, then, add to the evidence on the dynamic and symbiotic relationship between teachers, learners, and schools in mathematics education. Specifically, that engagement, task value and successful outcomes in mathematics are nurtured within an emotional ecosystem where students — through an instilled sense of competence and interest — forge a genuine bond with the subject.

The findings of this study highlight the importance of recognizing that disparities in educational achievement extend beyond school and class boundaries; they are also notably influenced by social class positions and entrenched gender norms. Schools faced with resource constraints may grapple with creating a learning atmosphere and fostering socialiser relationships that are conducive to collaborative learning. But, if successful, learners in these contexts can derive greater interest in and heightened utility from mathematics that can support future aspirations and socioeconomic mobility. In more affluent settings, interest takes precedence. This can arguably be achieved with smaller class sizes that encourage the exchange of diverse perspectives, and bolster peer attitudes toward mathematics and academic performance in general.

Amidst the strides made in fostering women's participation in STEM fields through dedicated initiatives, an overlooked aspect remains — motivating boys, especially those from disadvantaged backgrounds, to thrive through educational pursuits. Prevailing societal stereotypes often cast boys as academic underachievers; a narrative amplified by media and social portrayal. This compels boys to align their learning aspirations with their gender identities. For boys from marginalized backgrounds, this could translate to a focus on securing employment rather than further learning and post-secondary education. Similarly, boys from more affluent socioeconomic backgrounds might perceive educational attainment merely to achieve the benchmarks set by other male role models in society.

Perceptions of a supportive and engaged learning environment and a sense of school belonging emerged as significant determinants of utility value and performance amongst boys, and particularly those in under-resourced schools. This might be an assertion against prevailing stereotypes, and a demonstration of their need for validation within this domain. The mathematical proficiency of girls, on the other hand, is enabled through instruction that instils personal interest, particularly in a discipline often stigmatized by gender norms. Utilizing community-based approaches can enhance how boys *and* girls perceive school, and their aspirations for further education. Collaboration with the community through involving parents, universities, and local businesses can introduce cultural practices that interact with notions of gender identity and gender norms. This collaboration could also offer learners opportunities for practical learning experiences and exposure to university opportunities.

The evidence presented here has indicated the importance of retaining skilled educators — particularly those with specialized expertise in mathematics and the mastery in pedagogical knowledge — in schools that serve more vulnerable communities. Retaining younger teachers in the system is preferable, given the positive total effects of recent university graduates *and* experienced teachers. The effectiveness of quality teachers in maintaining or boosting positive learning dimensions while minimizing negative aspects has been recognized by the Australian Government Department of Education, Science and Training (2012) as an effective strategy to improve motivation and engagement in learning, particularly amongst boys. This might call for a broader reimagining of the teaching profession in South Africa. Offering degree-specific incentives to individuals who wish to venture into teaching after pursuing non-teaching STEM-based qualifications could render the path to teaching more enticing. Typically, teacher attraction strategies should involve an appeal to an individual's motivation to pursue the career, which includes a motivation of personal utility or social utility.

The former alludes to the individual receiving a grant or bursary for training, a higher salary, and a favourable working environment (Klassen et al., 2023). For instance, a study conducted in the US highlighted forgiving student debt as an effective strategy to enhance overall compensation, thereby contributing to the attraction of a teaching position. This approach, along with various financial incentives — such as housing benefits, salary increases, and continued retirement advantages — forms a comprehensive set of tactics to attract teachers. Stuart et al. (2011) found that a significant number of university students from low socio-economic status (SES) backgrounds in the UK engaged in substantial paid employment during their academic studies. Consequently, the government introduced a paid internship initiative for students enrolled in STEM disciplines. This program aimed to provide STEM students with a platform to delve into science education during their academic journey. A pivotal aspect of this initiative was that it furnished students with the opportunity to assess the viability of pursuing a career in science teaching prior to committing to pursuing a post-graduate teaching certificate.

Addressing these challenges necessitates a holistic approach that integrates tangible and intangible resources — such as cultural capital — that focuses on cultivating genuine educational aspirations and re-evaluates prevailing stereotypes. While obtaining a National Senior Certificate certainly sets learners apart — and improves future employability and earnings (Branson & Leibbrandt, 2013; van Broekhuizen, 2016) — it doesn't inherently translate into enriched educational aspirations. In other words, an emphasis on boosting the volume of secondary education qualifications risks eclipsing the imperative of elevating inclusiveness. Through comprehensive and collaborative efforts, the South African education system stands to nurture a diverse cohort of learners poised to flourish within a modern and inclusive society.

References

Abe, E. N. and Chikoko, V. (2020). Exploring the factors that influence the career decision of STEM students at a university in South Africa. International *Journal of STEM Education*, *7*(1), 1-14.

Akey, T. M., 2006. *School context, student attitudes and behavior, and academic achievement: An exploratory analysis*. New York: MDRC.

Akyol, G., Sungur, S. and Tekkaya, C., 2010. The contribution of cognitive and metacognitive strategy use to students' science achievement. *Educational Research and Evaluation, 16*(1), pp. 1-21.

Al-Bashir, M., Kabir, R. and Rahman, I., 2016. The value and effectiveness of feedback in improving students' learning and professionalizing teaching in higher education. *Journal of Education and Practice, 7*(16), pp. 38-41.

Visser, M. and Arends, F., 2019. The contribution of South African teachers to students' sense of belonging and mathematics achievement: Students' perspective from the 2015 Trends in International Mathematics and Science Study. *South African Journal of Childhood Education*, *9*(1), pp. 1-11.

Armstrong, P., 2015. Teacher characteristics and student performance: An analysis using hierarchical linear modelling. *South African Journal of Childhood Education*, *5*(2), pp. 124-145.

Atkinson, J. W., 1957. Motivational determinants of risk taking behavior. *Psychological Review, 64*, pp. 359-372.

Atteberry, A., Loeb, S. and Wyckoff, J. H., 2012. Do first impressions matter? Improvements in early teacher effectiveness. Paper presented at the Association for Public Policy Analysis & Management Fall Research Conference, Baltimore, MD.

Ayllon, S., Alsina, A. and Colomer, J., 2019. Teachers' ' involvement and students' self-efficacy: Keys to achievement in higher education. *PloS One, 14*(5), e0216865.

Bandura, A., 1977. Self-efficacy: Towards a unifying theory of behavioral change. *Psychological Review, 84*.

Bandura, A., 1986. *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Barlow, A., Brown, S., Lutz, B. and Pitterson, N., 2020. Development of the student course cognitive engagement instrument (SCCEI) for college engineering courses. *International Journal of STEM Education, 7*(1), pp. 1-20.

Bayat, A., Louw, W. and Rena, R., 2017. The impact of socio-economic eactors on the performance of selected high school learners in the Western Cape province, South Africa. *Journal of Human Ecology, 45*(3), pp. 183-196.

Berry, B., Daughtrey, A. and Wieder, A., 2009. *Collaboration: Closing the effective teaching gap.* Chapel Hill: Center for Teaching Quality.

Bircan, H. and Sungur, S., 2016. The role of motivation and cognitive engagement in science achievement. *Science Education International, 27*(4), pp. 509-529.

Branson, N. and Leibbrandt, M., 2013. Educational attainment and labour market outcomes in South Africa, 1994-2010. OECD Economics Department Working Papers.

Breton, T. R., 2014. Evidence that class size matters in 4th grade mathematics: An analysis of TIMSS 2007 data for Colombia. *International Journal of Educational Development, 34*, pp. 51-57.

Britner, S.L. and Pajares, F., 2006. Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *43*(5), pp. 485-499.

Brown, C. and Putwain, D. W., 2022. Socio-economic status, gender and achievement: the mediating role of expectancy and subjective task value. *Educational Psychology, 42*(6), pp. 730-748.

Byrne, B. M., 2010. *Structural equation modeling with Amos: Basic concepts, applications, and programming.* 2nd Edition ed. New York: Taylor and Francis Group.

Cardwell, M. E., 2011. *Patterns of relationships between teacher engagement and student engagement,* New York: St. John Fisher University Digital Publications.

Chaffee, K. E. an Plante, I., 2021. How parents’ stereotypical beliefs relate to students’ motivation and career aspirations in mathematics and language arts. *Frontiers in Psychology, 12*, p. 796073.

Chavous, T.M., Harris, A., Rivas, D., Helaire, L. and Green, L., 2004. Racial stereotypes and gender in context: African Americans at predominantly Black and predominantly White colleges. *Sex Roles*, *51*, pp. 1-16.

Cheng, A., Kopotic, K. and Zamarro, G., 2019. Parental Occupational Choice and Children's Entry into a Stem Field. *EDRE Working Paper No. 2019-16*, Available at SSRN: https://ssrn.com/abstract=3457307.

Chi, M. T. and Wylie, R., 2014. The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), pp. 219-243.

Chong, W.H., Liem, G.A.D., Huan, V.S., Kit, P.L. and Ang, R.P., 2018. Student perceptions of self-efficacy and teacher support for learning in fostering youth competencies: Roles of affective and cognitive engagement. *Journal of Adolescence, 68*, pp. 1-11.

Connell, J. P., 1990. Context, self, and action: a motivational analysis of self-system processes across the life span. In: D. Chicchetti & M. Beeghly, eds. *The self in transition: infancy to childhood.* Chicago, IL: University of Chicago Press, pp. 61-97.

Council on Higher Education. (2010). *Report on the national review of academic and professional programmes in education.* HE Monitor No 11. Pretoria: CHE.

Cresswell, C. and Speelman, C. P., 2020. Does mathematics training lead to better logical thinking and reasoning? A cross-sectional assessment from students to professors. *PLoS One, 15(*7), e0236153.x

Csikszenthmihalyi, M., 1997. *Finding flow: The psychology of engagement with everyday life.* First ed. New York: Basic Books.

Cunningham, M., 1999. African American adolescent males' perceptions of their community resources and constraints: A longitudinal analysis. *Journal of Community Psychology*, *27*(5), pp. 569-588.

Dai, D. and Rinn, A. N., 2008. The big-fish-little-pond effect: What do we know and where do we go from here?. *Educational Psychology, 20*(3), pp. 283-317.

Darling-Hammond, L., 2001. Inequality in teaching and schooling: How opportunity is rationed to students of color in America. In: BD Smedley, AY Stith, L. Colburn, C. & H. Evans (Eds.), *The right thing to do—The smart thing to do*. National Academies Press, pp.208-233.

De Clercq, F. and Shalem, Y., 2014. Teacher knowledge and employer-driven professional development: A critical analysis of the Gauteng Department of Education programmes. *Southern African Review of Education with Education with Production*, *20*(1), pp. 129-147.

Deci, E. L., and Ryan, R. M., 1985. *Intrinsic motivation and self-determination in human behavior,* New York: Plenum.

Deci, E. L., and Ryan, R. M., 2000. What is the self in self-directed learning? Findings from recent motivational research. In: G. Staka, ed. *Conceptions of self-directed learning: Theoretical and conceptual considerations.* Munster: Waxmann.

Dembo, M.H., 2001. Learning to teach is not enough—Future teachers also need to learn how to learn. *Teacher Education Quarterly*, *28*(4), pp. 23-35.

Department of Basic Education (DBE), 2014. *Report on the annual national assessment of 2014.* Pretoria: Department of Basic Education .

Dietrich , J., Viljaranta, J., Moeller, J., and Kracke, B., 2017. Situational expectancies and task values: Associations with students' effort. *Learning and Instruction, 47*, pp. 53-64.

Ding, H., Sun, H. and Chen, A., 2013. Expectancy-value and situational interest motivation specificity on engagement and achievement outcomes in physical education. *Journal of Teaching in Physical Education, 32*(3), pp. 253-269.

du Plessis, P., and Mestry, R., 2019. Teachers for rural schools - A challenge for South Africa. *South African Journal of Education, 39*(1), pp. S1-S9.

Eccles, J. S., 1983. Expectancies, values and academic behaviors. In: J. T. Spence, ed. *Achievement and achievement motives: Psychological and sociological approaches.* San Francisco: CA: Free Man, pp. 75-146.

Eccles, J. S., 1984. Sex differences in achievement patterns. In: T. Sonderegger, ed. *Nebraska symposium on motivation.* Lincoln, NE: University of Nebraska Press, pp. 97-132.

Eccles, J. S., 1986. Gender-roles and women's achievement. *Educational Researcher*, *15*(6), pp. 15-19.

Eccles, J. S., 2005. Subjective task values and the Eccles et al. model of achievementrelated choices. In: A. J. Elliot & C. S. Dweck, eds. *Handbook of competence and motivation.* New York: Guilford, pp. 105-121.

Eccles, J. S., 2007. Subjective task value and the Eccless et al. model of achievement-related choices. In: A. J. Elliot & C. S. Dweck, eds. *Handbook of competence and motivation.* New York: Guildford Press, pp. 105-121.

Eccles, J. S., and Jacobs, J. E., 1986. Social forces shape math attitudes and performance. *Signs: Journal of Women in Culture and Society*, *11*(2), 367-380.

Eccles, J.S., Jacobs, J.E. and Harold, R.D., 1990. Gender role stereotypes, expectancy effects, and parents' socialization of gender differences. *Journal of Social Issues*, *46*(2), pp.183-201.

Eccles, J. S., and Wigfield, A., 2020. From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology, 61*, p. 101859.

Edwards, O. V. and Taasoobshirazi, G., 2022. Social presence and teacher involvement: The link with expectancy, task value, and engagement. *The Internet and Higher Education, 55*, p. 100869.

Eriksson, K., 2020. Gender Differences in the Interest in Mathematics Schoolwork Across 50 Countries. *Frontiers in Psychology*, *11*, p.578092.

Eriksson, K., Helenius, O. and Ryve, A., 2019. Using TIMSS items to evaluate the effectiveness of different instructional practices. *Instructional Science, 47*, pp. 1-18.

Evans, A. B., Copping, K. E., Rowley, S. J. and Kurtz-Costes, B. 2011. Academic self-concept in black adolescents: do race and gender stereotypes matter? *Self Identity, 10*, pp. 263–277.

Fadiji, A. W. & Reddy, V., 2020. Learners' educational aspirations in South Africa: The role of the home and the school. South African Journal of Education, 40(2), pp. 2076-3433.

Fadiji, A. W. & Reddy, V., 2021. School and individual predictors of mathematics achievement in South Africa: The mediating role of learner aspirations. *African Journal of Research in Mathematics, Science and Technology Education*, *25*(1), pp. 65-76.

Fadiji, A. W. & Reddy, V., 2023. Well-being and mathematics achievement: What is the role of gender, instructional clarity, and parental involvement?. *Frontiers in Psychology*, *13*, 1044261.

Fan, W. and Williams, C.M., 2010. The effects of parental involvement on students' academic self-efficacy, engagement and intrinsic motivation. *Educational Psychology*, *30*(1), pp. 53-74.

Festinger, L., 1954. A theory of social comparison processes. *Human Relations, 7*(2), pp. 117-140.

Feza, N. N., 2014. *Good intentions are not actions: Mathematics education of South Africa demands action And pride from citizenry,* Phalaborwa: UNISA Press.

Fields, A., 2005. *Discovering statistics using SPSS.* 2nd Edition ed. London: Sage Publications.

Finn, J. D. and Voelkl, K. E., 1993. School characteristics related to school engagement. *Journal of Negro Education, 62*, pp. 249-268.

Fleisch, B., 2016. System-wide improvement at the instructional core: Changing reading teaching in South Africa. *Journal of Educational Change*, *17*, pp. 437-451.

Fleisch, B. and Schoer, V., 2014. Large-scale instructional reform in the Global South: insights from the mid-point evaluation of the Gauteng Primary Language and Mathematics Strategy. *South African Journal of Education*, *34*(3), pp. 1-12.

Fraser, B. J., 1994. Research on classroom and school climate. In: D. Gabel, ed. *Handbook of research on science teaching and learning.* New York: Macmillan, pp. 493-541.

Fredricks, J. A., Blumenfeld, P. C. and Paris, A. H., 2004. School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), pp. 59-109.

Galambos, N.L., 2004. Gender and gender role development in adolescence. In: R. M. Lerner and L. Steinberg, ed. *Handbook of Adolescent Psychology*. John Wiley & Sons, Inc. pp. 233-262.

Galungu, N. S., 2019. Academic self-concept, teacher's support and student's engagement in the school. *Journal of Psikologi Pendidkan & Konseling, 5*(2), pp. 141-147.

Gamage, K. A., Dehideniya, D. M. and Ekanayake, S. Y., 2021. The role of personal values in learning approaches and student achievements. *Behavioral Sciences, 11*(7), pp. 102.

Gašević, D., Jovanović, J., Pardo, A. and Dawson, S., 2017. Detecting learning strategies with analytics: Links with self-reported measures and academic performance. *Journal of Learning Analytics, 4*(2), pp. 113-128.

Gaspard, H., Dicke, A.L., Flunger, B., Schreier, B., Häfner, I., Trautwein, U. and Nagengast, B., 2015. More value through greater differentiation: Gender differences in value beliefs about math. *Journal of Educational Psychology, 107*(3), pp. 663-677.

Gates, P. & Vistro-Yu, C. P., 2011. Is mathematics for all?. In: *International handbook of mathematics education.* s.l.:Springer.

Gay, G., 2014. Teachers' beliefs about cultural diversity: Problems and possibilities. In: H. Fives and M. G. Gill eds., *International Handbook of Research on Reachers' Beliefs* (pp. 436-452). Routledge.

Gellert, U., Jablonka, E., and Keitel, C., 2001. Mathematical literacy and common sense in mathematics education. In: B. Atweh, H. Forgasz & B. Nebres, eds. *Sociocultural research in mathematics education.* s.l.:Lawrence Erlbaum Associates.

Gerber, C., Mans-Kemp, N., and Schlechter, A. F., 2019. Investigating the moderating effect of student engagement on academic performance. *Acta Academica, 45*(4), pp. 256-274.

Ghonsooly, B. and Ghanizadeh, A., 2011. Self-efficacy and self-regulation and their relationship: a study of Iranian EFL teachers. *The Language Learning Journal*, *41*(1), pp. 68-84.

Gor, P.O., Othuon, L.O.A. and Migunde, Q.A., 2020. Gender Difference in the Relationship between Self-Efficacy and Performance in Science among Secondary School Students in Migori County, Kenya, Education. *Society and Human Studies*, *1*(2), pp. 154-170.

Goto, T., 2023. Brief research report: The impact of a utility-value intervention on students' engagement. *The Journal of Experimental Education,* https://doi.org/10.1080/00220973.2023.2229757.

Grossmann, I. and Varnum, M. E. 2011. Social class, culture, and cognition. *Social Psychological and Personality Science*, *2*(1), pp. 81–89.

Gunderson, E.A., Ramirez, G., Levine, S.C. and Beilock, S.L., 2012. The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, *66*, pp. 153-166.

Gutfleisch, T., & Kogan, I. (2022). Parental occupation and students' STEM achievements by gender and ethnic origin: Evidence from Germany. *Research in Social Stratification and Mobility*, *82*, 100735.

Han, K., 2021. Fostering students' autonomy and engagement in EFL classroom through proximal classroom factors: Autonomy-supportive behaviors and student-teacher relationships. *Frontiers in Psychology, 12*, e767079.

Harackiewicz, J.M., Smith, J.L. and Priniski, S.J., 2016. Interest matters: The importance of promoting interest in education. *Policy Insights From the Behavioral and Brain Sciences*, *3*(2), pp. 220-227.

Harris, K. R., and Graham, S., 1999. Programmatic intervention research: Illustrations from the evolution of self-regulated strategy development. *Learning Disability Quarterly, 22*(4), pp. 251-262.

Hayat, A. A., Shateri, K., Amini, M. and Shokrpour, N., 2020. Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: a structural equation model. *BMC Medical Education, 20*, p. 76.

Heller, R., Calderon, S. and Medrich, E., 2003. *Academic achievement in the middle grades: What does research tell us? A review of the literature,* Atlana, GA: Southern Regional Education Board.

Henderson, J. B., 2019. Beyond "active learning": How the ICAP framework permits more acute examination of the popular peer instruction pedagogy. *Havard Educational Review, 89*(4), pp. 611-634.

Heyder, A. and Kessels, U., 2017. Boys don't work? On the psychological benefits of showing low effort in high school. *Sex Roles*, *77*, pp.72-85.

Howie, S. J., 2005. Contextual factors at the school and classroom level related to pupils' performance in mathematics in South Africa. *International Journal on Theory and Practice*, *11*(2), pp. 123-140.

HSRC, 2019. *TIMSS 2019: Highlights of South African grade 9 results in mathematics and science.* Pretoria: Department of Basic Education.

Hudley, C. and Graham, S., 2001. Stereotypes of achievement striving among early adolescents. *Social Psychology of Education*, *5*(2), pp. 201-224.

Hughes, J. N. and Chen, Q., 2011. Reciprocal effects of student–teacher and student–peer relatedness: Effects on academic self efficacy. *Journal of Applied Developmental Psychology, 32*(5), pp. 278-287.

Isdale, K., Reddy, V., Juan, A. and Arends, F., 2017. *TIMSS 2015 Grade 5 national report: understanding mathematics achievement amongst Grade 5 learners in South Africa: nurturing green shoots*. Cape Town: HSRC Press.

Jacobs, J.E., Chhin, C.S. and Bleeker, M.M., 2006. Enduring links: Parents' expectations and their young adult children's gender-typed occupational choices. *Educational Research and Evaluation*, *12*(4), pp. 395-407.

Jacobs, J. A., Ahmad, S., & Sax, L. J. 2017. Planning a career in engineering: Parental effects on sons and daughters. *Social Sciences*, *6*(1), pp. 1-25.

Jojo, Z., 2019. Mathematics education system in South Africa. In: G. Porto, ed. *Education Systems Around the World.* Palmas: Intechopen, pp. 1-11.

Juan, A., Hannan, S. and Namome, C., 2018. I believe I can do science: Self-efficacy and science achievement of Grade 9 students in South Africa. *South African Journal of Science*, *114*(7-8), pp. 48-54.

Klassen, R.M., Granger, H. and Bardach, L., 2023. Attracting prospective STEM teachers using realistic job previews: A mixed methods study. *European Journal of Teacher Education*, *46*(3), pp. 533-555.

Kline, R. B., 2015. *Principles and practice of structural equation modeling.* New York: Guildford Press.

Knogler, M., Harackiewicz, J. M., Gegenfurtner, A., and Lewalter , D., 2015. How situational is situational interest? Investigating the longitudinal structure of situational interest. *Contemporary Educational Psychology, 43*, pp. 39-50.

Köhler, T., 2022. Class size and learner outcomes in South African schools: The role of school socioeconomic status. *Development Southern Africa*, *39*(2), pp. 126-150.

Kurtz-Costes, B., Rowley, S. J., Harris-Britt, A., & Woods, T. A. 2008. Gender stereotypes about mathematics and science and self-perceptions of ability in late childhood and early adolescence. *Merrill Palmer Quarterly*, *54*, pp. 386–409.

Lam, S. F., Wong, B. P., Yang, H. and Liu, Y., 2012. Understanding student engagement with a contextual model.. In: S. L. Christenson, A. L. Reschly & C. Wylie, eds. *Handbook of Research on Student Engagement.* Boston, MA: Springer.

Lee, K. and Anderson, J., 2015. Gender Differences in Mathematics Attitudes in Coeducational and Single Sex Secondary Education. Paper presented at the Annual Meeting of the Mathematics Education Research Group of Australasia (MERGA), Sunshine Coast, Queensland, Australia.

Lee, T. and Shi, D., 2021. A comparison of full information maximum likelihood and multiple imputation in structural equation modeling with missing data. *Psycholgical Methods, 26*(4), pp. 466-485.

Lei, H., Cui, Y. and Zhou , W., 2018. Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality, 46*(3), pp. 517-528.

Li, W. and Konstantopoulos, S., 2016. Class size effects on fourth-grade mathematics achievement: Evidence from TIMSS 2011. *Journal of Research on Educational Effectiveness, 9*(4), pp. 503-530.

Lim, J., Ko, H., Yang, J. W., Kim, S., Lee, S., Chun, M. S., ... and Park, J. 2019. Active learning through discussion: ICAP framework for education in health professions. *BMC Medical Education, 19*(477).

Linnenbrink, E. A. and Pintrich, P. R., 2003. The role of self-efficacy beliefs in student engagement and learning in the classroom. *Reading & Writing Quarterly, 19*, pp. 119-137.

Määttä, K. and Uusiautti, S., 2020. Nine contradictory observations about girls' and boys' upbringing and education – The strength-based approach as the way to eliminate the gender gap. *Frontiers of Education, 5*(134).

Mabena, N., Mokgosi, P. N., and Ramapela, S. S., 2021. Factors contributing to poor learner performance in mathematics: A case of selected schools in Mpumalanga province, South Africa. *Problems of Education in The 21st Century, 79*(3), pp. 451-465.

Malmberg, L.E., Walls, T.A., Martin, A.J., Little, T.D. and Lim, W.H., 2013. Primary school students' learning experiences of, and self-beliefs about competence, effort, and difficulty: Random effects models. *Learning and Individual Differences, 28*, pp. 54-65.

Marchand, G. C. and Gutierrez, A. P., 2017. Processes involving perceived instructional support, task value, and engagement in graduate education. *The Journal of Experimental Education, 85*(1), pp. 87-105.

Marsh, H. W., 1986. Global self-esteem: Its relation to specific facets of self-concept and their importance. *Journal of Personality and Social Psychology, 51*(6).

Marsh, H. and Craven, R., 2006. Reciprocal effects of self-concept and performance from a multidimensional perspective: Beyond seductive pleasure and unidimensional perspectives. *Perspectives on Psychological Science, 1*(2), pp. 133-163.

Martin, M. O., von Davier, M. and Mullis, I. V., 2020. *Methods and procedures: TIMSS 2019 Technical Report.,* Amsterdam: International Association for the Evaluation of Educational Achievement.

McGuire, L., Hoffman, A.J., Mulvey, K.L., Hartstone-Rose, A., Winterbottom, M., Joy, A., Law, F., Balkwill, F., Burns, K.P., Butler, L. and Drews, M., (2022). Gender stereotypes and peer selection in STEM domains among children and adolescents. *Sex Roles*, *87*, pp. 455–470.

Meyer, J., Fleckenstein, J. and Köller, O., 2019. Expectancy value interactions and academic achievement: Differential relationships with achievement measures. *Contemporary Educational Psychology, 58*, pp. 58-74.

Midgley, C., Kaplan, A. and Middleton, M. J., 2001. Performance-approach goals: Good for what, for whom, under what circumstances, and at what cost?. *Journal of Education Psychology, 93*, pp. 77-86.

Mohamad, N. and Osman, K., 2017. Self efficacy as mediator between learning and behaviour among in-service science teachers training programme of higher order thinking skills. *The Eurasia Proceedings of Educational & Social Sciences, 6*, pp. 177-188.

Möller, J., Zitzmann, S., Helm, F., Machts, N. and Wolff, F., 2020. A meta-analysis of relations between achievement and self- concept. *Review of Educational Research, 90*(3), pp. 376-419.

Montoya, A., 2021. *Mediation, moderation, and conditional process analysis,* s.l.: Statistical Horizons.

Motsa, N., 2018. Vulnerable femininities: Implications for rural girls' schooling experiences in Swaziland. *Educational Research for Social Change*, *7*(2), pp. 102-116.

Mupa, P. and Chinooneka, T. I., 2015. Factors contributing to ineffective teaching and learning in primary schools: Why are schools in decadence? *Journal of Education and Practice, 6*(19), pp. 125-132.

Mwakapenda, W., 2008. Understanding connections in the school mathematics curriculum. *South African Journal of Education, 28*, pp. 189-202.

Nazamud-din, A., Zaini, M. H. and Jamil, N. H., 2020. The relationship of affective, behavioral and cognitive engagements in ESL higher learning classroom. *English Language Teaching and Linguistics Studies, 2*(4), p. 48.

Nichols, S.L. and Good, T.L., 1998. Students’ perceptions of fairness in school settings: A gender analysis. *Teachers College Record*, *100*(2), pp. 369-401.

Ntombela, S., 2011. The progress of inclusive education in South Africa: Teachers' experience in a selected district, KwaZulu-Natal. *Improving Schools, 14*(1), pp. 5-14.

Özdemir, N., Ayral, M., Fındık, L.Y., Ünlü, A., Özarslan, H. and Bozkurt, E., 2014. The relationship between students’ socioeconomic status and their Turkish achievements. *Procedia-Social and Behavioral Sciences*, *143*, pp. 726-731.

Olasehinde-Williams, F., Yahaya, L. and Owolabi, H., 2018. Teachers' knowledge indices as predictors of secondary school students' academic achievement in Kwara State, Nigeria. *Journal of Education, 6*(1), pp. 73-90.

Olivier, E., Archambault, I., De Clercq, M. and Galand, B., 2019. Student self-efficacy, classroom engagement, and academic achievement: Comparing three theoretical frameworks. *Journal of Youth and Adolescence , 48*, pp. 326-340.

Pajares, F. and Schunk, D. H., 2006. Self-efficacy and self-concept beliefs. In: H. Marsh, R. G. Craven & D. M. McInerney, eds. *New Frontiers for Self Research.* s.l.:IAP.

Passolunghi, M. C., Ferreira, T. I. R. and Tomasetto, C. 2014. Math–gender stereotypes and math-related beliefs in childhood and early adolescence. *Learning and Individual Differences, 34*, pp. 70–76.

Pekrun, R. and Stephens, E. J., 2010. Achievement emotions: A control-value approach. *Social and Personality Psychology Compass, 4*(4), pp. 238-255.

Pieterinen, J., Soini, T., and Pyhältö, K., 2014. Students’ emotional and cognitive engagement as the determinants of well-being and achievement in school. *International Journal of Educational Research, 67*, pp. 40-51.

Raufelder, D., and Kulakow, S., 2021. The role of the learning environment in adolescents’ motivational development. *Motivation and Emotion, 45*, pp. 299-311.

Ravindran, B., Greene, B. A. and Debacker, T. K., 2005. Predicting preservice teachers' cognitive engagement with goals and epistemological beliefs. *The Journal of Educational Research, 98*(4), pp. 222-233.

Reddy, V. 2021. 25 years of TIMSS in South Africa: Improved achievements but pace of improvement is slowing. *HSRC Review*, *19*(2), 1–7.

Reeve, J., 2013. How students create motivationally supportive learning environments for themselves: The concept of agentic engagement. *Journal of Educational Pyschology, 105*(3), pp. 579-595.

Reynolds-Keefers, L., 2010. Rubric-referenced assessment in teacher preparation: An opportunity to learn by using. *Practical Assessment, Research and Evaluation*, *15*(8), pp. 1–9.

Rice, J.K., 2013. Learning from experience? Evidence on the impact and distribution of teacher experience and the implications for teacher policy. *Education Finance and Policy*, *8*(3), pp. 332-348.

Rimm-Kaufman, S.E., Curby, T.W., Grimm, K.J., Nathanson, L. and Brock, L.L., 2009. The contribution of children's self-regulation and classroom quality to children's adaptive behaviors in the kindergarten classroom. *Developmental Pyschology, 45*(4), pp. 958-972.

Roeser, R. W., Eccles, J. S. and Sameroff, A. J., 1998. Academic and emotional functioning in early adolescence: longitudinal relations, patterns, and prediction by experience in middle school. *Development and Psychopathology, 10*, pp. 321-352.

Rosenzweig, E. Q., Wigfield, A. and Eccles, J. S., 2019. Expectancy-value theory and its relevance for student motivation and learning. In: K. A. Renninger, ed. *The Cambridge handbook of motivation and learning.* Cambridge: Cambridge University Press, pp. 617-644.

Rotgans, J. I. and Schmidt, H. G., 2010. The motivated strategies: The relationship between university students' metacognition and their performance. *Studies in Higher Education, 19*(3), pp. 359-366.

Rühle, R., 2022. Mind the gap – an analysis of gender differences in mathematics and science achievement in South Africa. Stellenbosch Economic Working Paper 04/2022, Stellenbosch University.

Ryan , R. M. and Deci, E. L., 2016. Facilitating and hindering motivation, learning, and well-being in schools: Research and observations from self-determination theory. In: K. R. Wentzel & D. B. Miele, eds. *Handbook of motivation at school.* New York: Routledge, pp. 96-119.

Sánchez, B., Colón, Y. and Esparza, P., 2005. The role of sense of school belonging and gender in the academic adjustment of Latino adolescents. *Journal of youth and Adolescence*, *34*, pp. 619-628.

Sani, A. and Hashim, C. N., 2016. Evaluating the students' level of cognitive engagement to achieve english language curriculum objectives at International Islamic School, Gombak. *Advances in Research, 8*(2), pp. 1-16.

Sayed, Y. and Kanjee, A., 2013. Assessment in Sub-Saharan Africa: challenges and prospects. *Assessment in Education: Principles, Policy & Practice*, *20*(4), pp. 373-384.

Schraw, G., Crippen, K., and Hartley, K., 2006. Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education, 31*(1), pp. 111-139.

Schumacker , R. E. & Lomax, R. G., 2016. *A beginner's guide to structural equation modeling.* 4th Edition ed. New York: Routledge.

Schunk, D. H., and Ertmer, P. A., 2000. Self-regulation and academic learning: Self-efficacy enhancing interventions. In: M. Boekaerts, P. R. Pintrich & M. Zeidner, eds. *Handbook of Self-Regulation.* San Diego: CA: Academic Press, pp. 631-649.

Schunk, D., and Mullen, C. A., 2012. Self-efficacy as an engaged learner. In: S. L. Christenson, A. L. Reschly & C. Wylie, eds. *Handbook of research on student engagement.* New York: Science Springer, pp. 219-235.

Sedaghat, M., Abedin, A., Hejazi, E. and Hassanabadi, H., 2011. Motivation, cognitive engagement, and academic achievement. *Procedia Social and Behavioral Sciences, 15*, pp. 2406-2410.

Shalem, Y. and De Clercq, F., 2019. Teacher development and inequality in schools: Do we now have a theory of change?. In: N. Spaull and J. Jansen eds, *South African Schooling: The Enigma of Inequality: A Study of the Present Situation and Future Possibilities* (pp. 243-261). Springer.

Shapiro, J.R. and Williams, A.M., 2012. The role of stereotype threats in undermining girls' and women's performance and interest in STEM fields. *Sex Roles*, *66*, pp.175-183.

Sharp, A. C., Brandt, L., Tuft, E. A. and Jay, S., 2016. Relationship of self-efficacy and teacher knowledge for prospective elementary education teachers. *Universal Journal of Educational Research, 4*(10), pp. 432-439.

Shepherd, D. L., 2015. Learn to teach, teach to learn: A within-pupil across subject approach to estimating the impact of teacher subject knowledge on South African grade 6 performance. *Stellenbosch Economic Working Paper 01/2015*, Stellenbosch University.

Shepherd, D. L., 2017. Gender, self-concept and mathematics and science peformance of South African Grade 9 students. *Stellenbosch Economic Working Paper 11/2017*, Stellenbosch University.

Shepherd, D. L. and Van der Berg, S. (2020). Analysing matric data to identify" promising" schools in mathematics performance. *Stellenbosch Economic Working Paper 16/2020*, Stellenbosch University.

Skae, V. A., Brown, B. J. and Wilmont, P. D., 2020. Teachers' engagement with learners in inclusive foundation phase classrooms. *South African Journal of Childhood Education, 10*(1), p. a873.

Song, J., Bong, M., Lee, K. and Kim, S., 2015. Longitudinal investigation into the role of perceived social support in adolescents' academic motivation and achievement. *Journal of Educational Psychology, 107*(3), pp. 821-841.

Spaull, N. and Courtney, P., 2022. Teacher knowledge and teacher age: What are the levels of in-service teacher knowledge? Policy note prepared for the Teacher Demographic Divided. Available at: https://resep.sun.ac.za/wp-content/uploads/2022/12/Note-10-In-service-Teacher-Knowledge-TDD-1-Dec-2022_v3.pdf.

Spaull, N., and Makaluza, N., 2019. Girls do better: The pro-female gender gap in learning outcomes in South Africa 1995–2018. *Agenda, 33*(4), pp. 11-28.

Spaull, N., and Van Broekhuizen , H., 2017. The 'Martha Effect': The compounding female advantage in South African higher education. *Stellenbosch Economic Working Papers 14/17*, Stellenbosch University.

Spencer, S. J., Steele, C. M., and Quinn, D. M., 1999. Stereotype threat and women's math performance. *Journal of Experimental Social Psychology*, *35*(1), pp. 4-28.

StataCorp, 2021. *Stata statistical software: Release 17*. College Station, TX: StataCorp LLC.

Steele, C. M., 1997. A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist*, *52*(6), pp. 613-629.

Steele, C.M. and Aronson, J., 1995. Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, *69*(5), p. 797.

Struyf, A., Boeve-de Pauw, J. and Van Petegem, P., 2017. 'Hard science': a career option for socially and societally interested students? Grade 12 students' vocational interest gap explored. *International Journal of Science Education*, *39*(17), pp. 2304-2320.

Stuart, M., Lido, C., Morgan, J., Solomon, L. and May, S., 2011. The impact of engagement with extracurricular activities on the student experience and graduate outcomes for widening participation populations. *Active Learning in Higher Education*, *12*(3), pp. 203-215.

Sun, L., Bradley, K.D. and Akers, K., 2012. A multilevel modelling approach to investigating factors impacting science achievement for secondary school students: PISA Hong Kong sample. *International Journal of Science Education*, *34*(14), pp.2107-2125.

Taylor, N. (2002). Accountability and support: Improving public schooling in South Africa: A systemic framework. Paper presented to the National Consultation on School Development Department of Education, 29 Jan 2002.

Taylor, S., Libago, N. & Pillay, R., 2013. *Macro indicator report,* Pretoria: Department of Basic Education.

Taylor, N. and Vinjevold, P., 1999. *Getting learning right: report of the President's Education Initiative Research Project*. Joint Education Trust.

Taylor, S., & Yu, D. (2009). The importance of socio-economic status in determining educational achievement in South Africa. *Stellenbosch Economic Working Paper 01/2009*, Stellenbosch University.

Trautwein, U., Lüdtke, O., Roberts, B.W., Schnyder, I. and Niggli, A., 2009. Different forces, same consequences: Conscientiousness and competence beliefs are independent predictors of academic effort and achievement. *Journal of Personality and Social Psychology, 97*, pp. 1115-1128.

Turner, J.C., Midgley, C., Meyer, D.K., Gheen, M., Anderman, E.M., Kang, Y. and Patrick, H., 2002. The classroom environment and students' reports of avoidance strategies in mathematics: A multimethod study. *Journal of Educational Psychology, 94*(1), pp. 88-106.

Valdes, O. M., Denner, J., Dickson, D. J. and Laursen, B., 2021. Teacher expectations and perceived teacher involvement anticipate changes in Latino/a middle school students' expectations of math success. *Educational Psychology, 41*(6), pp. 786-805.

Van Broekhuizen, H., 2016. Graduate unemployment, Higher Education access and success, and teacher production in South Africa. Doctoral dissertation, Stellenbosch: Stellenbosch University.

Venkat, H. and Spaull, N., 2015. What do we know about primary teachers' mathematical content knowledge in South Africa? An analysis of SACMEQ 2007. *International Journal of Educational Development*, *41*, pp. 121-130.

Visser, M., Juan, A. & Feza, N., 2015. Home and school resources as predictors of mathematics performance in South Africa. South African Journal of Education, 35(1), pp. 1-10.

Wang, C., Cho, H.J., Wiles, B., Moss, J.D., Bonem, E.M., Li, Q., Lu, Y. and Levesque-Bristol, C., 2022. Competence and autonomous motivation as motivational predictors of college students' mathematics achievement: from the perspective of self-determination theory. *International Journal of STEM Education , 41*(41).

Wang, J., Zang, X. and Zhang, L. J., 2022. Effects of teacher engagement on students' achievement in an online English as a Foreign Language classroom: The mediating role of autonomous motivation and positive emotions. *Frontiers in Psychology, 13*, e950652.

Wang, M. -T. and Eccles, J. S., 2013. School context, achievement motivation, and academic engagement: A longitudinal study of school engagement using a multidimensional perspective. *Learning and Instruction, 28*, pp. 12-23.

Wang, M. and Holcombe, R., 2010. Adolescents' perceptions of school environment, engagement, and academic achievement in middle school. *American Educational Research Association, 47*(3), pp. 633-662.

Wara, E., Aloka, P. J. and Odongo, B. C., 2018. Relationship between emotional engagement and academic achievement among Kenyan secondary school students. *Academic Journal of Interdisciplinary Studies, 7*(1), pp. 107-118.

Warren-Grice, A., 2017. Advocacy for equity: Extending culturally relevant pedagogy in predominantly white suburban schools. *Teachers College Record*, *119*(1), pp. 1-26.

Watt, H.M., Bucich, M. and Dacosta, L., 2019. Adolescents' motivational profiles in mathematics and science: Associations with achievement striving, career aspirations and psychological wellbeing. *Frontiers in Psychology*, *10*, p. 990.

Weiner, B., 1985. An attributional theory of achievement motivation and emotion. *Psychological Review,* 92(4).

Wentzel, K. R., 2003. Sociometric status and adjustment in middle school: a longitudinal study. *Journal of Early Adolescence, 23*, pp. 5-28.

Wigfield, A., and Eccles, J. S., 1992. The development of achievement task values: A theoretical analysis.. *Developmental Review, 12*(3).

Wigfield, A., and Eccles, J. S., 2000. Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology, 25*(1), pp. 68-81.

Wigfield, A., Rosenzweig, E. and Eccles, J.S., 2017. Achievement values. In: A. J. Elliot, C. S. Dweck and D. S. Yeager eds., *Handbook of Competence and Motivation: Theory and Application.* London: The Guilford Press, pp. 116 (2017).

Wiggins, B. L., Eddy, S. L., Grunspan, D. Z. and Crowe, A. J., 2017. The ICAP active learning framework predicts the learning gains observed in intensely active classroom experiences. *AERA Open, 3*(2), pp. 1-14.

Wills, G. and Hofmeyr, H., 2019. Academic resilience in challenging contexts: Evidence from township and rural primary schools in South Africa. *International Journal of Educational Research, 98*, pp. 192-205.

Wolff, F., Sticca, F., Niepel, C., Götz, T., Van Damme, J. and Möller, J., 2021. The reciprocal 2I/E model: An investigation of mutual relations between achievement and self-concept levels and changes in the math and verbal domain across three countries. *Journal of Educational Psychology, 113*(8), pp. 1529-1549.

Wolff, F. 2021. How classmates' gender stereotypes affect students' math self-concepts: A multilevel analysis. *Frontiers in Psychology*, *12*, e599199.

Xia, Y. and Yang, Y., 2019. RMSEA, CFI, and TLI in structural equation modeling with ordered categorical data: The story they tell depends on the estimation methods. *Behavior Research Methods*, *51*, pp. 409-428.

Xu, Y. and Brown, G.T., 2016. Teacher assessment literacy in practice: A reconceptualization. *Teaching and Teacher Education*, *58*, pp.149-162.

Yeung, A. S., Craven, R. G. and Kaur, G., 2014. Influences of mastery goal and perceived competence on educational outcomes. *Australian Journal of Educational & Developmental Psychology, 14*, pp. 117-130.

Zander, L., Höhne, E., Harms, S., Pfost, M. and 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*, p.552355.

Zimmerman, B. J., 1990. Theories of self-regulated learning and academic achievement: An overview and analysis. *Educational Psychologist, 25*(1), pp. 3-17.

Zimmerman, B.J. and Schunk, D.H., 2001. Reflections on theories of self-regulated learning and academic achievement. *Self-regulated learning and academic achievement: Theoretical perspectives*, *2*, pp. 289-307.

Appendix

Table A1: Weighted distribution of responses to items relating to S-EVT measures

Item	Proportion (standard error)			
	Agree a lot	Agree a little	Disagree a little	Disagree a lot
<u>Affective Engagement (N = 19 590)</u>				
I like being in school*	0.695 (0.010)	0.234 (0.007)	0.048 (0.003)	0.023 (0.002)
I feel safe when I am at school*	0.545 (0.008)	0.316 (0.005)	0.095 (0.004)	0.044 (0.002)
I feel like I belong at this school*	0.480 (0.007)	0.326 (0.005)	0.126 (0.004)	0.067 (0.003)
Teachers at my school are fair to me*	0.431 (0.006)	0.352 (0.006)	0.131 (0.004)	0.086 (0.004)
I am proud to go to this school*	0.630 (0.009)	0.242 (0.005)	0.080 (0.080)	0.049 (0.002)
<u>Mathematics Self-Efficacy (N = 18 880)</u>				
I usually do well in mathematics*	0.256 (0.007)	0.499 (0.006)	0.169 (0.004)	0.076 (0.004)
Mathematics is more difficult for me than for many of my classmates	0.224 (0.005)	0.387 (0.006)	0.230 (0.004)	0.159 (0.004)
Mathematics is not one of my strengths	0.246 (0.005)	0.340 (0.005)	0.207 (0.004)	0.207 (0.005)
I learn things quickly in mathematics*	0.273 (0.007)	0.384 (0.005)	0.231 (0.005)	0.112 (0.005)
I am good at working out difficult mathematics problems*	0.200 (0.007)	0.374 (0.006)	0.264 (0.005)	0.162 (0.007)
My teacher tells me I am good at mathematics*	0.175 (0.006)	0.321 (0.006)	0.260 (0.005)	0.245 (0.008)
Mathematics is harder for me than any other subject	0.296 (0.006)	0.297 (0.005)	0.204 (0.004)	0.203 (0.005)
Intrinsic Task Value (N = 18 744)				
I enjoy learning mathematics*	0.528 (0.009)	0.348 (0.007)	0.078 (0.003)	0.047 (0.003)
I wish I did not have to study mathematics	0.455 (0.007)	0.198 (0.004)	0.209 (0.005)	0.138 (0.004)
Mathematics is boring	0.469 (0.008)	0.232 (0.004)	0.214 (0.005)	0.085 (0.003)
I learn many interesting things in mathematics*	0.540 (0.007)	0.302 (0.006)	0.099 (0.003)	0.059 (0.004)
I like mathematics*	0.499 (0.009)	0.319 (0.006)	0.098 (0.003)	0.085 (0.004)
I like any schoolwork that involves numbers*	0.394 (0.008)	0.349 (0.005)	0.166 (0.005)	0.091 (0.004)
I like to solve mathematics problems*	0.405 (0.009)	0.355 (0.006)	0.146 (0.004)	0.094 (0.005)

Item	Proportion (standard error) Agree a lot	Agree a little	Disagree a little	Disagree a lot
I look forward to mathematics class*	0.449 (0.008)	0.330 (0.005)	0.137 (0.004)	0.084 (0.005)
Mathematics is one of my favourite subjects*	0.371 (0.008)	0.295 (0.005)	0.160 (0.004)	0.175 (0.005)
Utility Task Value (N = 19 615)				
I think learning mathematics will help me in my daily life*	0.773 (0.006)	0.161 (0.004)	0.037 (0.002)	0.029 (0.002)
I need mathematics to learn other school subjects*	0.540 (0.006)	0.306 (0.005)	0.097 (0.003)	0.056 (0.003)
I need to do well in mathematics to get into the university of my choice*	0.808 (0.006)	0.129 (0.004)	0.040 (0.002)	0.023 (0.002)
I need to do well in mathematics to get the job I want*	0.780 (0.006)	0.139 (0.004)	0.049 (0.003)	0.031 (0.002)
I would like a job that involves using mathematics*	0.426 (0.008)	0.312 (0.005)	0.134 (0.004)	0.127 (0.004)
It is important to learn about mathematics to get ahead in the world*	0.679 (0.007)	0.225 (0.005)	0.063 (0.003)	0.033 (0.003)
Learning mathematics will give me more job opportunities when I am an adult*	0.755 (0.006)	0.171 (0.004)	0.048 (0.003)	0.027 (0.002)
My parents think that it is important that I do well in mathematics*	0.718 (0.007)	0.206 (0.005)	0.052 (0.003)	0.024 (0.002)
It is important to do well in mathematics*	0.819 (0.005)	0.134 (0.004)	0.028 (0.002)	0.020 (0.002)
Teacher Social Support and Engagement (N = 19 552)				
I know what my teacher expects me to do*	0.605 (0.007)	0.310 (0.006)	0.057 (0.003)	0.027 (0.002)
My teacher is easy to understand*	0.497 (0.010)	0.310 (0.006)	0.121 (0.005)	0.072 (0.005)
My teacher has clear answers to my questions*	0.526 (0.009)	0.305 (0.006)	0.114 (0.005)	0.056 (0.003)
My teacher is good at explaining mathematics*	0.633 (0.011)	0.217 (0.006)	0.091 (0.004)	0.059 (0.004)
My teacher does a variety of things to help us learn*	0.590 (0.009)	0.278 (0.006)	0.081 (0.003)	0.051 (0.003)
My teacher links new lessons to what I already know*	0.461 (0.007)	0.359 (0.006)	0.118 (0.004)	0.062 (0.003)
My teacher explains a topic again when we don’t understand*	0.712 (0.009)	0.166 (0.004)	0.065 (0.003)	0.058 (0.004)

	Proportion (standard error)			
	Every/ almost every lesson	About half the lessons	Some lessons	Never
Classroom Collaboration and Interaction (N = 19 588)				
Students don't listen to what the teacher says	0.294 (0.008)	0.246 (0.005)	0.344 (0.006)	0.116 (0.006)
There is disruptive noise	0.285 (0.008)	0.237 (0.005)	0.337 (0.006)	0.141 (0.007)
It is too disorderly for students to work well	0.245 (0.007)	0.294 (0.005)	0.274 (0.005)	0.187 (0.007)
My teacher has to wait a long time for students to quieten down	0.298 (0.008)	0.190 (0.004)	0.264 (0.006)	0.247 (0.009)
Students interrupt the teacher	0.283 (0.008)	0.192 (0.005)	0.318 (0.006)	0.207 (0.008)
My teacher has to keep telling us to follow the classroom rules	0.464 (0.010)	0.139 (0.003)	0.213 (0.006)	0.184 (0.007)
	At least once a week	Once/twice a month	A few times a year	Never
Peer Relations (N = 18 484)				
Other learners…				
… said mean things about my physical appearance	0.275 (0.006)	0.171 (0.004)	0.215 (0.005)	0.339 (0.006)
… spread lies about me	0.164 (0.004)	0.190 (0.004)	0.246 (0.005)	0.400 (0.005)
… shared my secrets with others	0.142 (0.004)	0.138 (0.004)	0.177 (0.004)	0.543 (0.007)
… refused to talk to me	0.193 (0.006)	0.145 (0.003)	0.167 (0.004)	0.495 (0.007)
… insulted a member of my family	0.143 (0.005)	0.104 (0.003)	0.140 (0.003)	0.613 (0.007)
… stole something from me	0.306 (0.007)	0.201 (0.005)	0.219 (0.005)	0.273 (0.008)
… made me do things I didn't want to do	0.105 (0.004)	0.117 (0.004)	0.149 (0.004)	0.629 (0.007)
… sent me nasty or hurtful messages online	0.100 (0.004)	0.100 (0.004)	0.135 (0.003)	0.665 (0.007)
… shared nasty or hurtful things about me online	0.079 (0.004)	0.090 (0.004)	0.119 (0.003)	0.712 (0.007)
… shared embarrassing photos of me online	0.054 (0.003)	0.054 (0.003)	0.078 (0.003)	0.814 (0.006)
… threatened me	0.103 (0.004)	0.101 (0.003)	0.175 (0.005)	0.620 (0.008)
… physically hurt me	0.102 (0.004)	0.105 (0.004)	0.170 (0.005)	0.623 (0.008)
… excluded me from their group	0.116 (0.004)	0.125 (0.004)	0.176 (0.004)	0.583 (0.007)
… damaged something of mine on purpose	0.134 (0.004)	0.133 (0.004)	0.202 (0.004)	0.531 (0.007)

Source: Authors' calculations from TIMSS (2019).

Note: * refers to reverse-scored items. 'N' refers to the number of non-missing observations.

Table A2: Confirmatory factor analysis, by school quintile

		School SES quintile				
Factor	Full sample	1	2	3	4	5
MSC						
Item 1	0.755	0.741	0.730	0.725	0.763	0.865
Item 2	0.413	0.238	0.305	0.302	0.456	0.710
Item 3	0.568	0.364	0.459	0.472	0.611	0.844
Item 4	0.735	0.736	0.728	0.721	0.746	0.818
Item 5	0.740	0.735	0.740	0.757	0.740	0.818
Item 6	0.687	0.710	0.684	0.679	0.695	0.733
Item 7	0.521	0.341	0.414	0.413	0.573	0.790
Factor 1 λ	2.894	2.440	2.553	2.564	3.080	4.464
AE						
Item 1	0.631	0.670	0.641	0.650	0.649	0.609
Item 2	0.623	0.606	0.596	0.605	0.655	0.663
Item 3	0.754	0.721	0.727	0.742	0.762	0.797
Item 4	0.414	0.369	0.345	0.411	0.459	0.552
Item 5	0.755	0.701	0.708	0.755	0.796	0.800
Factor 1 λ	2.095	1.962	1.914	2.079	2.276	2.392
IV						
Item 1	0.862	0.833	0.855	0.857	0.848	0.896
Item 2	0.610	0.505	0.569	0.600	0.615	0.723
Item 3	0.668	0.620	0.629	0.656	0.654	0.753
Item 4	0.679	0.665	0.649	0.676	0.669	0.716
Item 5	0.922	0.907	0.908	0.919	0.928	0.946
Item 6	0.740	0.693	0.710	0.717	0.747	0.775
Item 7	0.843	0.832	0.819	0.841	0.843	0.869
Item 8	0.790	0.751	0.754	0.775	0.803	0.818
Item 9	0.859	0.843	0.836	0.844	0.872	0.910
Factor 1 λ	5.492	5.046	5.139	5.362	5.506	6.154
UV						
Item 1	0.724	0.753	0.727	0.699	0.719	0.713
Item 2	0.603	0.588	0.548	0.575	0.617	0.692
Item 3	0.829	0.828	0.816	0.817	0.862	0.823
Item 4	0.840	0.829	0.824	0.837	0.835	0.863
Item 5	0.583	0.553	0.554	0.536	0.575	0.712
Item 6	0.784	0.773	0.746	0.765	0.804	0.820
Item 7	0.788	0.762	0.774	0.797	0.816	0.816
Item 8	0.594	0.627	0.602	0.618	0.635	0.605
Item 9	0.792	0.799	0.773	0.774	0.813	0.810
Factor 1 λ	4.836	4.799	4.595	4.674	5.045	5.278
TSSE						
Item 1	0.531	0.510	0.490	0.491	0.582	0.616
Item 2	0.794	0.749	0.759	0.771	0.824	0.877
Item 3	0.784	0.720	0.741	0.757	0.834	0.877
Item 4	0.842	0.820	0.803	0.821	0.866	0.906

Factor	Full sample	School SES quintile				
		1	2	3	4	5
Item 5	0.719	0.648	0.661	0.694	0.793	0.817
Item 6	0.627	0.572	0.587	0.614	0.678	0.696
Item 7	0.758	0.717	0.742	0.780	0.779	0.763
Factor 1 λ	3.720	3.271	3.341	3.550	4.159	4.474
CCI						
Item 1	0.679	0.637	0.615	0.699	0.734	0.775
Item 2	0.767	0.714	0.713	0.784	0.834	0.864
Item 3	0.674	0.559	0.566	0.644	0.754	0.834
Item 4	0.765	0.701	0.710	0.758	0.824	0.859
Item 5	0,792	0.749	0.755	0.787	0.823	0.833
Item 6	0.589	0.463	0.494	0.557	0.669	0.775
Factor 1 λ	3.060	2.494	2.523	3.022	3.605	4.074
PR						
Item 1	0.542	0.474	0.496	0.495	0.595	0.648
Item 2	0.585	0.556	0.563	0.544	0.634	0.716
Item 3	0.542	0.507	0.514	0.508	0.594	0.635
Item 4	0.597	0.597	0.573	0.575	0.600	0.601
Item 5	0.623	0.640	0.618	0.612	0.616	0.604
Item 6	0.357	0.275	0.252	0.330	0.437	0.453
Item 7	0.628	0.616	0.607	0.588	0.659	0.616
Item 8	0.756	0.737	0.731	0.742	0.793	0.751
Item 9	0.780	0.780	0.781	0.760	0.791	0.777
Item 10	0.681	0.700	0.719	0.706	0.712	0.500
Item 11	0.685	0.663	0.644	0.659	0.707	0.733
Item 12	0.668	0.655	0.665	0.623	0.690	0.636
Item 13	0.604	0.581	0.622	0.598	0.634	0.600
Item 14	0.637	0.607	0.612	0.595	0.646	0.716
Factor 1 λ	5.526	5.228	5.249	5.118	6.026	5.892
SES						
Item 1	0.670	0.491	0.485	0.446	0.462	0.728
Item 2	0.504	0.366	0.389	0.360	0.380	0.593
Item 3	0.454	0.466	0.459	0.406	0.342	0.541
Item 4	0.603	0.441	0.380	0.375	0.510	0.672
Item 5	0.532	0.508	0.470	0.501	0.449	0.450
Item 6	0.510	0.388	0.437	0.390	0.409	0.225
Item 7	0.604	0.424	0.679	0.664	0.685	0.291
Item 8	0.595	0.405	0.524	0.462	0.435	0.535
Item 9	0.738	0.429	0.489	0.484	0.520	0.782
Factor 1 λ	3.078	1.724	2.127	1.925	2.032	2.860

Source: Authors' calculations from TIMSS (2019).

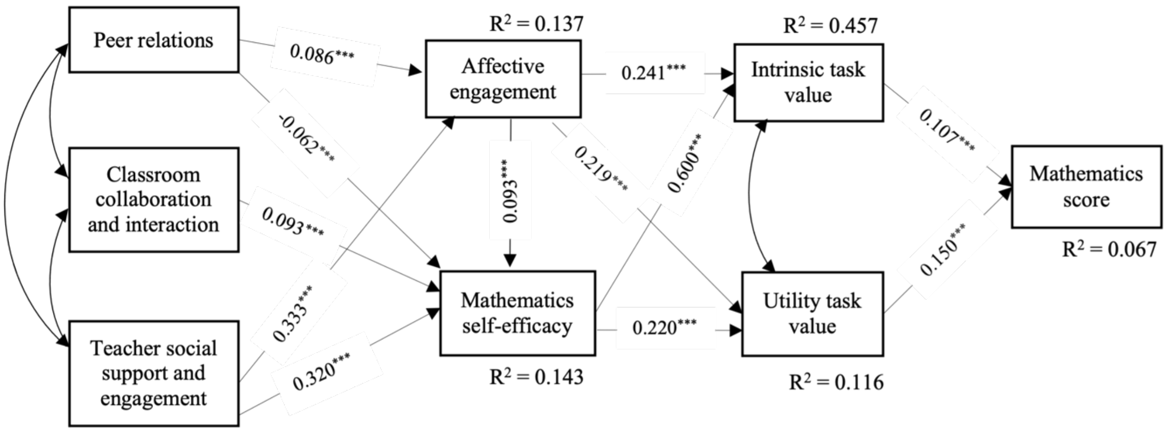
Note: MSC = mathematics self-concept; AE = affective engagement; IV = intrinsic task value; UV = utility task value; TSSE = teacher social support and engagement; CCI = classroom collaboration and interaction; PR = peer relations. Items are listed in Table A1 under each construct, while lambda (λ) represents the factor eigenvalue.

Table A3: Weighted distribution of responses to items relating to covariates and controls

	Observations	Mean (standard error)
Girl	10 780	0.520 (0.006)
Boy	9 942	0.480 (0.006)
Possessions:		
Computer/Tablet	20 431	0.479 (0.012)
Study desk	20 361	0.567 (0.010)
Own room	20 429	0.680 (0.008)
Internet connection	20 157	0.410 (0.011)
Mobile phone	20 476	0.773 (0.007)
Electricity	20 360	0.753 (0.009)
Running tap water	19 317	0.940 (0.002)
Flush toilet	20 379	0.782 (0.003)
Hot water from geyser	20 362	0.397 (0.004)
School quintile:		
1st	6 223	0.300 (0.031)
2nd	4 730	0.228 (0.026)
3rd	4 307	0.208 (0.024)
4th	3 072	0.148 (0.020)
5th	2 390	0.115 (0.014)

Source: Authors' calculations from TIMSS (2019).

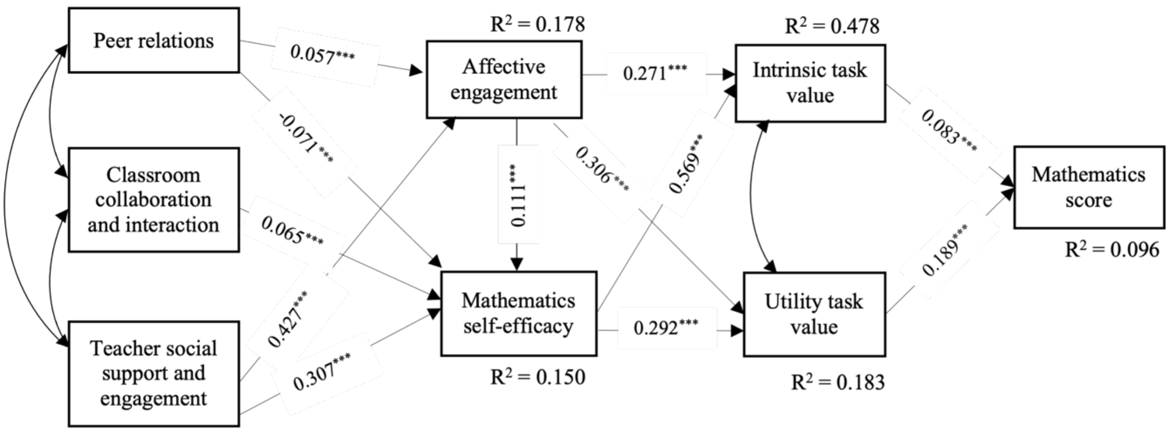
Figure A1: Full conceptual model (girls in poorest 60% of schools, n = 7 283)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at $p < 0.001$. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

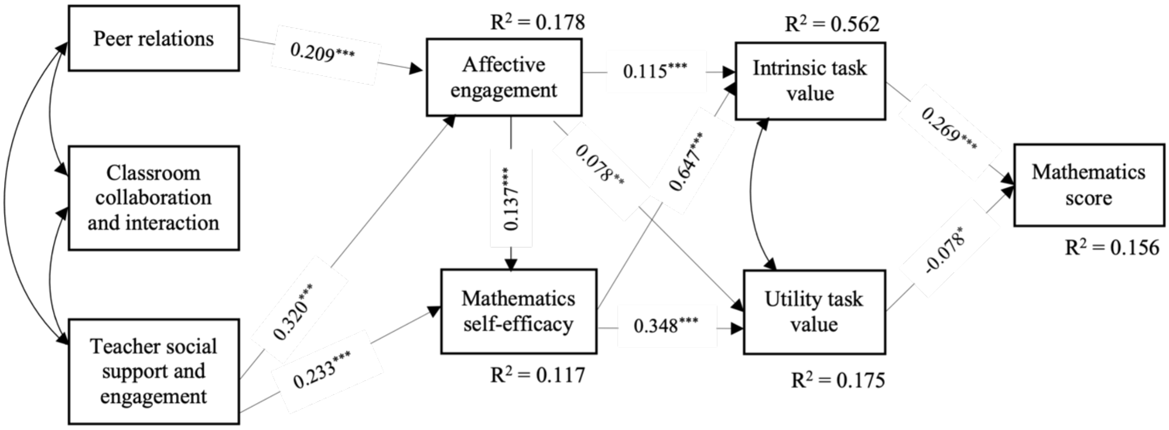
Figure A2: Full conceptual model (boys in poorest 60% of schools, n = 6 523)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at $p < 0.001$. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

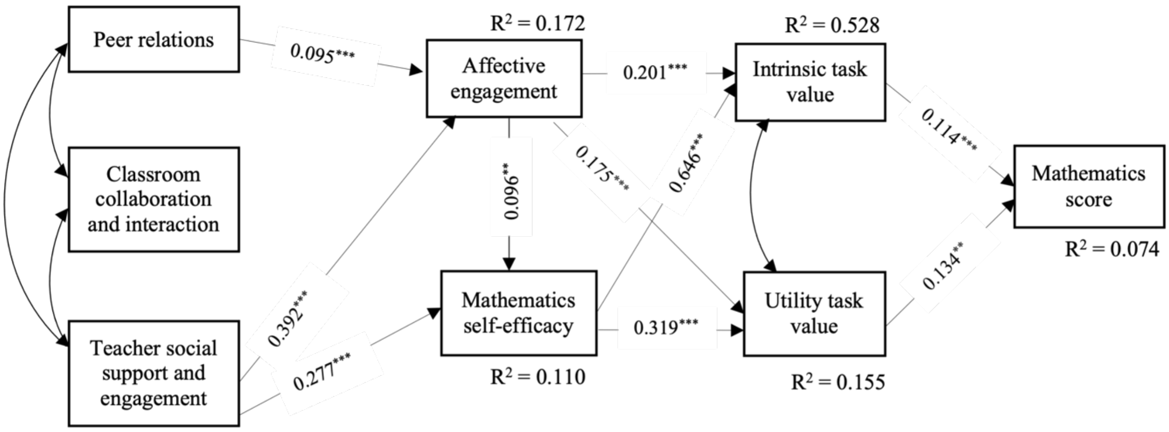
Figure A3: Full conceptual model (girls in quintile 4 schools, n = 2 133)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at $p < 0.001$. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

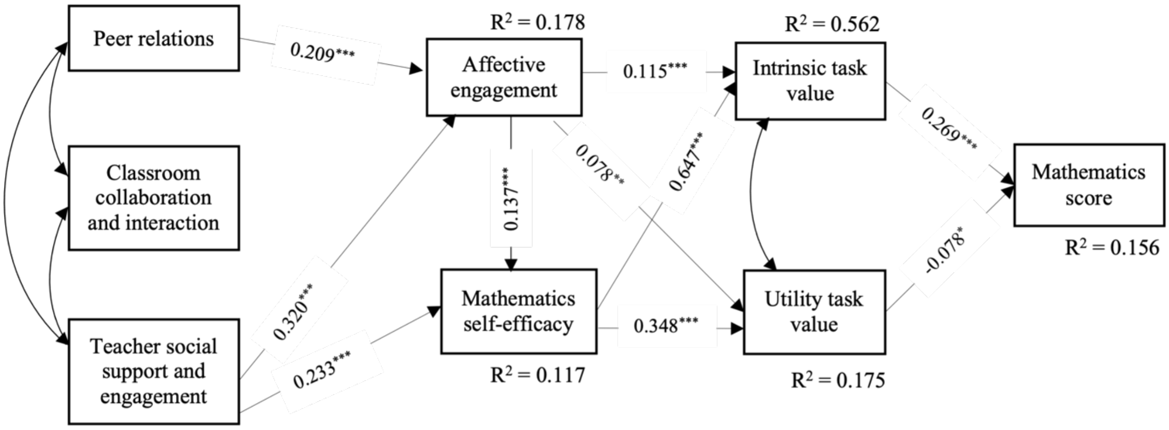
Figure A4: Full conceptual model (boys in quintile 4 schools, n = 1 852)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at $p < 0.001$. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

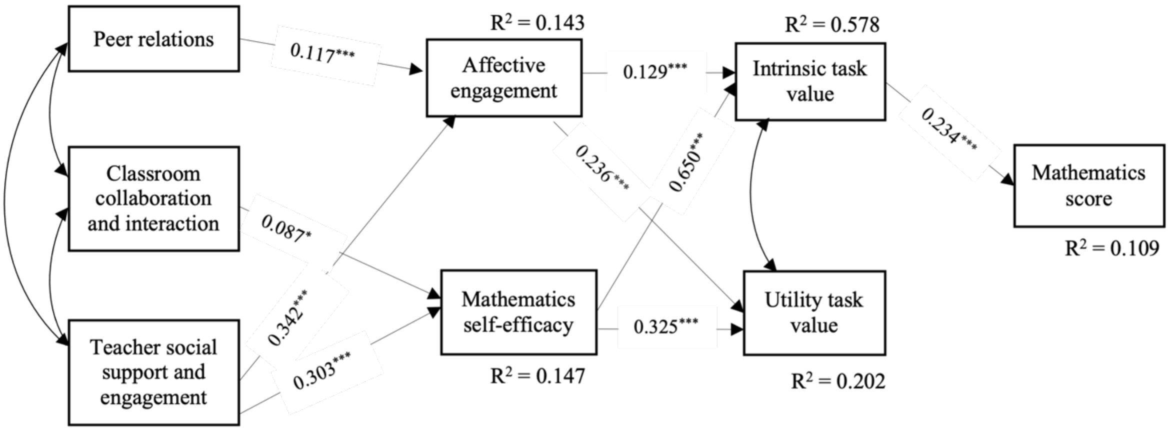
Figure A5: Full conceptual model (girls in quintile 5 schools, n = 1 617)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at $p < 0.001$. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.

Figure A6: Full conceptual model (boys in quintile 5 schools, n = 1 314)



Source: Authors' calculations using TIMSS (2019) data and "pv" and "sem" commands in Stata17.

Note: Only statistically significant paths indicated. Standardised (beta) coefficients are shown. All error terms are significant at $p < 0.001$. Model is estimated using MLMV and adjusted for the complex sample design and plausible values. The socioeconomic status of the learner's household is controlled for at every level of the model.