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# Effect of student engagement on Mathematics performance: The moderating role of Math anxiety

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**Abstract**

**Aim:** This study examined the effects of cognitive, affective, and behavioral student engagement on mathematics performance and investigated the moderating role of math anxiety among Grade 10 students in selected public secondary schools in Antipolo City. The study sought to generate insights that may support improved mathematics instruction and student learning outcomes.

**Methodology:** A descriptive-correlational research design was employed involving 330 Grade 10 students from three public secondary schools. Data were collected using adopted and validated survey questionnaires measuring student engagement and mathematics anxiety. Relationships among variables were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) through WarpPLS 7.0.

**Results:** Findings revealed that affective and behavioral engagement had significant positive effects on mathematics performance, whereas cognitive engagement did not significantly predict performance. Affective math anxiety significantly weakened the positive relationship between affective engagement and mathematics performance. Although students demonstrated high levels of mathematics anxiety, particularly in cognitive and behavioral dimensions, they generally remained actively engaged in mathematics learning.

**Conclusion:** The findings highlight the importance of fostering students' emotional investment and active participation in mathematics to improve academic performance. Mathematics teachers should implement learner-centered and anxiety-sensitive instructional strategies that strengthen engagement while addressing anxiety-related barriers to learning. The study contributes to educational practice by providing evidence that supports the development of interventions aimed at enhancing mathematics achievement and student well-being. Future studies may expand the investigation to broader educational settings and learner populations.

***Keywords:*** *student engagement, mathematics performance, math anxiety, cognitive engagement, affective engagement, behavioral engagement, PLS-SEM, secondary education*

## INTRODUCTION

Mathematics plays a vital role in developing students' logical reasoning and problem-solving abilities (Ariyanti & Santoso, 2020). Despite its importance, many learners perceive mathematics as difficult or uninteresting (Marshman & Brown, 2014; Shabab, 2024), a perception that frequently translates into disengagement from the subject (Collie et al., 2019; Martin et al., 2015). This disengagement is often rooted in weak conceptual understanding (Salehudin et al., 2015), which can, in turn, heighten anxiety and dampen students' willingness to pursue further learning (Nachiappan, 2016; Yahya & Amir, 2018). The pattern is cyclical rather than isolated: conceptual confusion breeds anxiety, and anxiety deepens disengagement. Improving mathematics education therefore requires attention not only to instructional content but also to the psychological and emotional conditions under which students learn.

This concern has taken on renewed urgency in the post-pandemic global education landscape. School closures and instructional disruptions during COVID-19 intensified pre-existing learning gaps, with international evidence documenting substantial setbacks in mathematics achievement alongside elevated disengagement and anxiety across education systems worldwide (Engzell et al., 2021; Maldonado & De Witte, 2022). In response, recovery efforts in multiple countries have shifted toward learner-centered interventions that address psychological as well as academic

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barriers to mathematics learning (OECD, 2021; Schleicher, 2022). Cross-national research further confirms that mathematics anxiety is not a localized phenomenon but a pattern observed across diverse cultural and educational contexts, with consistent effects on motivation, performance, and sustained engagement in STEM fields (Mammarella et al., 2019; Vukovic et al., 2013). These global patterns make clear that understanding how engagement, anxiety, and achievement interact is a matter of international, not merely local, relevance—directly bearing on education systems such as the Philippines.

Within this global context, the Philippines continues to register persistent underperformance in mathematics across both national and international assessments (Bernardo, 2020; Department of Education, 2019; San Juan, 2019). The 2016–2017 Global Competitiveness Report ranked the country 79th of 138 nations in the quality of science and mathematics education (Capuno et al., 2019), and more recent data reinforce this trend: the National Achievement Test (NAT) recorded an average mathematics score of 48.63%, falling short of the Department of Education's 50% benchmark; the 2022 Programme for International Student Assessment (PISA) placed Filipino students at 353 against an OECD average of 489; and the Trends in International Mathematics and Science Study (TIMSS) reported an average score of 297 (Mullis et al., 2019). Collectively, these outcomes point to systemic weaknesses in curriculum design, instructional strategy, and teacher preparedness, underscoring the need for reforms that strengthen conceptual understanding while improving engagement and emotional support.

Contemporary developments in mathematics education offer promising directions for such reform. A growing body of 2021–2026 literature documents a global shift toward learner-centered and inquiry-based pedagogy, in which students construct mathematical understanding through active problem-solving and collaborative tasks rather than passive reception (Cevikbas & Kaiser, 2022; Weinhandl et al., 2023). Technology-enhanced instruction has likewise gained traction, with digital tools supporting more interactive and differentiated mathematics learning experiences (Bester & Brand, 2013; Reinhold et al., 2021). Parallel attention is being paid to social-emotional learning and student well-being, reflecting growing recognition that positive emotional climates are foundational—not incidental—to sustained engagement and anxiety reduction in mathematics classrooms (Pekrun et al., 2023; King & Datu, 2017). Data-driven instructional approaches, in which teachers use assessment evidence to identify and respond to engagement and anxiety barriers, are increasingly regarded as effective levers for improving outcomes (OECD, 2021). Together, these trends call for research that examines mathematics learning not only as a cognitive process but also as a psychological and emotional one, particularly in settings such as the Philippines where achievement gaps remain entrenched.

Student engagement is widely recognized as central to improving both the quality of mathematics instruction and the academic outcomes it produces (Flores et al., 2021; Nayir, 2015). Engaged students tend to perform better academically, attend school more consistently, and demonstrate greater openness to learning (Bear et al., 2018; Rimm-Kaufman et al., 2015), whereas disengagement—marked by reduced effort and diminished focus—undermines learning progress (Mustika & Kusdiyati, 2015). Strengthening engagement is accordingly viewed as a key lever for addressing underachievement and dropout (Fredricks et al., 2004; Fung et al., 2018). Yet despite expanding research on engagement broadly, studies that connect it specifically to mathematics achievement remain comparatively scarce (Trenholm et al., 2018), even though existing findings consistently link cognitive, behavioral, and affective engagement to improved mathematical performance (Baroody et al., 2016; Wang et al., 2017).

Engagement and achievement in mathematics are shaped by an interacting set of factors, including student attitudes, teacher support, family involvement, and school climate (Caponera & Losito, 2016; Fung et al., 2018; Maamin et al., 2022). As a construct, engagement is now understood as multidimensional—encompassing behavioral, cognitive, and affective components that reflect, respectively, students' actions, thought processes, and emotional connection to learning (Fredricks et al., 2004; Kong et al., 2003). Some frameworks extend this model further to include psychological and agentic dimensions, capturing students' self-directed participation and internal motivational states (Appleton et al., 2006; Mameli & Passini, 2017), while others foreground environmental and social influences such as school and peer context (Chang & Beilock, 2016; Lei et al., 2018). This conceptual diversity underscores that engagement is shaped jointly by personal and contextual factors, both of which are critical to improving learning outcomes.

Mathematics anxiety, meanwhile, is consistently and negatively associated with academic performance across educational levels (Barroso et al., 2021; Hart & Ganley, 2019; Ramirez et al., 2018). Students experiencing high anxiety tend to report lower enjoyment, greater avoidance, and weaker performance in mathematics (Andrews & Brown, 2015). Anxiety typically intensifies with age, peaking in adolescence—particularly between ages 14 and 16—as students confront increasingly complex content such as probability and polynomials (Anindyarini & Supahar, 2019; Dowker et al., 2016; Zhang et al., 2019). In the Philippine setting, the spiral curriculum's early introduction of advanced topics in junior high school may further compound this anxiety (Duyapat et al., 2023), with documented consequences for standardized test performance and learner confidence (Chang & Beilock, 2016; Furner & Higgins, 2019). International

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data corroborate the scale of the issue: PISA findings indicate that roughly one-third of 15-year-olds experience mathematics anxiety during assessment tasks (OECD, 2013; Ramirez et al., 2018), while related survey evidence shows that more than half of adolescents find mathematics coursework challenging, with substantial proportions reporting tension around homework and nervousness during problem-solving (Luttenberger et al., 2018).

Despite this extensive body of work, important gaps remain. Much of the existing literature addresses general academic achievement rather than mathematics-specific outcomes (Chang et al., 2016; Ciric & Jovanovic, 2016), and few studies examine the cognitive, behavioral, and affective dimensions of engagement simultaneously (Dogan, 2015; Lei et al., 2018). Moreover, research in this area has concentrated disproportionately on higher education, leaving secondary-level dynamics comparatively underexplored (Schnitzler et al., 2021). These gaps carry both methodological and theoretical significance. Prior studies have largely treated engagement and anxiety as separate constructs, with little attention to how they interact (Dogan, 2015; Lei et al., 2018), and most rely on correlational or regression-based designs that cannot capture the conditional nature of such relationships. Moderation analysis using Partial Least Squares Structural Equation Modeling (PLS-SEM) offers a methodologically stronger alternative, allowing for a more precise understanding of how anxiety alters the strength of engagement's effect on performance (Hair et al., 2019). Theoretically, this shift matters because it moves the research question beyond whether engagement predicts performance to under what psychological conditions that relationship holds—a question with direct implications for instructional design.

Grade 10 students – the final year of Junior High School and the conclusion of basic education's first phase – constitute a particularly important population for this inquiry. They are at a developmental stage where mathematics anxiety typically peaks (Dowker et al., 2016), are exposed to the most conceptually demanding content within the Philippine K–12 basic education framework, and face mathematics outcomes at this level that carry substantial consequences for senior high school track selection and subsequent academic trajectories. To date, no Philippine study has simultaneously modeled all three dimensions of student engagement alongside all three dimensions of mathematics anxiety within a moderation framework, positioning the present study as a distinct and original contribution to both local and international scholarship on mathematics education.

This study therefore examines how cognitive, affective, and behavioral engagement relate to the mathematics performance of Grade 10 students and investigates whether mathematics anxiety moderates these relationships. In doing so, it seeks to generate evidence that can inform more responsive instructional strategies, mitigate the effects of mathematics anxiety, and strengthen engagement-driven approaches to improving achievement. The findings are intended to offer practical guidance for mathematics teachers in designing engagement-enhancing instruction and identifying anxiety-related barriers within their classrooms. At the institutional level, the results may inform school leaders, department heads, and instructional supervisors as they develop policies and professional development initiatives that foster emotionally and instructionally supportive mathematics environments. More broadly, by generating empirical evidence from a developing-country context, this study contributes to the expanding international research base on the psychological dimensions of mathematics education, enriching scholarly discourse on the relationship between engagement, anxiety, and academic achievement.

## Review of Related Literature and Studies

### Student Engagement

Student engagement is a multidimensional construct comprising cognitive, behavioral, and affective components, and remains one of the most consistently validated predictors of academic achievement, motivation, and retention (Fredricks et al., 2004). This tripartite model is foundational rather than current — it was formulated more than two decades ago — yet it continues to organize contemporary research because no subsequent framework has displaced its core distinctions; recent studies instead extend it empirically. Awofala et al. (2024) confirmed engagement as a significant predictor of mathematics achievement among Nigerian senior secondary students, while Datu et al. (2023) found that engagement and grit jointly predicted both academic and well-being outcomes among Hong Kong and Macau students during pandemic-disrupted learning. These recent findings corroborate the original model's central claim while demonstrating its applicability well beyond the contexts in which it was first developed.

Recent scholarship increasingly treats engagement as relationally produced rather than purely dispositional. Gan and Peng (2024) found that teacher support predicted mathematics engagement among college students through students' intrinsic valuation of the subject, an effect moderated by self-efficacy. Liu et al. (2018) reported a parallel mediated-moderation pathway, reinforcing that engagement is cultivated through supportive instructional relationships rather than arising independently of context. Within mathematics specifically, Flores et al. (2021) linked engagement to performance among Filipino secondary students, and Weinhandl et al. (2023) showed that enjoyment, engagement,

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and anxiety interact dynamically among upper secondary learners — evidence that engagement cannot be understood in isolation from students' concurrent emotional states.

**Behavioral engagement**, which refers to observable participation in academic tasks, including effort, persistence, attentiveness, and adherence to classroom expectations (Fredricks et al., 2004; Rimm-Kaufman et al., 2015), remains the most consistently documented predictor of mathematics achievement. Spann et al. (2020) found that diligence in mathematics tasks predicts performance independently of diligence in other domains, while Datu et al. (2023) showed that behavioral persistence buffered academic and well-being outcomes during pandemic disruption. Shimizu (2025) further demonstrated that behavioral engagement predicted achievement among Japanese students even under conditions of anxiety, though the strength of this relationship depended on students' self-efficacy — suggesting behavioral persistence alone is necessary but not sufficient without adequate instructional support. This finding aligns with earlier work suggesting that sustained effort can act as a partial buffer against the performance-eroding effects of anxiety (Putwain & Daly, 2014), while also highlighting that behavioral persistence alone may be insufficient without adequate instructional support.

**Affective engagement**, which captures students' emotional responses to learning, including interest, enjoyment, and a sense of belonging, as well as the relative absence of negative emotions such as boredom or anxiety (Fredricks et al., 2004; Pekrun et al., 2007), has been considerably refined by recent research on emotions in education. Pekrun et al. (2023) proposed a three-dimensional taxonomy of achievement emotions (valence, activation, object focus) that allows finer-grained analysis of how specific emotions, such as enjoyment versus anxiety, differentially shape engagement. The social dimension of affect has also gained attention: King and Datu (2017) demonstrated that classmates' collective well-being predicts individual students' subsequent well-being, evidencing a social-contagion effect with direct relevance to classroom climate, while Lee et al. (2023) confirmed that both school- and student-level factors jointly shape affective mathematics engagement.

**Cognitive engagement**, which involves the psychological investment and self-regulatory effort students direct toward understanding and mastering content, often distinguished between deep and surface learning strategies (Fredricks et al., 2004; Maamin et al., 2022), has shown the least consistent relationship with achievement among the three dimensions of engagement. Guo and Leung (2020) found no significant link between deep learning strategies and achievement among Chinese students, and Maamin et al. (2022) reported that cognitive engagement characterized by teacher dependence was negatively associated with Malaysian secondary students' achievement — indicating that the independence and quality of cognitive strategy use, not its mere presence, determines its value. Cevikbas and Kaiser (2022) found that flipped, learner-centered instruction fostered deeper cognitive engagement than teacher-directed approaches, a pattern corroborated by Weinhandl et al. (2020) using GeoGebra-supported instruction. Together, these findings suggest cognitive engagement is shaped more by instructional design than by strategy use alone.

**Mathematics Anxiety**

Mathematics anxiety (MA) is defined as a negative emotional and physiological response — tension, apprehension, fear, and avoidance — triggered by mathematical tasks (Richardson & Suinn, 1972). This definition, though more than fifty years old, remains the field's standard operational baseline and is treated here as foundational terminology rather than current evidence; the substantive findings on prevalence, structure, and intervention discussed below are drawn from recent literature. Duyapat et al. (2023) found that Filipino students experience moderate, predominantly cognitive mathematics anxiety, intensifying during test preparation rather than routine learning. Musa and Maat (2021) identified two principal sources — content-complexity-driven learning anxiety and evaluative assessment-related anxiety — both of which escalate as curricular demands increase.

International evidence confirms mathematics anxiety as a cross-cultural phenomenon rather than a localized artifact. Weinhandl et al. (2023) documented complex, sometimes counterintuitive interactions between anxiety, enjoyment, and engagement among Austrian students, while comparative developmental evidence indicates that anxiety reliably intensifies during early adolescence across diverse educational systems (Arslan, 2020). In the Philippine context, the spiral curriculum's early introduction of advanced topics such as polynomials and probability has been specifically linked to heightened anxiety during junior high school (Duyapat et al., 2023) — a contextual detail directly relevant to the present study's Grade 10 population.

**Cognitive manifestations.** Mathematics anxiety disrupts working memory and strategic thinking. Passolunghi et al. (2016) found that mathematics anxiety was significantly associated with reduced working memory capacity and lower mathematics performance among secondary school students, with working memory functioning as a key mechanism linking anxiety to achievement deficits. Chen et al. (2023) similarly found that cognitive and behavioral indicators — lost concentration, difficulty recalling prior learning — were more salient markers of anxiety than overt

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emotional distress, suggesting anxiety often manifests through impaired cognition rather than visible affect. Szczygieł (2021) refined this further, showing that the anxiety-achievement relationship in young children is mediated specifically through working memory rather than number sense, and is indirect rather than direct. Musa and Maat (2021) added that lower mathematical self-efficacy compounds this cognitive disruption through intrusive, worry-based thinking.

**Behavioral and affective manifestations.** Anxiety also produces task avoidance, reduced participation, and feelings of fear or diminished confidence (Ramirez et al., 2018). Caviola et al. (2017) validated the Abbreviated Math Anxiety Scale across genders among Italian primary students, confirming the multidimensional structure assumed throughout this review. Stoehr (2017) cautioned against treating anxiety as uniform, arguing that instructional responses must differ depending on whether anxiety manifests cognitively, behaviorally, or affectively. Encouragingly, Sammallahti et al. (2023), in a meta-analysis of intervention studies, found that programs combining cognitive-behavioral strategies with structured practice produced more consistent anxiety reductions than emotion-focused interventions alone — evidence that anxiety is most effectively addressed through concrete skill-building rather than affective support in isolation.

### Student Engagement and Academic Achievement in Mathematics

The engagement-achievement relationship is well-established but dimensionally uneven. Maamin et al. (2022) found affective engagement to be the strongest predictor among Malaysian secondary students, while teacher-dependent cognitive engagement was negatively associated with performance — a finding that diverges from earlier work positioning cognitive engagement as dominant (Fung et al., 2018), illustrating that the relative weight of each dimension varies across context.

Behavioral engagement again shows the most consistent support: Spann et al. (2020) confirmed domain-specific predictive power for mathematics diligence, and Datu et al. (2023) linked behavioral persistence to both achievement and well-being amid pandemic disruption. Gan and Peng (2024) extended this by showing engagement is shaped externally — through teacher support acting both directly and via students' intrinsic valuation of mathematics — rather than arising purely from individual disposition.

Most directly relevant to the present study, recent research has begun examining how anxiety moderates the engagement-achievement relationship rather than simply co-occurring with it. Quintero et al. (2022) found that affective anxiety significantly weakened the positive relationship between affective engagement and achievement, while cognitive and behavioral anxiety showed weaker or non-significant moderating effects — a dimension-specific pattern echoed by Shimizu (2025), who found behavioral engagement retained predictive power for achievement even under anxiety. This body of work directly motivates the present study's moderation design. Instructional context further conditions these relationships: Cevikbas and Kaiser (2022) linked flipped classrooms to stronger engagement-achievement outcomes, and Reinhold et al. (2021) found technology-supported instruction disproportionately benefited low-achieving students' engagement and understanding.

### Synthesis and Research Gap

The reviewed literature converges on two well-supported conclusions: student engagement — behavioral and affective dimensions especially — and mathematics anxiety are both robust, independently documented predictors of mathematics achievement (Fredricks et al., 2004; Maamin et al., 2022; Quintero et al., 2022). Foundational frameworks — including Fredricks et al.'s (2004) tripartite engagement model and Richardson and Suinn's (1972) anxiety construct — remain conceptually necessary as definitional scaffolding, but the empirical substance of current understanding — how engagement is socially produced (Gan & Peng, 2024; Liu et al., 2018), how anxiety manifests differentially across cognitive, behavioral, and affective channels (Chen et al., 2023; Stoehr, 2017; Szczygieł, 2021), and how anxiety is best remediated (Sammallahti et al., 2023) — comes overwhelmingly from 2020–2025 scholarship, satisfying the currency demands of an evolving field.

Despite this depth, three specific gaps remain, each directly addressed by the present study's design. First, few studies model the interaction between engagement and anxiety within a single structural framework, and fewer still disaggregate both constructs into their full dimensional sets simultaneously (Quintero et al., 2022; Shimizu, 2025); the present study's PLS-SEM model, incorporating three engagement dimensions and three anxiety dimensions concurrently, directly closes this methodological gap. Second, recent moderation and interaction studies cluster in East Asian, European, and North American contexts (Gan & Peng, 2024; Shimizu, 2025; Weinhandl et al., 2023), leaving Philippine secondary mathematics education comparatively underexamined despite documented national underperformance. Third, most existing studies use correlational or regression approaches that cannot capture conditional, moderated relationships; PLS-SEM offers the structural precision needed to specify under what conditions engagement predicts achievement (Hair et al., 2019) — precisely the question this study poses.

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The present study addresses these gaps by simultaneously modeling the three dimensions of student engagement and the three corresponding dimensions of mathematics anxiety within a single PLS-SEM moderation framework, using a sample of Grade 10 students in the Philippines—a population and developmental stage at which mathematics anxiety is known to peak (Dowker et al., 2016) and at which engagement-related interventions may yield substantial downstream benefits for senior high school track selection and subsequent academic trajectories. In doing so, the study extends the foundational engagement and anxiety literature reviewed above into an integrated, context-specific, and methodologically rigorous empirical contribution.

## Theoretical Framework

This study is grounded in established learning and motivation theories that explain how student engagement relates to mathematics performance, with mathematics anxiety acting as a potential influencing factor.

Constructivist Learning Theory explains that learners actively build knowledge through reasoning, problem-solving, and reflection. In this study, it supports the idea of cognitive engagement, where students develop mathematical understanding through active mental involvement. However, mathematics anxiety may interfere with this process by disrupting attention and limiting cognitive efficiency, which can negatively affect learning outcomes.

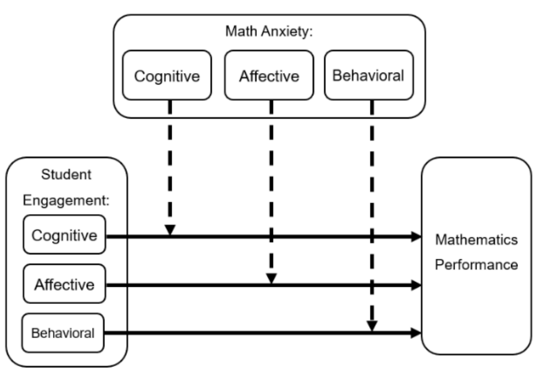
Pekrun's Control-Value Theory of Achievement Emotions highlights the role of emotions in academic learning. It provides a basis for affective engagement, where positive feelings such as interest and enjoyment promote motivation and sustained effort. In contrast, mathematics anxiety generates negative emotions that reduce engagement and weaken academic performance.

Flow Theory explains behavioral engagement as the result of deep involvement in tasks that match a learner's skill level. When students experience appropriate challenge, they are more likely to show persistence, focus, and active participation. Although anxiety may influence confidence, behavioral engagement is generally more resistant compared to cognitive and emotional engagement.

Taken together, these theories suggest that student engagement positively contributes to mathematics performance, while mathematics anxiety may disrupt this relationship by affecting thinking processes, emotional responses, and learning behavior.

## Conceptual Framework

**Figure 1**
*Research Paradigm*




The conceptual framework illustrates how student engagement and mathematics anxiety interact to influence mathematics performance.

Student engagement is the independent variable and is composed of three dimensions: cognitive engagement (mental effort and use of strategies in solving problems), affective engagement (students' emotions, interest, and attitudes toward mathematics), and behavioral engagement (participation, effort, and persistence in learning activities).

Mathematics performance is the dependent variable, representing students' achievement in mathematics.

Mathematics anxiety serves as a moderating variable that can alter the strength of the relationship between engagement and performance. When anxiety levels are high, particularly in emotional and cognitive aspects, students may struggle to fully apply their engagement in learning, which may lead to lower performance outcomes.

Overall, the framework emphasizes that student engagement supports mathematics performance, but its impact may vary depending on the level of mathematics anxiety experienced by students.

## Statement of the Problem

Mathematics remains one of the most challenging subjects for many secondary school students despite its importance in developing critical thinking, problem-solving, and analytical skills. While student engagement is recognized as a key factor in improving academic achievement, many learners continue to experience mathematics anxiety that may hinder their participation, motivation, and performance. Previous studies have examined student engagement and mathematics anxiety independently; however, limited research has investigated how the cognitive,

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affective, and behavioral dimensions of engagement influence mathematics performance and how mathematics anxiety moderates these relationships, particularly among Filipino junior high school students. Addressing this gap is important for developing instructional strategies and learning environments that promote both academic success and students' emotional well-being. Hence, this study examined the effects of student engagement on mathematics performance and determined the moderating role of mathematics anxiety among Grade 10 students.

**General Objective**

To examine the effects of cognitive, affective, and behavioral student engagement on mathematics performance and to determine the moderating role of mathematics anxiety in this relationship among Grade 10 students.

**Specific Objectives**

This study aims to:

1. Determine the level of student engagement in mathematics in terms of:
   1.1. Cognitive engagement;
   1.2. Affective engagement; and
   1.3. Behavioral engagement.
2. Assess the mathematics performance of Grade 10 students.
3. Determine the level of mathematics anxiety among Grade 10 students in terms of:
   3.1. Cognitive anxiety;
   3.2. Affective anxiety; and
   3.3. Behavioral anxiety.
4. Examine the effects of cognitive, affective, and behavioral engagement on mathematics performance.
5. Determine the moderating effects of cognitive, affective, and behavioral mathematics anxiety on the relationship between student engagement and mathematics performance.

**Research Questions**

This study sought to answer the following questions:

1. What is the level of student engagement in mathematics in terms of:
   1.1. Cognitive engagement?
   1.2. Affective engagement?
   1.3. Behavioral engagement?
2. What is the mathematics performance of Grade 10 students?
3. What is the level of mathematics anxiety of Grade 10 students in terms of:
   3.1. Cognitive anxiety?
   3.2. Affective anxiety?
   3.3. Behavioral anxiety?
4. To what extent do the following dimensions of student engagement significantly influence mathematics performance?
   4.1. Cognitive engagement?
   4.2. Affective engagement?
   4.3. Behavioral engagement?
5. To what extent do the following dimensions of mathematics anxiety significantly moderate the relationship between student engagement and mathematics performance?
   5.1. Mathematics cognitive anxiety?
   5.2. Mathematics affective anxiety?
   5.3. Mathematics behavioral anxiety?

**Research Hypotheses**

H01: Cognitive engagement does not significantly influence mathematics performance among Grade 10 students.
H02: Affective engagement does not significantly influence mathematics performance among Grade 10 students.
H03: Behavioral engagement does not significantly influence mathematics performance among Grade 10 students.
H04: Mathematics cognitive anxiety does not significantly moderate the relationship between cognitive engagement and mathematics performance.
H05: Mathematics affective anxiety does not significantly moderate the relationship between affective engagement and mathematics performance.

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H06: Mathematics behavioral anxiety does not significantly moderate the relationship between behavioral engagement and mathematics performance.

**METHODOLOGY**

**Research Design**

This study used a quantitative research design that combined descriptive-correlational analysis with explanatory predictive modeling. The descriptive-correlational component examined the relationships among student engagement (cognitive, affective, and behavioral), mathematics anxiety (cognitive, affective, and behavioral), and mathematics performance without manipulating variables, allowing the identification of the strength and direction of associations among these constructs.

To further explain these relationships, Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied using WarpPLS 7.0 – a statistical software used for analyzing complex relationships and evaluating measurement models. This method tested both direct and moderating effects within the proposed model, specifically how dimensions of engagement influence mathematics performance and how mathematics anxiety affects these relationships. PLS-SEM was appropriate for this study because it effectively analyzes complex relationships among latent variables measured through Likert-scale data (Wold, 1985; Hair et al., 2017).

Overall, the design not only described levels of engagement, anxiety, and performance but also tested an integrated model explaining how these variables interact to influence mathematics performance.

**Population and Sampling**

This study involved 330 Grade 10 students from three public secondary schools in District 1-C of Antipolo City during the School Year 2024–2025, excluding pilot sections. The district was selected due to its relatively low mathematics performance, making it a relevant context for examining student engagement, anxiety, and achievement.

The participants, aged approximately 14 to 19, were drawn from Mayamot National High School, Mambugan National High School, and Muntindilaw National High School. From a total population of 2,327 Grade 10 students, Cochran's formula for finite populations was applied at a 95% confidence level and a 5% margin of error to determine the required sample size. Stratified random sampling was then applied to ensure proportional representation across schools and student groups, enhancing the validity and generalizability of the findings.

**Research Instruments**

This study utilized validated and adopted instruments to measure student engagement in mathematics and mathematics anxiety, with permission secured from the original authors. Defined Likert scales and descriptive criteria were also established to interpret levels of student engagement, mathematics performance, and anxiety.

Student engagement was measured using the Student Engagement in the Mathematics Classroom Scale, originally developed by Kong et al. (2003) and subsequently refined by Maamin et al. (2022). The original instrument was constructed through classroom observations and student interviews, drawing on established tools including the Affective Engagement Questionnaire (Miserandino, 1996), the Student Engagement Questionnaire (Marks, 2000), and the Learning Process Questionnaire (Biggs, 1987). Validity and reliability were established through exploratory factor analysis and confirmatory factor analysis using LISREL-8, yielding satisfactory goodness-of-fit indices (AGFI and TLI ≥ 0.89) and Cronbach's alpha values ranging from 0.79 to 0.90 across subscales. In the study by Maamin et al. (2022), the instrument underwent expert validation and pilot testing, with exploratory factor analysis confirming high reliability values of 0.806 for cognitive engagement and 0.864 for both behavioral and affective engagement. The finalized instrument used in this study consisted of 51 items rated on a five-point Likert scale.

Mathematics anxiety was assessed using a validated instrument developed by Anindyarini and Supahar (2019), structured around three dimensions: cognitive, affective, and behavioral anxiety. Content validity was established through Aiken's V with seven raters using three scale options, yielding a V Aiken value of 0.857 at a 5% error rate. Construct validity was confirmed through exploratory factor analysis, with a KMO-MSA value of 0.703, a significant Bartlett's Test of Sphericity ($\chi^2 = 1069.7$, $p < .05$), and all items meeting the MSA threshold of > 0.5. The instrument employs a four-point Likert scale and was finalized with 24 items.

Mathematics performance was obtained from students' official General Weighted Average (GWA) – a cumulative final grade used in Philippines' basic education – in Mathematics as reported in their school records, following Department of Education grading standards.

Prior to actual data gathering, the researcher conducted pilot testing with 85 Grade 10 students who were not part of the main study. This procedure is recommended when instruments are adopted from previous studies

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(Creswell, 2014). Analysis of the pilot data yielded an overall Cronbach's alpha of 0.918, indicating excellent reliability and confirming the consistency and applicability of the adopted instruments for use in this study.

**Data Collection Procedure**

Data collection was conducted from January to March 2025, spanning approximately three months during School Year 2024–2025. It commenced after securing approval from the Schools Division Superintendent, the chief executive officer of a Schools Division Office (SDO) under the Department of Education (DepEd), as well as from the principals of the three participating public secondary schools in District 1-C, a local administrative unit comprising a cluster of public schools in Antipolo City.

Prior to the main survey, a pilot test involving 85 students from non-participating sections was conducted to establish the reliability of the instrument. After confirming its validity and reliability, the finalized survey was administered to Grade 10 students during regular class periods with the assistance of mathematics teachers, and questionnaires were retrieved immediately after completion. Standardized instructions were provided to all participants to ensure consistency of responses.

Before data gathering, informed consent was secured from all participants. As the respondents were minors, parental consent was likewise obtained alongside the students' own assent, in accordance with ethical research standards. All data were handled with strict confidentiality and used exclusively for research purposes. Students' mathematics performance was obtained from their final General Weighted Average (GWA) in Mathematics as recorded in official school records.

**Treatment of Data**

The data were organized and analyzed in accordance with the study objectives using appropriate statistical techniques. Descriptive statistics, particularly the mean, were used to summarize students' levels of cognitive, affective, and behavioral engagement, mathematics anxiety, and mathematics performance based on Likert-scale responses.

The main analytical approach was Partial Least Squares Structural Equation Modeling (PLS-SEM) using WarpPLS 7.0. This method was used to test the hypothesized relationships among variables, including the direct effects of student engagement on mathematics performance and the moderating effects of mathematics anxiety. Following the two-stage analytical procedure recommended by Hair et al. (2019), the measurement model was assessed prior to evaluating the structural model. This measurement model assessment included four components: (1) outer model factor loadings, which evaluated the strength of the relationship between each observed indicator and its corresponding latent construct; (2) composite reliability (CR), which assessed the internal consistency of each construct with an acceptable threshold of CR $\geq$ 0.70; (3) average variance extracted (AVE), which evaluated convergent validity by indicating the proportion of indicator variance explained by the construct, with AVE $\geq$ 0.50 as the benchmark; and (4) discriminant validity, assessed through the Fornell-Larcker criterion, which requires that the square root of each construct's AVE exceeds its highest correlation with any other construct in the model. Path coefficients and p-values were used to determine the strength and significance of relationships, while the coefficient of determination ($R^2$) values indicated the amount of variance explained in mathematics performance. Moderation analysis through interaction terms were also analyzed to assess moderation effects.

**Ethical Considerations**

Ethical approval and permissions were obtained from the Schools Division Office of Antipolo City and the principals of the participating schools prior to data collection. As the respondents were minors, parental consent was secured before participation. Students' assent was likewise obtained, ensuring that both parents and students were fully informed about the study's purpose, procedures, and the voluntary nature of participation, including their right to withdraw at any time without penalty. Informed consent forms were distributed and collected from all Grade 10 student participants prior to the administration of the survey instruments.

Confidentiality and anonymity were maintained by not collecting personal identifiers, and all data were used strictly for research purposes and reported in aggregated form. The study also ensured that the questionnaire design was age-appropriate and non-threatening to minimize any potential discomfort related to mathematics anxiety.

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## RESULTS and DISCUSSION

This section presents the collected data and offers a detailed analysis and interpretation of the findings, organized according to the research questions specified in the statement of the problem.

### 1. Level of student engagement in mathematics in terms of:

#### 1.1. Cognitive engagement

**Table 1**
*Mean and Verbal Description of Engaging Learning Activity in terms of Cognitive Aspect*

| Statements | Mean | Verbal Description | Transposed Value |
|---|---|---|---|
| 1. I believe memorizing formulas helps me learn math effectively. | 4.24 | Agree | HE |
| 2. I prefer memorizing formulas over understanding underlying concepts. | 3.32 | Disagree | SE |
| 3. Focusing on details through repetition works better for me than grasping the overall idea. | 3.11 | Disagree | SE |
| 4. Memorizing steps to solve word problems is useful in math. | 4.24 | Agree | HE |
| 5. Learning various solution methods through memorization is effective for me. | 4.00 | Neutral | NE |
| 6. I find that solving problems repeatedly helps me remember facts better. | 4.33 | Agree | HE |
| 7. I often rely on memory rather than full understanding when learning math. | 2.98 | Disagree | SE |
| 8. I think about how math applies in real-life situations. | 3.91 | Neutral | NE |
| 9. I reflect on what I already know to make better sense of new lessons. | 3.95 | Neutral | NE |
| 10. When reading a textbook, I try to deeply understand key concepts, not just read through. | 3.79 | Neutral | NE |
| 11. I connect math lessons with other subjects or life experiences. | 3.75 | Neutral | NE |
| 12. I use my free time to explore math topics I find interesting. | 3.09 | Disagree | SE |
| 13. I review topics from class during my spare time. | 3.44 | Neutral | NE |
| 14. I learn best by following my teacher's instructions. | 4.50 | Agree | HE |
| 15. I think teacher instructions are the most effective way to learn math. | 4.57 | Agree | HE |
| 16. I usually learn what my teacher teaches. | 4.36 | Agree | HE |
| 17. I follow the methods shown by the teacher. | 4.34 | Agree | HE |
| 18. I solve problems the way my teacher demonstrates. | 3.98 | Neutral | NE |
| 19. I rely on the teacher's guidance to solve math problems. | 4.06 | Agree | HE |
| 20. I strictly follow the teacher's instructions in learning math. | 4.09 | Agree | HE |
| **GRAND MEAN** | **3.90** | **Neutral** | **NE** |

*Note. Adopted from "Student engagement in mathematics: Development of instrument and validation of construct" (p. 11), by Q. P. Kong, N. Y. Wong, and C. C. Lam, 2003, Mathematics Education Research Journal, 15(1), 4–21. https://doi.org/10.1007/BF03217366*
*HE = High Engagement; SE = Slight Engagement; NE = Neither Engage nor No Engagement.*

The results indicated that Grade 10 students showed a moderate level of cognitive engagement in mathematics (GM = 3.90), indicating average involvement in learning tasks. Results revealed strong dependence on teacher-guided instruction, particularly in following procedures and solving demonstrated problems (M = 4.36–4.57). Memorization was inconsistently used (M = 2.98–4.24), while higher-order thinking skills such as applying concepts, making connections, and independent learning were generally neutral (M = 3.75–3.91). Overall, engagement was more procedural than conceptual, with limited autonomous learning.

These findings suggest that students rely heavily on structured teaching, which may restrict deeper understanding and independent thinking. This is consistent with Kong et al. (2003), who noted that reliance on teacher direction often reflects surface-level engagement. Similarly, Gan and Peng (2024), Çağırgan and Soytürk (2021), and Siebers (2015) emphasized that while teacher support aids learning, excessive dependence reduces learner autonomy. In addition, Maamin et al. (2022) and Awofala et al. (2024) reported that heavy reliance on teacher-centered strategies may negatively affect mathematics achievement. Although some studies found benefits of deep learning approaches,

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others reported no significant effect (e.g., Guo & Leung, 2020), suggesting that both strategy quality and learner independence are crucial.

These results underscore the importance of transitioning toward more learner-centered mathematics instruction. Teachers are encouraged to incorporate inquiry-based and problem-based learning tasks that promote independent mathematical reasoning and reduce procedural dependency (Cevikbas & Kaiser, 2022; Weinhandl et al., 2023). At the curriculum level, embedding competency-based tasks and real-world applications can help students move beyond rote memorization toward conceptual understanding (OECD, 2021). School leaders and department heads may direct instructional supervision efforts toward cultivating inquiry-oriented classroom cultures. Teacher education programs and professional development initiatives should build capacity for fostering metacognitive strategies and self-directed problem-solving, as preparation focused solely on content knowledge may inadequately equip teachers to develop deep cognitive engagement among learners (Stoehr, 2017). For policymakers, these findings support the adoption of evidence-based instructional reforms that institutionalize active learning as a national standard, particularly as the Philippines continues to pursue improved performance in international assessments such as PISA and TIMSS.

### 1.2. Affective engagement

**Table 2**
*Mean and Verbal Description of Engaging Learning Activity in terms of Affective Aspect*

| Items/Statements | Mean | Verbal Description | Transposed Value |
|---|---|---|---|
| 1. I find math interesting and enjoyable. | 3.93 | Neutral | NE |
| 2. I enjoy solving math problems. | 3.78 | Neutral | NE |
| 3. I feel satisfied when completing math tasks. | 3.71 | Neutral | NE |
| 4. I'm curious and happy when learning new math concepts. | 3.85 | Neutral | NE |
| 5. I feel excited about starting new math topics. | 3.50 | Neutral | NE |
| 6. Learning new math problems gives me pleasure. | 3.65 | Neutral | NE |
| 7. Even though math is difficult, I feel happy when I complete tasks. | 4.32 | Agree | HE |
| 8. Math may be boring sometimes, but good results make me happy. | 4.27 | Agree | HE |
| 9. Learning math is hard, but getting high scores is rewarding. | 4.47 | Agree | HE |
| 10. I feel fulfilled when my effort in math pays off. | 4.50 | Agree | HE |
| 11. As long as I do well, I'm happy even if math is difficult. | 4.40 | Agree | HE |
| 12. I feel satisfied when I achieve good results in math despite the challenges. | 4.43 | Agree | HE |
| 13. I get nervous during math tests. | 3.97 | Neutral | NE |
| 14. I worry during math exams. | 3.96 | Neutral | NE |
| 15. I panic when I don't understand test questions. | 4.05 | Agree | HE |
| 16. I'm afraid of getting low scores in math. | 4.20 | Agree | HE |
| 17. I feel anxious when I encounter hard problems in exams. | 3.93 | Neutral | NE |
| 18. I'm uncomfortable when we start a new topic. | 2.91 | Disagree | SE |
| 19. I'm tired of constantly learning new lessons. | 2.39 | Strongly Disagree | NO |
| 20. I don't enjoy attending math class. | 2.13 | Strongly Disagree | NO |
| **GRAND MEAN** | **3.82** | **Neutral** | **NE** |

*Note. Adopted from "Student engagement in mathematics: Development of instrument and validation of construct" (p. 11), by Q. P. Kong, N. Y. Wong, and C. C. Lam, 2003, Mathematics Education Research Journal, 15(1), 4–21. https://doi.org/10.1007/BF03217366*
*HE = High Engagement, SE = Slight Engagement, NE = Neither Engage nor No Engagement, NO = No Engagement*

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The results indicated that Grade 10 students demonstrated a moderate level of affective engagement in mathematics (GM = 3.82). Their positive emotions were mainly linked to academic success, as they reported satisfaction and fulfillment when achieving good results (M = 4.32–4.50). In contrast, intrinsic interest and enjoyment in mathematics remained neutral (M = 3.50–3.93), indicating that emotional engagement was more performance-driven than subject-centered. Mathematics anxiety was also evident, particularly fear of low scores and panic during difficult tasks (M = 4.05–4.20), although overall negative attitudes toward the subject were not dominant.

These findings indicate that students' emotional engagement is largely performance-driven, where motivation is sustained by results rather than genuine subject interest. This is consistent with Kong et al. (2003) and Wahid and Shahrill (2014), who identified achievement orientation as a central driver of students' emotional responses to mathematics. Maamin et al. (2022) and Awofala et al. (2024) similarly found that while outcome-based motivation can support engagement, the presence of anxiety tends to undermine its consistency. King and Areepattamannil (2014) further noted that interest in mathematics varies considerably across learners, reinforcing the view that affective engagement is shaped by multiple and often competing emotional factors. Collectively, these results point to the need for instructional strategies that cultivate intrinsic motivation and mitigate mathematics anxiety to sustain deeper and more stable affective engagement.

These findings have broad implications across instructional, curricular, leadership, and policy domains. Teachers can strengthen affective engagement by designing tasks that connect mathematical content to students' personal goals and everyday experiences, building on the achievement-driven motivation already present while fostering genuine interest in the subject (King & Datu, 2017; Pekrun et al., 2023). Integrating social-emotional learning (SEL) frameworks into mathematics instruction can equip students with skills to recognize and regulate their emotional responses, particularly during evaluative situations where anxiety is most disruptive (Caviola et al., 2022; Quintero et al., 2022). Establishing classroom environments characterized by psychological safety, peer support, and encouragement can further reduce anxiety and sustain positive affect (Suren & Kandemir, 2020). At the curriculum level, explicitly embedding affective competencies—such as mathematical confidence, resilience, and interest development—into program design can ensure that the emotional dimension of learning receives deliberate attention alongside academic standards (OECD, 2021). School leaders are encouraged to foster professional learning communities where teachers collectively develop and refine emotionally responsive mathematics instruction. Teacher education and professional development programs should incorporate training on motivation theory, emotional intelligence, and SEL strategies, preparing both pre-service and in-service educators to address students' affective needs effectively. For policymakers, these findings highlight the importance of institutionalizing student well-being initiatives and anxiety reduction programs, affirming that affective factors are integral—not incidental—to mathematics achievement (Lee et al., 2023).

### 1.3. Behavioral engagement

**Table 3**
*Mean and Verbal Description of Engaging Learning Activity in terms of Behavioral Aspect*

| Items/Statements | Mean | Verbal Description | Transposed Value |
|---|---|---|---|
| 1. I listen attentively to my teacher. | 4.11 | Agree | HE |
| 2. I actively share my thoughts during class discussions. | 3.65 | Neutral | NE |
| 3. I put effort into learning math. | 4.05 | Agree | HE |
| 4. I focus hard when new math ideas are introduced. | 3.95 | Neutral | NE |
| 5. I use every way I can to understand math lessons. | 4.20 | Agree | HE |
| 6. I participate in math class discussions. | 3.56 | Neutral | NE |
| 7. I try again later if I don’t get the answer right away. | 4.20 | Agree | HE |
| 8. I keep working on problems I can't solve immediately. | 4.16 | Agree | HE |
| 9. I correct my mistakes when solving problems. | 4.22 | Agree | HE |
| 10. I believe persistence leads to correct answers. | 4.20 | Agree | HE |
| 11. I keep trying different methods until I find the right solution. | 4.20 | Agree | HE |
| **GRAND MEAN** | **4.05** | **Agree** | **HE** |

*Note. Adopted from "Student engagement in mathematics: Development of instrument and validation of construct" (p. 11), by Q. P. Kong, N. Y. Wong, and C. C. Lam, 2003, Mathematics Education Research Journal, 15(1), 4–21. https://doi.org/10.1007/BF03217366*
*HE = High Engagement, SE = Slight Engagement, NE = Neither Engage nor No Engagement*


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The results indicated that Grade 10 students demonstrated a high level of behavioral engagement in mathematics (GM = 4.05). They showed strong attentiveness, effort, and persistence, particularly in following teacher instructions, completing tasks, and repeatedly working through problems until correct solutions were reached (M = 4.11–4.22). These indicate consistent effort and resilience in learning. However, participation in class discussions and sharing of ideas was relatively lower (M = 3.56–3.65), suggesting limited active verbal engagement and a tendency toward individual work.

These findings imply that students are generally hardworking and persistent but less interactive in classroom discourse, possibly due to low confidence or preference for independent learning. This finding aligns with previous studies indicating that persistence and effort are associated with better mathematics outcomes (Awofala et al., 2024; Datu et al., 2023; Hidayat et al., 2019; Maamin et al., 2022; Spann et al., 2020). Bester and Brand (2013) and Awofala and Falolu (2017) similarly emphasized the role of sustained effort in solving complex tasks. However, Shimizu (2025) noted that behavioral engagement alone may not guarantee high achievement without effective instructional support. These findings collectively highlight the need to strengthen collaborative and participatory learning opportunities to complement students' strong persistence and effort.

The observed disparity between strong individual effort and limited discussion participation carries significant implications for instruction, curriculum, leadership, and policy. Mathematics teachers are encouraged to implement structured collaborative strategies—such as think-pair-share, group problem-solving, and peer-assisted learning—that channel students' existing diligence into active social participation and mathematical communication (Datu et al., 2023; Spann et al., 2020). Such approaches deepen conceptual understanding, build mathematical discourse skills, and foster shared responsibility for learning outcomes. Peer interaction during mathematical tasks has been shown to enhance both procedural fluency and conceptual reasoning, particularly when students are prompted to articulate and defend their thinking (Cevikbas & Kaiser, 2022). At the curriculum level, collaborative competencies and active participation should be embedded as explicit learning outcomes within mathematics programs rather than treated as secondary to content delivery. School leaders can model and reinforce a culture of collaborative learning by incorporating discussion-based instructional formats into professional development and classroom observation frameworks. Teacher education programs should equip pre-service and in-service educators with discourse facilitation strategies that build on students' existing persistence while developing interpersonal dimensions of mathematical engagement. For policymakers, investing in school improvement programs that institutionalize peer learning structures and professional learning communities—particularly in low-performing districts such as District 1-C—may generate systemic and sustainable gains in both engagement and academic achievement (Maamin et al., 2022; Weinhandl et al., 2023).

## 2. Mathematics performance of Grade 10 students

**Table 4**
*Distribution of Grade 10 Students' Mathematics Performance*

| Grade | Frequency | Percentage | Average Grade | Verbal Interpretation |
|---|---|---|---|---|
| 90 – 100 | 54 | 16.36% | **82.51** | **Satisfactory** |
| 85 – 89 | 63 | 19.09% | | |
| 80 – 84 | 92 | 27.88% | | |
| 75 – 79 | 119 | 36.06% | | |
| Below 75 | 2 | 0.61% | | |
| **TOTAL** | **330** | **100%** | | |

The results showed that Grade 10 students obtained an average mathematics grade of 82.51, classified as "Satisfactory." Most learners scored between 75–84 (63.94%), indicating that they generally met minimum competencies. However, only 16.36% reached the 90–100 range, while very few (0.61%) performed below 75, suggesting a generally passing performance but limited high achievement.

These findings indicate that students' mathematics performance is adequate but concentrated at mid-level proficiency, with few demonstrating advanced skills. This aligns with Capuno et al. (2019), who observed that students often cluster within satisfactory levels and require targeted support to improve outcomes. Cabuquin and Abocejo (2023) further emphasized that performance is influenced by study habits, motivation, and attitudes toward learning. In addition, Huang et al. (2020), Cleary and Kitsantas (2017), and Tanujaya and Mumu (2022) noted that engagement

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and effective learning strategies enhance achievement, while weak skills may limit performance. Overall, the results suggest the need for strengthened instructional strategies and targeted interventions to improve higher-level mathematics performance.

### 3. Level of mathematics anxiety of Grade 10 students in terms of:

#### 3.1. Mathematics Behavioral Anxiety

**Table 5**

*Mean and Verbal Description of Mathematics Anxiety Level in terms of Behavioral Aspect*

| Statements | Mean | Verbal Description | Transposed Value |
|---|---|---|---|
| 1. My voice becomes shaky when I answer math questions. | 3.06 | Often | High |
| 2. I react with shock when I encounter difficult math problems. | 3.13 | Often | High |
| 3. I tend to speak quickly or nervously about math. | 2.96 | Often | High |
| 4. I like to avoid math problems whenever I can. | 2.51 | Rarely | Low |
| 5. I stay alert to avoid mistakes in math. | 3.20 | Often | High |
| 6. I feel guilty about wrong answers after a math test. | 3.09 | Often | High |
| 7. I worry that something bad will happen if I perform poorly in math. | 3.26 | Often | High |
| 8. I feel embarrassed to ask questions in math class. | 2.78 | Rarely | Low |
| 9. I avoid discussing my math work with others. | 2.50 | Rarely | Low |
| **GRAND MEAN** | **2.94** | **Often** | **High** |

*Note. Adopted from "A mathematical anxiety scale instrument for junior high school students" (p. 447), by R. Anindyarini and Supahar, 2019, Journal of Education and Learning (EduLearn), 13(4), 447–453.* https://doi.org/10.11591/edulearn.v13i4.13267

The results showed that Grade 10 students exhibited a high level of behavioral mathematics anxiety (GM = 2.94), generally occurring “Often.” This was reflected in frequent visible anxiety responses such as shaky voice, nervous speech, shock when encountering difficult problems, and heightened alertness during math tasks (M = 2.96–3.26). Feelings of guilt and worry about poor performance were also common. However, avoidance behaviors such as skipping tasks, avoiding discussions, or reluctance to ask questions were less evident (M = 2.50–2.78).

These findings suggest that students’ anxiety is primarily expressed through physiological and emotional reactions rather than avoidance of learning activities, indicating that they continue to engage in mathematics despite experiencing stress. This supports Ramirez et al. (2018), who found that students may remain academically involved even when showing anxiety-related behaviors, although such anxiety can still hinder performance. Overall, the results highlight the need for classroom strategies that reduce anxiety responses while sustaining student engagement in mathematical tasks.

#### 3.2. Mathematics Cognitive Anxiety

**Table 6**

*Mean and Verbal Description of Mathematics Anxiety Level in terms of Cognitive Aspect*

| Statements | Mean | Verbal Description | Transposed Value |
|---|---|---|---|
| 1. I lose focus when faced with difficult math problems. | 3.02 | Often | High |
| 2. I often arrive at incorrect answers due to anxiety. | 2.94 | Often | High |
| 3. I have trouble sleeping before math exams. | 2.52 | Rarely | Low |
| 4. I feel confused when I study math by myself | 2.99 | Often | High |
| 5. I lose concentration easily while working on math. | 2.92 | Often | High |
| 6. I feel confused during math tests. | 2.96 | Often | High |
| 7. I forget math concepts under time pressure. | 3.19 | Often | High |
| **GRAND MEAN** | **2.93** | **Often** | **High** |

*Note. Adopted from "A mathematical anxiety scale instrument for junior high school students" (p. 447), by R. Anindyarini and Supahar, 2019, Journal of Education and Learning (EduLearn), 13(4), 447–453.* https://doi.org/10.11591/edulearn.v13i4.13267

The findings indicated that Grade 10 students showed a high level of cognitive mathematics anxiety (GM = 2.93), occurring “Often.” This was reflected in frequent experiences of loss of focus, confusion, reduced concentration,

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and forgetting concepts under pressure, especially during tests and independent study (M = 2.92–3.19). Students also reported making errors due to anxiety. Only sleep-related disturbance was low (M = 2.52), indicating minimal effect on rest.

These results suggest that mathematics anxiety mainly disrupts cognitive processing and attention, particularly in time-pressured situations. This supports Carey et al. (2019), who found that mathematics anxiety interferes with working memory and increases intrusive thoughts that hinder problem-solving performance. Overall, the findings imply the need for instructional approaches that reduce cognitive load and strengthen students' focus and confidence during mathematical tasks and assessments.

### 3.3. Mathematics Affective Anxiety

**Table 7**

*Mean and Verbal Description of Mathematics Anxiety Level in terms of Affective Aspect*

| Statements | Mean | Verbal Description | Transposed Value |
|---|---|---|---|
| 1. I am more afraid of math exams than other tests. | 3.00 | Often | High |
| 2. I suddenly feel nervous about math, even when I know the material. | 3.01 | Often | High |
| 3. I feel guilty about not understanding math concepts. | 2.87 | Rarely | Low |
| 4. I feel stressed before entering math class. | 2.56 | Rarely | Low |
| 5. I feel anxious about solving math problems in front of others. | 2.83 | Rarely | Low |
| 6. I feel uneasy when reviewing math problems with friends. | 2.60 | Rarely | Low |
| 7. Math tests make me feel more anxious than tests in other subjects. | 2.84 | Rarely | Low |
| 8. I feel shame if I struggle with math concepts in public. | 3.05 | Often | High |
| **GRAND MEAN** | **2.85** | **Rarely** | **Low** |

*Note. Adopted from "A mathematical anxiety scale instrument for junior high school students" (p. 447), by R. Anindyarini and Supahar, 2019, Journal of Education and Learning (EduLearn), 13(4), 447–453. https://doi.org/10.11591/edulearn.v13i4.13267*

The results indicated that Grade 10 students exhibited a low level of affective mathematics anxiety (GM = 2.85), generally occurring "Rarely." Results showed minimal emotional distress in most situations, including low stress before math class, limited anxiety when working with peers, and uncommon feelings of guilt or embarrassment (M = 2.56–2.87). However, some students still experienced occasional nervousness during math exams and fear of public performance (M = 3.00–3.05).

These findings indicate that students' emotional anxiety is situational rather than persistent, emerging mainly in evaluative contexts. This supports Szczygieł (2021), who noted that affective components of mathematics anxiety are generally less intense than cognitive and behavioral aspects among actively engaged learners. Overall, the results suggest that maintaining a supportive and low-pressure learning environment, particularly during assessments, may help further reduce emotional anxiety in mathematics.

**Table 8**

*Grand Mean and Verbal Description of Mathematics Anxiety Level*

| Mathematics Anxiety | Mean | Verbal Interpretation | Mathematics Anxiety Level |
|---|---|---|---|
| Behavioral | 2.94 | Often | High |
| Cognitive | 2.93 | Often | High |
| Affective | 2.85 | Rarely | Low |
| **GRAND MEAN** | **2.91** | **Often** | **High** |

The results showed that Grade 10 students experienced an overall high level of mathematics anxiety (GM = 2.91). This was most evident in behavioral (M = 2.94) and cognitive anxiety (M = 2.93), both categorized as "Often," while affective anxiety was lower (M = 2.85) and categorized as "Rarely." Students frequently displayed behavioral signs such as nervousness and heightened alertness during math tasks, along with cognitive difficulties including loss of focus, confusion, and forgetting concepts under pressure. In contrast, emotional responses such as guilt, shame, and intense fear were less frequently reported.

These findings indicate that mathematics anxiety is primarily expressed through cognitive disruption and observable behaviors rather than strong emotional distress, suggesting that students continue engaging in mathematics

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despite internal difficulties. This pattern aligns with Carey et al. (2019), who found that mathematics anxiety impairs working memory and concentration, and Ramirez et al. (2018), who noted that students may remain engaged even while experiencing cognitive strain. Chen et al. (2023) and Szczygieł (2021) similarly reported that cognitive and behavioral symptoms are more prominent than affective responses. Collectively, these findings suggest that interventions should prioritize reducing cognitive load and improving coping strategies to lessen the impact of mathematics anxiety on learning.

These results carry critical implications for school support systems, teacher preparation, and educational policy. Mathematics teachers should be equipped with anxiety-sensitive pedagogical approaches that recognize cognitive and physiological anxiety indicators and respond through instructional scaffolding, encouragement, and flexible assessment designs that minimize unnecessary evaluative pressure (Stoehr, 2017; Musa & Maat, 2021). Formative assessment strategies—such as low-stakes quizzes and exit activities—can sustain academic rigor while reducing the performance anxiety associated with high-stakes testing. School counseling services should be strengthened to include structured mathematics anxiety interventions, particularly cognitive-behavioral approaches that enable students to identify and reframe negative self-perceptions about their mathematical competence (Supekar et al., 2015; Sammallahti et al., 2023). Peer tutoring, mentoring, and supplementary mathematics support programs can further provide emotionally supportive learning environments for anxiety-affected students. At the curriculum level, incorporating gradual skill-building sequences and mastery-based progressions may buffer against the anxiety intensified by abrupt content difficulty increases, particularly given that the Philippine K–12 spiral curriculum introduces advanced topics such as polynomials and probability at the Grade 10 level (Duyapat et al., 2023). School leaders should integrate targeted mathematics anxiety intervention programs into school improvement plans, supported by monitoring mechanisms and embedded professional development for teachers. Teacher education institutions should incorporate anxiety management strategies and trauma-informed instructional practices as core components of mathematics teacher preparation. At the policy level, national anxiety reduction initiatives within the Department of Education are warranted, as the pervasive nature of mathematics anxiety among Filipino secondary students reflects a systemic challenge requiring coordinated and sustained institutional response (Capuno et al., 2019; OECD, 2021).

**Measurement Model Assessment**

In accordance with the two-stage analytical procedure recommended by Hair et al. (2019), the reflective measurement model was evaluated prior to structural model estimation. This sequential approach is essential because the validity of structural path coefficients depends on prior confirmation that each latent construct is measured with sufficient reliability, convergent validity, and discriminant validity. The measurement model assessment encompassed four components: (1) outer model factor loadings, (2) composite reliability (CR), (3) average variance extracted (AVE), and (4) discriminant validity via the Fornell-Larcker criterion. All analyses were conducted using WarpPLS 7.0 with a final study sample of 330 Grade 10 students.

**Indicator Reliability and Factor Loadings**

Table 9 presents a summary of standardized outer loadings for all survey indicators across the seven latent constructs: Cognitive Engagement (SE_CE; 20 items), Affective Engagement (SE_AE; 20 items), Behavioral Engagement (SE_BE; 11 items), Behavioral Mathematics Anxiety (MABR; 9 items), Cognitive Mathematics Anxiety (MACR; 7 items), Affective Mathematics Anxiety (MAAR; 8 items), and Mathematics Performance (MATH_PER; 1 observable indicator).

Within the Cognitive Engagement subscale, outer loadings ranged from 0.113 to 0.708. The highest loadings were observed on items reflecting reliance on teacher-directed instruction (CE16 = 0.698, CE17 = 0.708, CE18 = 0.676, CE19 = 0.665), consistent with the dominant surface-level engagement pattern identified in the descriptive results. Items tapping deep learning strategies and independent exploration yielded comparatively lower loadings (CE3 = 0.113, CE8 = 0.382), reflecting the inherently heterogeneous structure of cognitive engagement as operationalized by the Kong et al. (2003) instrument.

For Affective Engagement, items loaded significantly on their construct across the range of 0.480 to 0.761, with achievement-driven emotional satisfaction items loading most strongly (AE21 = 0.761, AE22 = 0.720, AE24 = 0.722). Two items — AE33 and AE34 — failed to reach statistical significance ($p = .382$ and $p = .193$, respectively), and AE35 was marginally significant ($p = .036$). Six items within the affective subscale exhibited near-zero or negative loadings, suggesting they tap anxiety-adjacent emotional content directionally distinct from positive affective engagement. These items were retained to preserve the validated instrument structure; their retention did not improve CR or AVE above established thresholds (Hair et al., 2017).

Behavioral Engagement items displayed consistently strong loadings ranging from 0.607 to 0.782, with persistence and repeated-effort items loading highest (BE49 = 0.782, BE48 = 0.760, BE47 = 0.749). Two items

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capturing verbal class participation yielded substantially weaker loadings (BE52 = 0.200, BE53 = 0.253), consistent with the descriptive finding that active discussion participation was the weakest behavioral engagement sub-dimension.

All items across the three mathematics anxiety subscales loaded significantly on their respective constructs. MACR items ranged from 0.659 to 0.764, MAAR items from 0.675 to 0.822, and MABR items from 0.331 to 0.753. MABR5 (0.331) and MABR7 (0.554) yielded the weakest loadings within the behavioral anxiety subscale, partly reflecting the conceptual distance of avoidance-related items from the core physiological anxiety response.

Per Hair et al. (2017), indicators with loadings between 0.40 and 0.70 may be retained when their removal does not produce a meaningful increase in CR or AVE. In the present study, removing low-loading items did not raise AVE or CR values sufficiently to justify re-specification of the validated instruments. All items were therefore retained to preserve construct integrity and fidelity to the original instrument structures (Kong et al., 2003; Maamin et al., 2022; Anindyarini & Supahar, 2019).

**Table 9**
*Summary of Outer Loadings by Construct*

| Construct | Items (n) | Loading Range | Significant Items | Non-significant Items |
|---|---|---|---|---|
| Cognitive Engagement (SE_CE) | 20 | 0.113 – 0.708 | 18 items (p < .001) | CE3, CE8 (p > .05) |
| Affective Engagement (SE_AE) | 20 | 0.480 – 0.761 | 18 items (p < .001) | AE33 (p = .382); AE34 (p = .193) |
| Behavioral Engagement (SE_BE) | 11 | 0.200 – 0.782 | 9 items (p < .001) | BE52 (p > .05); BE53 (p > .05) |
| Cognitive Math Anxiety (MACR) | 7 | 0.659 – 0.764 | All 7 (p < .001) | — |
| Affective Math Anxiety (MAAR) | 8 | 0.675 – 0.822 | All 8 (p < .001) | — |
| Behavioral Math Anxiety (MABR) | 9 | 0.331 – 0.753 | All 9 (p < .001) | — |
| Mathematics Performance (MATH_PER) | 1 | 1.000 | n/a (single item) | — |

***Note.*** *All loadings were estimated using WarpPLS 7.0 with the final study sample (N = 330). Significance thresholds follow Hair et al. (2017). Items with loadings below 0.40 were evaluated for potential removal; retention decisions were based on the criterion that removal not meaningfully increase AVE or CR above threshold levels.*

**Composite Reliability and Average Variance Extracted**

Table 10 presents composite reliability (CR) and average variance extracted (AVE) values for each construct. Composite reliability assesses the degree to which a set of indicators consistently measures its intended latent construct, with values of 0.70 or above indicating acceptable internal consistency (Hair et al., 2019). All six multi-item constructs satisfied this threshold: SE_CE (CR = 0.872), SE_AE (CR = 0.808), SE_BE (CR = 0.892), MABR (CR = 0.855), MACR (CR = 0.887), and MAAR (CR = 0.906). Composite reliability was particularly strong for Affective Mathematics Anxiety (0.906) and Behavioral Engagement (0.892).

Average variance extracted indicates the proportion of indicator variance captured by the latent construct relative to measurement error. The conventional threshold for acceptable convergent validity is AVE ≥ 0.50, indicating that the construct accounts for more than half the variance in its indicators (Fornell & Larcker, 1981; Hair et al., 2019). Two constructs met this threshold: MACR (AVE = 0.530) and MAAR (AVE = 0.548). Four constructs yielded AVE values below 0.50: SE_CE (AVE = 0.273), SE_AE (AVE = 0.267), SE_BE (AVE = 0.408), and MABR (AVE = 0.404).

AVE values below 0.50 are, in part, a structural consequence of the large number of heterogeneous items comprising each subscale. The Cognitive and Affective Engagement subscales each contain 20 items spanning theoretically distinct facets — memorization, teacher reliance, deep learning, and teacher dependence for SE_CE; intrinsic interest, achievement satisfaction, and anxiety for SE_AE — such that no single factor can account for the

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majority of variance across so broad a range of indicators. This is a recognized limitation in multidimensional instruments with wide content coverage, where the breadth of item content by design reduces convergent AVE (Diamantopoulos & Siguaw, 2006). Importantly, Hair et al. (2017) affirm that AVE values below 0.50 are tolerable when CR exceeds 0.60, because the CR coefficient is less sensitive to item count and assigns greater weight to highly loading indicators. Since all four constructs with below-threshold AVE values have CR values well above 0.80, the reliability of the composite latent variable scores is nonetheless established. This AVE limitation is acknowledged as a methodological boundary of the adopted multi-item instruments; results should be interpreted with appropriate caution regarding convergent validity for these four constructs.

**Table 10**
*Construct Reliability and Convergent Validity*

| Construct | Items (n) | CR | AVE | CR ≥ 0.70? | AVE ≥ 0.50? |
|---|---|---|---|---|---|
| MATH_PER | 1 | 1.000 | 1.000 | ✓ | ✓ |
| SE_CE (Cognitive Engagement) | 20 | 0.872 | 0.273 | ✓ | ✗ Below 0.50 |
| SE_AE (Affective Engagement) | 20 | 0.808 | 0.267 | ✓ | ✗ Below 0.50 |
| SE_BE (Behavioral Engagement) | 11 | 0.892 | 0.408 | ✓ | ✗ Below 0.50 |
| MABR (Behavioral Anxiety) | 9 | 0.855 | 0.404 | ✓ | ✗ Below 0.50 |
| MACR (Cognitive Anxiety) | 7 | 0.887 | 0.530 | ✓ | ✓ |
| MAAR (Affective Anxiety) | 8 | 0.906 | 0.548 | ✓ | ✓ |

***Note.*** *CR = Composite Reliability; AVE = Average Variance Extracted. Thresholds: CR ≥ 0.70; AVE ≥ 0.50. Constructs with AVE < 0.50 are tolerable when CR > 0.60 (Hair et al., 2017). MATH_PER is a single-item observable variable; CR and AVE equal 1.0 by definition. ✓ = threshold met; ✗ = threshold not met.*

**Discriminant Validity**

Discriminant validity was assessed using the Fornell-Larcker criterion, which requires that the square root of each construct's AVE (√AVE) exceeds its highest bivariate correlation with all other constructs in the model (Fornell & Larcker, 1981). Table 11 presents the full discriminant validity matrix, with diagonal values representing √AVE and off-diagonal values representing Pearson correlations between constructs.

Inspection of Table 11 reveals that the Fornell-Larcker criterion is formally satisfied for MATH_PER (√AVE = 1.000), MACR (√AVE = 0.728 vs. highest correlation = 0.758 with MAAR), and MAAR (√AVE = 0.740 vs. highest correlation = 0.758 with MACR). However, the diagonal values for SE_CE (√AVE = 0.522), SE_AE (√AVE = 0.517), SE_BE (√AVE = 0.639), and MABR (√AVE = 0.636) do not strictly exceed their highest off-diagonal correlations. Specifically, the three student engagement dimensions share inter-correlations of 0.690 to 0.726, and the three anxiety dimensions share inter-correlations of 0.729 to 0.758.

The high inter-correlations among the engagement dimensions are theoretically expected and well-documented in the engagement literature (Fredricks et al., 2004; Maamin et al., 2022). Cognitive, affective, and behavioral engagement are conceptually related facets of the same overarching construct, and substantial inter-dimensional correlations are consistent with prior validation studies. Similarly, the three mathematics anxiety dimensions are facets of a single broader anxiety construct, and high inter-dimensional correlations reflect this multidimensional structure (Anindyarini & Supahar, 2019; Duyapat et al., 2023). Both sets of constructs were modeled as distinct because the theoretical framework and hypotheses require their separate examination, and prior validation studies have confirmed their conceptual distinctiveness despite their relatedness (Kong et al., 2003; Maamin et al., 2022).

It is further noted that the Fornell-Larcker criterion has been critiqued as both overly lenient in certain situations and overly conservative when constructs are theoretically related facets of a higher-order multidimensional construct (Henseler et al., 2015). The Heterotrait-Monotrait (HTMT) ratio — widely regarded as a more sensitive and

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accurate discriminant validity indicator in PLS-SEM (Henseler et al., 2015; Kline, 2016) — was not generated by the present analysis pipeline but is recommended for future investigations to provide a more nuanced assessment, particularly given the faceted structure of the engagement and anxiety constructs. The failure of the strict Fornell-Larcker criterion for four constructs is accordingly acknowledged as a methodological limitation of the present study, consistent with the theoretical architecture of the adopted multidimensional instruments. This limitation does not invalidate the structural model findings but does require that results be interpreted within this measurement boundary.

**Table 11**
*Fornell-Larcker Discriminant Validity Matrix*

| | MATH_PER | SE–CE | SE–AE | SE–BE | MABR | MACR | MAAR |
|---|---|---|---|---|---|---|---|
| MATH_PER | **(1.000)** | 0.285 | 0.357 | 0.332 | -0.219 | -0.300 | -0.195 |
| SE–CE | 0.285 | **(0.522)** | 0.690 | 0.702 | 0.031 | 0.014 | 0.020 |
| SE–AE | 0.357 | 0.690 | **(0.517)** | 0.726 | -0.058 | -0.093 | -0.064 |
| SE–BE | 0.332 | 0.702 | 0.726 | **(0.639)** | 0.005 | -0.014 | -0.028 |
| MABR | -0.219 | 0.031 | -0.058 | 0.005 | **(0.636)** | 0.729 | 0.749 |
| MACR | -0.300 | 0.014 | -0.093 | -0.014 | 0.729 | **(0.728)** | 0.758 |
| MAAR | -0.195 | 0.020 | -0.064 | -0.028 | 0.749 | 0.758 | **(0.740)** |

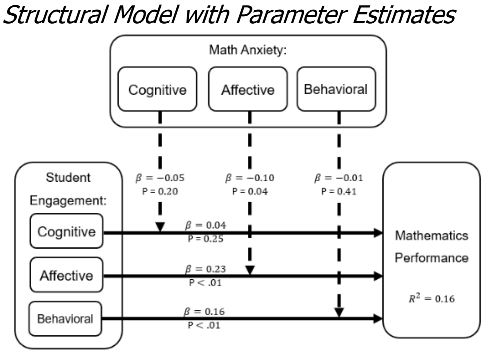
***Note.*** *Diagonal values (in parentheses) represent the square root of the Average Variance Extracted (√AVE) for each construct. Off-diagonal values are Pearson correlations between constructs. Discriminant validity is supported where the diagonal value exceeds all values in the same row and column. Interaction term constructs (MABR×SE_BE, MACR×SE_CE, MAAR×SE_AE) are excluded from this matrix as they are product indicators rather than independent reflective constructs.*

**Summary of Measurement Model Evaluation**

In summary, the measurement model was evaluated comprehensively prior to structural model estimation in accordance with Hair et al.'s (2019) recommended two-stage PLS-SEM procedure. The sequence of assessment covered: (1) item-level outer loading review and significance testing; (2) composite reliability estimation; (3) average variance extracted for convergent validity; and (4) Fornell-Larcker discriminant validity matrix examination.

All six multi-item constructs demonstrated acceptable composite reliability (CR ≥ 0.80 for all constructs). Convergent validity was established for MACR and MAAR (AVE ≥ 0.50), while the remaining four constructs (SE_CE, SE_AE, SE_BE, MABR) showed below-threshold AVE values attributable to the multidimensional heterogeneity of the adopted validated instruments; these are tolerated given the high CR values (Hair et al., 2017). Discriminant validity via the Fornell-Larcker criterion was formally satisfied for MATH_PER; the engagement and anxiety dimensions showed high inter-dimensional correlations that are theoretically expected given their faceted higher-order structure. These measurement limitations are acknowledged as study boundaries and are considered in interpreting the structural model results that follow.

**Figure 2**
*Structural Model with Parameter Estimates*




The structural model showed how student engagement, mathematics anxiety, and mathematics performance were related. The PLS-SEM analysis yielded an $R^2$ value of 0.16, indicating that 16% of the variance in mathematics performance was explained by the combined influence of cognitive, affective, and behavioral engagement, along with the moderating effects of the three dimensions of mathematics anxiety.

The structural model analysis examined how each dimension of student engagement directly affected mathematics performance and how each type of mathematics anxiety moderated these relationships. The detailed findings were presented and discussed in the subsequent tables.

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**4. To what extent do the following aspects significantly and positively influence perceived student engagement to mathematics performance?**

**4.1. Cognitive engagement**

**Table 12**

*Direct Effects of Cognitive Engagement on Mathematics Performance*

| Hypothesis | $\beta$ | $P$ | $R^2$ | Significance | Direction | Decision |
|---|---|---|---|---|---|---|
| ***Direct effects*** | | | | | | |
| $SE\_CE \rightarrow MP$ | 0.04 | 0.25 | 0.16 | No | Positive | Not statistically significant |

The results showed that cognitive engagement had a positive but non-significant effect ($\beta = 0.04$, $p = 0.25$), indicating that cognitive strategies such as memorization and problem-solving did not directly translate into higher achievement. This suggests that cognitive use alone is insufficient unless supported by deeper and more meaningful learning processes, consistent with Guo and Leung (2020) and Maamin et al. (2022), who noted that strategy use without active application may not improve performance.

**4.2. Affective engagement**

**Table 13**

*Direct Effects of Affective Engagement on Mathematics Performance*

| Hypothesis | $\beta$ | $P$ | $R^2$ | Significance | Direction | Decision |
|---|---|---|---|---|---|---|
| ***Direct effects*** | | | | | | |
| $SE\_AE \rightarrow MP$ | 0.23 | $< 0.001$ | 0.16 | Yes | Positive | Statistically significant and positive effect |

The results indicated that affective engagement had a significant positive effect on mathematics performance ($\beta = 0.23$, $p < 0.001$), indicating that students with higher interest, enjoyment, and satisfaction performed better in mathematics. This supports Maamin et al. (2022) and Quintero et al. (2022), who emphasized that positive emotions enhance focus, persistence, and learning retention.

**4.3. Behavioral engagement**

**Table 14**

*Direct Effects of Behavioral Engagement on Mathematics Performance*

| Hypothesis | $\beta$ | $P$ | $R^2$ | Significance | Direction | Decision |
|---|---|---|---|---|---|---|
| ***Direct effects*** | | | | | | |
| $SE\_BE \rightarrow MP$ | 0.16 | $< 0.001$ | 0.16 | Yes | Positive | Statistically significant and positive effect |

The results showed that behavioral engagement had a significant positive effect ($\beta = 0.16$, $p < 0.001$), suggesting that attentiveness, persistence, and active participation contribute to improved performance. This aligns with Maamin et al. (2022) and Spann et al. (2020), who highlighted consistent effort and engagement as key predictors of mathematics achievement.

Overall, the findings indicate that affective and behavioral engagement significantly enhance mathematics performance, while cognitive engagement alone does not have a direct impact, underscoring the importance of emotional involvement and active participation in mathematics learning.

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**5. To what extent do the following dimensions of mathematics anxiety significantly moderate the relationship between student engagement and mathematics performance?**

**5.1. Mathematics Cognitive Anxiety**

**Table 15**
*Moderating Effect of Math Cognitive Anxiety to Cognitive Engagement and Mathematics Performance*

| Hypothesis | Interaction Term Coefficient | $P$ | Significance | Direction | Decision |
|---|---|---|---|---|---|
| ***Moderating effect*** | | | | | |
| $MACR\ on\ SE\_CE \rightarrow MP$ | -0.05 | 0.20 | No | Negative | Does not significantly moderate |

The results indicated that cognitive mathematics anxiety (MACR) did not significantly moderate the link between cognitive engagement and performance (β = -0.05, p = 0.20), suggesting that students' problem-solving and reasoning processes were relatively stable despite anxious thoughts. This aligns with Guo and Leung (2020) and Suren and Kandemir (2020), who reported weak or inconsistent moderating effects of anxiety on cognitive learning processes.

**5.2. Mathematics Affective Anxiety**

**Table 16**
*Moderating Effect of Math Affective Anxiety to Affective Engagement and Mathematics Performance*

| Hypothesis | Interaction Term Coefficient | $P$ | Significance | Direction | Decision |
|---|---|---|---|---|---|
| ***Moderating effect*** | | | | | |
| $MAAR\ on\ SE\_AE \rightarrow MP$ | -0.10 | 0.04 | Yes | Negative | Statistically significant and negatively moderate |

The results showed that affective mathematics anxiety (MAAR) significantly moderated the relationship between affective engagement and performance (β = -0.10, p = 0.04). The negative effect indicates that emotional anxiety weakened the benefits of interest, enjoyment, and motivation on achievement, implying that fear of failure can limit the positive impact of emotional engagement. This supports Quintero et al. (2022) and Suren and Kandemir (2020), who noted that emotional anxiety reduces motivation and persistence.

**5.3. Mathematics Behavioral Anxiety**

**Table 17**
*Moderating Effect of Math Behavioral Anxiety to Behavioral Engagement and Mathematics Performance*

| Hypothesis | Interaction Term Coefficient | $P$ | Significance | Direction | Decision |
|---|---|---|---|---|---|
| ***Moderating effect*** | | | | | |
| $MABR\ on\ SE\_BE \rightarrow MP$ | -0.01 | 0.41 | No | Negative | Does not significantly moderate |

The results indicated that behavioral mathematics anxiety (MABR) did not significantly moderate the relationship between behavioral engagement and performance (β = -0.01, p = 0.41), indicating that persistent effort and attentiveness still contributed to achievement despite observable anxiety symptoms. This is consistent with Putwain and Daly (2014) and Datu et al. (2023), who emphasized that grit and sustained effort can buffer the negative effects of anxiety.


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Overall, the findings suggest that only affective anxiety weakens the engagement–performance relationship, highlighting the importance of addressing emotional anxiety to maximize the positive effects of student engagement in mathematics learning.

These structural findings carry wide-ranging implications for instructional design, curriculum development, professional development, and educational policy. The significance of affective and behavioral engagement, alongside the moderating role of affective anxiety, affirms that mathematics educators must cultivate emotionally supportive and behaviorally stimulating learning environments while reducing anxiety through scaffolded, low-threat instructional progressions (Quintero et al., 2022; Maamin et al., 2022). The non-significant direct effect of cognitive engagement further suggests that anxiety management is not supplementary but essential to converting engagement into measurable achievement gains. Curriculum developers should revisit the sequencing and pacing of Grade 10 mathematics content to ensure that increased complexity does not exceed students' emotional readiness and self-regulatory capacity, with enrichment activities designed to balance cognitive challenge with emotional scaffolding (Duyapat et al., 2023; OECD, 2021). Professional development programs should build teachers' capacity to promote affective and behavioral engagement, facilitate anxiety-sensitive classrooms, and apply formative assessment data to inform instructional adjustments in real time (Stoehr, 2017; Cevikbas & Kaiser, 2022). Teacher educators at both pre-service and in-service levels should embed engagement theory, anxiety-sensitive pedagogy, and positive classroom climate strategies into their curricula. School leaders and instructional supervisors can translate these findings into mathematics intervention programs aligned with school improvement goals, supported by professional learning communities where evidence-based practices are shared and refined. At the policy level, holistic student support frameworks that integrate academic, emotional, and behavioral dimensions of learning should be institutionalized, with the Department of Education encouraged to mandate well-being assessments alongside academic monitoring and to invest in school counseling infrastructure that treats mathematics anxiety as a systemic rather than individual concern (Sammallahti et al., 2023; King & Datu, 2017).

**Conclusions**

This study revealed that Grade 10 students demonstrated moderate to high levels of engagement in mathematics. Behavioral engagement emerged as the strongest dimension, characterized by consistent persistence, attentiveness, and effort in mathematical tasks. Cognitive engagement remained largely teacher-directed and procedural, with limited evidence of independent or metacognitive strategy use. Affective engagement was primarily driven by achievement-related outcomes rather than intrinsic interest, reflecting a performance-oriented emotional orientation toward mathematics.

Students generally attained satisfactory mathematics performance, though the concentration of scores within the lower satisfactory range indicates considerable room for developing higher-order thinking skills and elevating achievement toward advanced proficiency levels. Mathematics anxiety was prominent, particularly in its cognitive and behavioral dimensions, manifesting as difficulties with concentration, self-confidence, and performance pressure—patterns that point to a widespread and systemic challenge among secondary mathematics learners.

Affective and behavioral engagement significantly predicted mathematics performance, whereas cognitive engagement alone did not produce a direct effect on achievement. Furthermore, affective mathematics anxiety significantly moderated and weakened the positive influence of affective engagement on performance, establishing emotional anxiety as a critical barrier to translating student engagement into academic gains. These findings advance educational research by demonstrating that emotional investment and behavioral commitment are stronger proximal determinants of mathematics achievement than cognitive strategy use in isolation, and that anxiety management is central—not peripheral—to effective mathematics instruction.

The study offers substantive contributions across several dimensions of educational practice. In terms of curriculum development, the findings underscore the need to move beyond content-focused delivery toward an engagement-centered curriculum that explicitly incorporates mathematical reasoning development, higher-order thinking tasks, and competency-based progressions aligned with students' emotional and behavioral readiness. Curriculum designers should integrate affective goals and collaborative learning outcomes as deliberate components of mathematics program design, ensuring that the sequencing and complexity of content supports rather than undermines student engagement and confidence.

With respect to pedagogical innovation, the results support a reorientation of mathematics instruction toward active, learner-centered, and anxiety-sensitive pedagogical approaches. Instructional strategies that promote meaningful engagement—such as inquiry-based learning, problem-based tasks, peer collaboration, and social-emotional scaffolding—represent evidence-based innovations that can simultaneously strengthen affective and

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behavioral engagement while reducing the cognitive and emotional burden of mathematics anxiety. These approaches move beyond traditional teacher-directed instruction and reflect a broader pedagogical shift toward holistic and responsive mathematics teaching.

Regarding educational leadership, school leaders and instructional supervisors can draw directly on these findings to guide instructional improvement efforts, design targeted mathematics intervention programs for anxiety-affected students, and establish school improvement plans that prioritize engagement-focused teaching practices. Leaders are well-positioned to build professional learning communities where mathematics teachers collaboratively examine student engagement data, share anxiety-sensitive strategies, and develop contextually responsive instructional responses. Supporting teachers through structured observation, mentoring, and feedback cycles grounded in engagement research can accelerate school-wide improvement in mathematics outcomes.

In the domain of teacher professional development, the findings highlight an urgent need for both pre-service preparation and in-service training that equips mathematics educators with practical competencies in promoting affective and behavioral engagement, facilitating collaborative classroom discourse, and implementing anxiety-sensitive assessment and instructional practices. Professional development programs should incorporate frameworks from engagement theory, social-emotional learning, and motivation research, preparing teachers not only to deliver mathematical content but to create the emotional and behavioral conditions under which students can genuinely thrive in mathematics learning.

**Recommendations**

Based on the findings of the study, mathematics teachers may adopt instructional practices that strengthen cognitive, affective, and behavioral engagement through inquiry-based learning, collaborative problem solving, technology-enhanced instruction, and meaningful real-world applications of mathematics. Learning environments may also be designed to encourage active participation, reflective thinking, and positive attitudes toward mathematics.

Schools and educational leaders may develop intervention programs that support students experiencing mathematics anxiety through counseling services, learner support initiatives, low-stakes assessments, and classroom practices that promote psychological safety and confidence in learning.

Curriculum developers may consider integrating activities that foster higher-order thinking skills, mathematical reasoning, student autonomy, and emotional engagement within mathematics learning competencies and instructional materials.

Teacher education institutions and professional development providers may incorporate training on student engagement, mathematics anxiety management, social-emotional learning, and learner-centered instructional approaches to better prepare teachers for diverse classroom needs.

Future researchers may conduct longitudinal, mixed-method, or intervention-based studies to further examine the relationships among engagement, anxiety, and achievement across different educational contexts and learner populations.

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