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Research Article

Mathematics Learning Motivation and Negative Academic Emotions in Elementary School: A Multivariate Examination of Grade-Level, Age, and Gender Differences

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Abstract: This study aimed to examine whether mathematics learning motivation and negative academic emotions differ simultaneously according to grade level, age, and gender among elementary school students. A quantitative cross-sectional comparative survey design was employed involving 260 students in Grades 3–5 from elementary schools in Cirebon Regency, Indonesia, selected through purposive sampling. Data were collected using two self-report questionnaires measuring mathematics learning motivation and negative academic emotions on five-point Likert scales. Instrument measurement properties were evaluated using SmartPLS 3, while descriptive statistics and Multivariate Analysis of Variance (MANOVA) were performed using IBM SPSS, with Pillai's Trace used as the principal multivariate statistic. The findings revealed significant multivariate differences in the combined outcomes according to grade level ($p < .001$) and age ($p = .015$), whereas gender differences were not significant ($p = .474$). Follow-up analyses showed that these differences were attributable primarily to negative academic emotions, which differed significantly across grade levels ($p < .001$) and age groups ($p = .003$), while mathematics learning motivation remained relatively stable. Neither motivation nor negative academic emotions differed significantly by gender. The study concludes that negative academic emotional experiences were more differentiated by grade level and age than overall mathematics learning motivation. The study contributes multivariate evidence from the Indonesian elementary education context by examining motivation and negative academic emotions concurrently, highlighting the relevance of students' emotional experiences alongside motivation in mathematics learning.

Keywords: elementary education, gender, grade level, mathematics learning motivation, negative academic emotions.

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INTRODUCTION

Mathematics learning motivation constitutes an important psychological foundation for students' engagement, persistence, and willingness to invest effort when confronting mathematical tasks. Within Situated Expectancy-Value Theory (SEVT), students' motivation is shaped by their expectations of success, the subjective value they assign to learning activities, and the perceived costs associated with participating in those activities (Eccles & Wigfield, 2020). More recent developments of the expectancy-value perspective emphasize that these motivational processes are situated within specific social, developmental, and educational contexts rather than functioning independently of students' learning experiences (Eccles & Wigfield, 2024). Motivation is therefore central to explaining the direction, intensity, and persistence of students' learning behavior (Urhahne & Wijnia, 2023). Empirical evidence further indicates that self-efficacy and autonomous motivation are positively associated with academic achievement, reinforcing the importance of motivational resources in students' learning experiences (Basileo et al., 2024).

Students' experiences in mathematics, however, cannot be understood through motivation alone. Academic learning also involves emotional responses that influence attention, information processing, engagement, and students' reactions to learning activities and outcomes (Pekrun, 2022). Control-Value Theory (CVT) explains that achievement emotions arise primarily from students' appraisals of control over academic activities and outcomes and the value they attach to those activities (Pekrun, 2024). In mathematics, students may experience positive emotions such as enjoyment and pride as well as negative emotions such as anxiety, boredom, hopelessness, and shame across classroom, learning, and testing situations (Bieleke et al., 2023). Recent systematic-review and meta-analytic evidence confirms the educational significance of these emotions, showing that enjoyment, hope, and pride are positively associated with mathematics achievement, whereas anger, boredom, frustration, hopelessness, and shame are negatively associated with achievement (Schoenherr et al., 2025). Although academic emotions encompass both positive and negative experiences, the present study focuses specifically on negative academic emotional responses because the items used in the academic emotion measure assess experiences such as anger, embarrassment, hopelessness, boredom, tension, nervousness, and embarrassment across classroom, learning, and testing contexts. Thus, throughout this study, the term academic emotions refers specifically to the negative academic emotions assessed by the instrument.

Motivational and emotional experiences are also embedded in the environments in which mathematics learning occurs. Lesson-specific autonomy support has been associated with students' motivation and engagement, indicating that motivational experiences may vary according to the immediate instructional context (Flunger et al., 2022). Similarly, the effectiveness of mathematics motivation interventions is related to the motivational support provided through regular classroom practices (Gaspard et al., 2023). Teachers' emotional support and their confidence in engaging students may also contribute to a classroom climate that sustains students' interest in mathematics (Hettinger et al., 2023). Importantly, cross-national evidence involving 11,782 third- and fourth-grade students indicates that intrinsic value and perceived mathematical competence are positively related to enjoyment of mathematics, while gender differences in motivational experiences are already observable during primary education (Radišić et al., 2024). These findings suggest that mathematics learning needs to be understood not only from a cognitive perspective but also through the motivational and emotional experiences that accompany students' participation in learning.

Despite increasing attention to these psychological dimensions, important gaps remain regarding how motivation and negative academic emotions vary across student characteristics during elementary education. Developmental research has demonstrated that achievement emotions in mathematics may follow different trajectories as students progress through schooling (Sakaki et al., 2024). Evidence further suggests heterogeneous combinations of emotional and motivational characteristics, indicating that students' psychological experiences of mathematics are not uniform across educational stages (Hanin & Gay, 2023). Among primary school students, combinations of control, value, enjoyment, boredom, and anxiety have also been shown to differ according to gender, with girls having a greater likelihood of belonging to mixed or negative emotional profiles in some contexts (Symes et al., 2025). Longitudinal evidence across Grades 4 and 5 likewise demonstrates distinct and relatively stable patterns of mathematics anxiety, enjoyment, boredom, and performance among primary school students (Pavlova et al., 2025). Collectively, these findings establish developmental and demographic variation as an important issue, yet they do not provide a consistent account of whether mathematics learning motivation and negative academic emotions jointly differ according to grade level, chronological age, and gender.

A further gap concerns the analytical treatment of motivation and negative academic emotions. Recent research has established meaningful relationships between academic motivation, self-efficacy, and affective engagement in mathematics-related learning (Valenzuela-Peñuñuri et al., 2024), while contemporary mathematics education scholarship increasingly emphasizes that motivation and emotions should be considered jointly rather than as isolated psychological processes (Schukajlow et al., 2023). Nevertheless, much of the available evidence has examined specific relationships, mediating mechanisms, individual emotions, or person-centered profiles. Comparatively less evidence has examined mathematics learning motivation and negative academic emotions as concurrent dependent outcomes while simultaneously comparing students across grade level, age, and gender, particularly in elementary education. A multivariate approach is therefore appropriate because it enables both outcomes to be examined simultaneously within a common analytical framework rather than through separate univariate comparisons.

Accordingly, the novelty of this study lies in the simultaneous examination of mathematics learning motivation and negative academic emotions across grade level, age, and gender among elementary school students using a multivariate framework. The study involves 260 students from Grades 3, 4, and 5 in Cirebon, Indonesia, thereby extending empirical evidence on motivational and emotional experiences within an elementary education context. Theoretically, the study integrates perspectives from SEVT and CVT to provide a more comprehensive account of students' psychological experiences in mathematics learning; empirically, it examines whether motivation and negative academic emotions display similar or distinct patterns across student characteristics; and practically, the findings may inform mathematics learning environments that respond more appropriately to students' motivational and emotional needs. However, because the study employs a cross-sectional design and purposive sampling within a geographically bounded context, observed patterns should be interpreted as between-group differences rather than developmental changes or causal effects, and generalization beyond the study population requires appropriate caution. Therefore, this study aims to examine whether mathematics learning motivation and negative academic emotions differ simultaneously according to grade level, age, and gender among elementary school students. Based on the theoretical frameworks and empirical evidence discussed above, the following hypotheses are proposed:

H1: There are significant multivariate differences in mathematics learning motivation and negative academic emotions across grade levels among elementary school students.
H2: There are significant multivariate differences in mathematics learning motivation and negative academic emotions across age groups among elementary school students.
H3: There are significant multivariate differences in mathematics learning motivation and negative academic emotions between male and female elementary school students.

THEORETICAL FRAMEWORK

This study conceptualizes mathematics learning motivation and negative academic emotions as two interrelated psychological dimensions of students' mathematics learning experiences. Mathematics learning motivation is primarily grounded in the Situated Expectancy-Value Theory (SEVT), whereas negative academic emotions are interpreted through the Control-Value Theory (CVT). SEVT emphasizes students' expectations regarding their competence and the value they attribute to mathematical activities, while CVT explains how evaluations of control and value contribute to emotional experiences in achievement settings. These perspectives are theoretically compatible because students' motivational beliefs and achievement emotions develop through interconnected processes within academic contexts. Integrating both frameworks therefore provides a comprehensive basis for understanding students' motivational and negative emotional experiences in mathematics learning (Rubach et al., 2023).

Mathematics Learning Motivation

Within the expectancy-value perspective, students' motivation to learn mathematics is shaped particularly by beliefs regarding their competence and the value attributed to mathematics. Competence beliefs reflect students' judgments about their ability to successfully perform mathematics tasks, whereas task values represent the perceived importance, usefulness, and intrinsic attractiveness of engaging in mathematics. Evidence from primary education demonstrates that elementary school students can distinguish competence self-perceptions from different forms of task value, including intrinsic and utility values, making these constructs appropriate for examining mathematics motivation in Grades 3-5 (Peixoto et al., 2023). Mathematics motivation is particularly important during primary education because it develops alongside students' mathematical competence, academic emotions, identity, and experiences within classroom and home environments (Radišić & Baucal, 2024).

In the present study, mathematics learning motivation is operationalized through intrinsic value, self-regulation, self-efficacy, utility value, and test anxiety. Intrinsic value refers to students' interest in and enjoyment of mathematics, whereas utility value reflects their perception of the usefulness of mathematics for present or future goals. Self-efficacy concerns students' confidence in their ability to successfully perform mathematics-related tasks. Contemporary research characterizes mathematics self-efficacy as a dynamic and context-sensitive belief associated with learning behaviors and mathematical performance (Street et al., 2024). Large-scale evidence further indicates a positive association between mathematics self-efficacy and mathematics achievement, supporting its importance as a motivational resource in mathematics education (Yang et al., 2024).

Self-regulation complements expectancy and value components by representing students' capacity to manage their learning through planning, strategic action, monitoring, and evaluation. In elementary education, self-regulated learning enables students to organize their learning activities, maintain goal-directed behavior, and select strategies appropriate to academic demands. Experimental evidence indicates that strengthening self-regulatory strategies among elementary school students can improve their reported use of learning strategies and contribute to academic achievement (Núñez et al., 2022). In the present study, test anxiety is retained as an affective component within the operationalization of mathematics learning motivation because anxiety experienced in assessment situations may influence students' cognitive resources, task engagement, and responses to mathematics learning demands. This operational placement follows the structure of the measurement framework adopted in the study and does not imply that test anxiety is conceptually identical to academic emotions more broadly. Rather, test anxiety is treated as an affective component of the motivation measure because it reflects students' responses to evaluative demands that may shape their engagement with mathematics learning.

Academic Emotions

Academic emotions refer to emotional experiences directly associated with academic activities and outcomes. According to CVT, these emotions emerge primarily from students' appraisals of their perceived control over learning activities and outcomes and the subjective value they attach to those activities. Mathematics-related achievement emotions include positive activating emotions such as enjoyment as well as negative emotions such as anxiety and boredom. Longitudinal evidence from primary school students indicates that these emotions are already differentiated during the early school years and may exhibit different developmental patterns, including decreasing enjoyment and increasing boredom as students progress through elementary education (Rawlings et al., 2023). Although academic emotions may theoretically include both positive and negative experiences, the present study specifically examines negative academic emotions because the items used in the instrument primarily assess negative emotional responses in mathematics learning. Accordingly, the term negative academic emotions is used here to distinguish the construct measured in this study from the broader domain of academic emotions.

In the present study, negative academic emotions are operationalized according to three academic contexts: class-related emotions, learning-related emotions, and test-related emotions. Class-related emotions represent students' emotional experiences during mathematics lessons, learning-related emotions concern feelings arising while engaging in mathematics learning activities, and test-related emotions refer to emotional responses associated with mathematics assessments. The distinction between test anxiety within the motivation measure and test-related emotions within the negative academic emotion measure is based on their operational placement within two separate instruments and their respective measurement frameworks. Although both concern affective responses in evaluative situations and may be conceptually related, they are not assumed to represent identical constructs. Test situations are particularly important because mathematics anxiety may emerge during the early years of schooling and can involve both mathematics-learning and mathematics-testing situations. Longitudinal evidence among primary school children further demonstrates a reciprocal relationship between mathematics anxiety and mathematics achievement, indicating that emotional experiences and mathematics performance can be closely connected during early schooling (Szczygieł et al., 2024). The theoretical relationship between mathematics learning motivation and negative academic emotions, together with the dimensions used to operationalize both constructs in this study, is summarized in Figure 1.

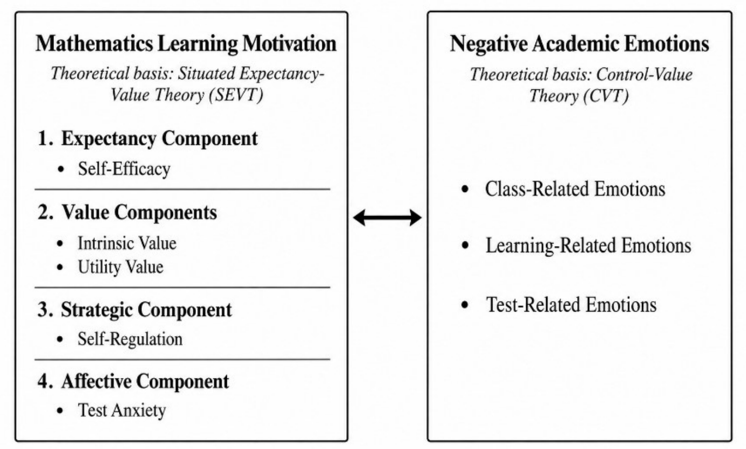

Figure 1. Theoretical Framework of Mathematics Learning Motivation and Negative Academic Emotions

As illustrated in Figure 1, mathematics learning motivation and negative academic emotions are treated as distinct but theoretically related dimensions of students' mathematics learning experiences. The motivational dimension comprises expectancy, value, strategic, and affective components, whereas the negative academic emotion dimension represents negative emotional experiences arising in classroom, learning, and testing contexts. The bidirectional connection in the framework indicates theoretical interrelatedness rather than a causal relationship tested in the present study. It indicates that motivational beliefs and emotional experiences may be theoretically connected within students' mathematics learning experiences, while the present study does not test the direction or causal nature of this relationship. This framework therefore provides the conceptual basis for examining mathematics learning motivation and negative academic emotions simultaneously and for comparing their multivariate patterns across grade level, age, and gender.

METHODS

Research Design

This study employed a quantitative cross-sectional comparative survey design to examine differences in mathematics learning motivation and negative academic emotions among elementary school students according to grade level, chronological age, and gender. A quantitative approach was selected because the study focused on the numerical measurement of psychological constructs and statistical comparisons across predefined student groups. The cross-sectional design was appropriate because all variables were measured during a single period of data collection, providing a snapshot of students' motivational and emotional characteristics without longitudinal follow-up. Cross-sectional studies allow multiple outcomes and participant characteristics to be examined simultaneously at a specific point in time, although they do not permit conclusions regarding temporal development or causal relationships (Figueiredo et al., 2025)

The study was comparative rather than experimental because no instructional treatment or manipulation was introduced. Grade level, age, and gender served as naturally occurring grouping variables, whereas mathematics learning motivation and negative academic emotions were treated as the dependent variables. This design was therefore consistent with the purpose of examining whether the two psychological outcomes differed simultaneously across student characteristics.

Participants and Sampling

The participants were 260 elementary school students enrolled in Grades 3, 4, and 5 from elementary schools in Cirebon Regency, Indonesia, during the 2025/2026 academic year. The sample comprised 66 third-grade students (25.4%), 101 fourth-grade students (38.8%), and 93 fifth-grade students (35.8%). Overall, 121 participants were girls (46.5%) and 139 were boys (53.5%). Grade 3 consisted of 29 girls (43.9%) and 37 boys (56.1%), Grade 4 consisted of 50 girls (49.5%) and 51 boys (50.5%), and Grade 5 consisted of 42 girls (45.2%) and 51 boys (54.8%). Age was recorded as an additional grouping characteristic because chronological age does not necessarily correspond completely with grade level and may represent a distinct source of variation in students' psychological experiences. Grade 3 was predominantly represented by 9-year-old students (n = 36, 54.5%), Grade 4 by 10-year-old students (n = 76, 75.2%), and Grade 5 by 11-year-old students (n = 63, 67.7%).

Participants were selected using purposive sampling because the study required students with predefined characteristics relevant to the research objectives, particularly students in Grades 3-5 who had sufficient experience with formal mathematics learning and were able to respond to the research instruments. Purposive sampling allows researchers to intentionally select participants who meet specific study criteria, although its non-probability nature requires caution when generalizing the results beyond the sampled population (Ahmed, 2024). The inclusion criteria were active enrollment during the study year, willingness to participate, and permission from a parent or guardian.

Research Instruments and Data Collection

Data were collected using two self-report questionnaire instruments, each employing a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The first instrument measured mathematics learning motivation and consisted of 16 items distributed across five dimensions: intrinsic value (3 items), self-regulation (4 items), self-efficacy (3 items), utility value (3 items), and test anxiety (3 items). The instrument was adapted from motivational measures associated with the Motivated Strategies for Learning Questionnaire (MSLQ) and expectancy-value perspectives on learning. These dimensions were retained to represent students' perceived value of mathematics, competence beliefs, strategic regulation of learning, and affective responses to mathematics assessment (de Araujo et al., 2023). The term previously reported as efficacy value was standardized as self-efficacy without altering its corresponding items or numerical data.

Test anxiety requires particular clarification because it can also be conceptualized as an achievement-related emotional response. In the present study, test anxiety was retained as one component of the operationalization of mathematics learning motivation because it was part of the measurement framework adopted for the study and was intended to capture students' affective responses to evaluative demands that may influence their engagement with mathematics learning. This operational placement does not imply that test anxiety is conceptually identical to negative academic emotions. Rather, test anxiety was retained within the motivation measure because of its specified role in the adopted measurement structure. Nevertheless, its conceptual proximity to test-related negative academic emotions was explicitly recognized as a potential source of construct overlap and was considered when interpreting the measurement and multivariate results.

The second instrument measured negative academic emotions and contained 8 items distributed across three academic contexts: class-related emotions (3 items), learning-related emotions (2 items), and test-related emotions (3 items). This contextual organization is consistent with the Achievement Emotions Questionnaire–Elementary School approach, which distinguishes emotional experiences associated with classroom participation, learning activities, and testing situations. Previous validation with elementary school students demonstrates that children are able to differentiate achievement emotions across these academic contexts (Suzuki & Tonegawa, 2022). The terminology negative academic emotions is used throughout the present study because the items primarily assess negative emotional responses, including anger, embarrassment, hopelessness, boredom, tension, and nervousness across classroom, learning, and testing contexts. Accordingly, the instrument is not interpreted as a comprehensive measure of the full domain of academic emotions, which theoretically includes both positive and negative experiences. Instead, it represents the negative academic emotional experiences captured by the specific items included in the instrument. Each response was numerically coded according to the five-point response scale. Items were organized according to their theoretically defined dimensions, and aggregate scores representing mathematics learning motivation and negative academic emotions were subsequently used as the dependent variables in the multivariate analysis.

Validity and Reliability Assessment

The psychometric properties of both instruments were evaluated using SmartPLS 3 before the main statistical analysis. Indicator reliability was examined through outer loadings, convergent validity through Average Variance Extracted (AVE), and internal consistency reliability through Composite Reliability (CR). AVE and CR were evaluated separately because AVE represents the amount of indicator variance captured by a construct, whereas CR represents the internal consistency of the indicators measuring that construct (Hair & Alamer, 2022).

As general reference criteria, outer loadings of approximately .70 or higher, AVE values of .50 or higher, and CR values of approximately .70 or higher were considered desirable. These thresholds were treated as reference criteria rather than automatic item-deletion rules. Indicator retention was considered in conjunction with theoretical relevance, content coverage, and the consistency of the prespecified measurement structure. Discriminant validity was evaluated separately because it concerns the empirical distinctiveness of the measured constructs. Contemporary PLS-SEM guidelines recommend the Heterotrait-Monotrait ratio (HTMT) for discriminant validity assessment, commonly using threshold values of .85 or .90 depending on the conceptual similarity between constructs (Ringle et al., 2023). The results of the convergent validity and internal consistency assessment for the five dimensions of mathematics learning motivation across Grades 3, 4, and 5 are presented in Table 1.

Table 1. Convergent Validity and Reliability of Mathematics Learning Motivation Measures

Dimension	Item	Statement	G3 Load	G4 Load	G5 Load	CR G3	CR G4	CR G5	AVE G3	AVE G4	AVE G5
Intrinsic value	IV1	I enjoy learning math	.855	.775	.769	.822	.835	.816	.615	.628	.596
	IV2	I find studying math interesting	.893	.824	.777						

	IV3	I like math that challenges me	.562	.777	.769						
Self-regulation	SR1	If I have trouble learning math, I try to figure out why	.594	.623	.648	.759	.723	.799	.433	.400	.500
	SR2	I put in a fair amount of effort studying math	.582	.580	.787						
	SR3	I use strategies that ensure I learn math well	.644	.766	.707						
	SR4	I prepare well for math exams and quizzes	.791	.537	.679						
Self-efficacy	SE1	I believe I can master the knowledge and skills in mathematics	.815	.791	.751	.830	.781	.763	.622	.546	.519
	SE2	I'm confident I'll do well on the math exam	.859	.805	.753						
	SE3	I believe I can get a perfect score in math	.683	.605	.651						
Utility value	UV1	I think about how the math I'm learning will be useful to me	.788	.838	.829	.745	.718	.746	.496	.471	.499
	UV2	I'm thinking about how learning math can help me in my daily life	.657	.478	.607						
	UV3	I think about how I will use the math I've learned	.658	.694	.665						
Test anxiety	TA1	I'm nervous about how	.679	.515	.959	.758	.747	.718	.511	.504	.496

	I'll do on the math exam				
TA2	I'm worried I'll fail the math exam	.714	.795	.682	
TA3	I'm thinking about how my math grade will affect my overall GPA	.749	.784	.322	

As presented in Table 1, CR values for the mathematics learning motivation dimensions ranged from .718 to .835, indicating generally adequate internal consistency. However, several indicators had outer loadings below the conventional .70 reference value, while some AVE values were below .50, particularly for self-regulation and utility value. These findings indicate that convergent validity was not uniformly strong across all dimensions and grade groups. Self-regulation showed AVE values of .433 and .400 for Grades 3 and 4, respectively, while utility value showed AVE values of .496 and .471. In addition, several individual indicators showed relatively weak loadings, including SR1, SR2, SR3, SR4, SE3, UV2, UV3, and TA3 in particular grade groups.

The weak indicators were reviewed rather than automatically deleted solely on the basis of their individual loading values. Item deletion was not undertaken because the indicators formed part of theoretically specified dimensions, and removing individual items could reduce the intended content coverage of the constructs and alter the comparability of the measurement structure across groups. However, retaining these indicators does not eliminate the associated construct-validity concern. The sub-threshold AVE values and weak loadings indicate that convergent validity was imperfect for some constructs, particularly self-regulation and utility value. These limitations were therefore explicitly considered when interpreting the composite scores and subsequent MANOVA results.

Table 2. Square Root of AVE (Fornell-Larcker Diagonal Values) for Mathematics Learning Motivation

Dimension	Grade 3	Grade 4	Grade 5
Intrinsic value	.784	.792	.772
Self-regulation	.658	.632	.707
Self-efficacy	.789	.739	.720
Utility value	.704	.686	.707
Test anxiety	.715	.710	.704

The values in Table 2 correspond to the square roots of the reported AVE values and therefore represent the diagonal values associated with the Fornell-Larcker criterion. Because the corresponding pairwise construct correlations are not presented in the available measurement output, these values alone do not constitute a complete assessment of discriminant validity. They are therefore reported transparently as diagonal Fornell-Larcker values rather than being interpreted as HTMT coefficients. The convergent validity and internal consistency results for the three dimensions of negative academic emotions across Grades 3, 4, and 5 are presented in Table 3.

Table 3. Convergent Validity and Reliability of Negative Academic Emotion Measures

Dimension	Item	Statement	G3 Load	G4 Load	G5 Load	CR G3	CR G4	CR G5	AVE G3	AVE G4	AVE G5
Class-related emotions	CE1	I feel angry when I'm in class	.773	.748	.870	.831	.830	.858	.669	.621	.669
	CE2	I feel embarrassed when I'm in class	.767	.747	.810						
	CE3	I feel hopeless in class	.874	.864	.771						
Learning-related emotions	LE1	I feel bored in class	.936	.859	.824	.658	.789	.752	.603	.653	.603
	LE2	I feel tense and nervous when studying math	.417	.753	.726						
Test-related emotions	TE1	I feel embarrassed because I cannot understand the material in detail, even the simplest parts	.674	.631	.788	.765	.758	.803	.576	.518	.576
	TE2	Math really bores me	.834	.680	.725						
	TE3	I feel embarrassed about my test results	.549	.418	.762						

As presented in Table 3, AVE values for the negative academic emotion dimensions ranged from .518 to .669, indicating that the dimensions met the conventional .50 criterion for convergent validity. CR values ranged from .658 to .858. Most dimensions therefore demonstrated satisfactory internal consistency, although the Grade 3 learning-related emotion dimension (CR = .658) was slightly below the conventional .70 reference value and should therefore be interpreted cautiously. Several indicators nevertheless showed relatively weak loadings. LE2 had a loading of .417 in Grade 3, while TE3 had loadings of .549 and .418 in Grades 3 and 4, respectively. These findings indicate that indicator-level construct validity was not equally strong across all grade groups. The indicators were retained because they represented theoretically relevant aspects of their respective negative academic emotion dimensions; however, their weak loadings were treated as measurement limitations rather than disregarded. The resulting negative academic emotion scores should therefore be interpreted as observed composite measures with some degree of measurement uncertainty.

Table 4. Square Root of AVE (Fornell-Larcker Diagonal Values) for Negative Academic Emotions

Dimension	Grade 3	Grade 4	Grade 5
Class-related emotions	.818	.788	.818
Learning-related emotions	.777	.808	.777
Test-related emotions	.759	.720	.759

The values in Table 4 are reported as the square roots of the corresponding AVE values and therefore represent the diagonal values associated with the Fornell–Larcker criterion. As with mathematics learning motivation, pairwise construct correlations are not provided in the available output; therefore, these values alone are insufficient to establish discriminant validity conclusively. They are presented as the available diagonal evidence and are not interpreted as HTMT coefficients. Overall, the measurement assessment indicated generally adequate internal consistency for most dimensions, but construct validity was not uniformly strong across all grade-specific measurement models. The principal concerns were the sub-threshold AVE values for self-regulation and utility value in some grade groups and the relatively weak loadings of several indicators, particularly TA3 in Grade 5, LE2 in Grade 3, and TE3 in Grades 3 and 4.

These findings indicate that some constructs may contain greater measurement error or may not capture their intended dimensions equally well across grade levels. The measurement model was therefore not treated as perfectly validated or measurement-invariant across groups. Instead, the theoretically specified structure was retained because item deletion or model re-specification based solely on isolated loading values could compromise content coverage and comparability. The observed measurement limitations were incorporated into the interpretation of the subsequent multivariate results.

Research Procedure

The research was conducted during the 2025/2026 academic year after permission had been obtained from the participating schools. Parents or guardians provided permission for student participation. Before data collection, participants received information regarding the objectives of the study, the voluntary nature of their participation, confidentiality of their responses, and their right to withdraw without penalty. Eligible participants subsequently completed the mathematics learning motivation and negative academic emotions questionnaires. The completed responses were coded according to the predetermined five-point scale and organized according to grade level, age, and gender. The dataset was then screened and prepared for psychometric assessment, descriptive analysis, and subsequent multivariate statistical analysis.

Data Analysis

Data analysis was conducted using IBM SPSS for descriptive and inferential statistics, whereas SmartPLS 3 was used to evaluate the measurement properties of the instruments. Descriptive statistics were first calculated to summarize mathematics learning motivation and negative academic emotions across grade level, age, and gender. The two dependent variables were represented by composite scores derived from the theoretically specified item structures described above. The measurement limitations identified through the loading, CR, and AVE assessments were considered when interpreting these observed composite scores. The primary inferential analysis employed Multivariate Analysis of Variance (MANOVA) because the study examined two dependent variables, mathematics learning motivation and negative academic emotions, simultaneously across multiple grouping variables. MANOVA extends univariate analysis of variance to multiple dependent outcomes and allows overall group differences to be evaluated within a common multivariate framework (Gallego & Oller, 2024). Before interpreting the MANOVA results, relevant statistical assumptions were evaluated. These included examination of the distributions of the dependent variables, potential multivariate outliers, equality of error variances, and homogeneity of covariance matrices.

Levene's test was used to examine the equality of error variances, whereas Box's M test was used to assess the homogeneity of covariance matrices. Multivariate tests were then used to determine whether the combined dependent variables differed significantly according to grade level, age, and gender. When a multivariate effect was identified, univariate between-subject tests were examined to determine which dependent variable contributed to the observed group difference. Because the assumptions of covariance-matrix homogeneity and, for negative academic emotions, equality of error variances were not fully satisfied, Pillai's Trace was used as the principal multivariate statistic because of its relative robustness under such violations. Statistical significance was evaluated at $\alpha = .05$. Given the observed measurement weaknesses, statistically significant MANOVA effects were interpreted as evidence of differences in the observed composite scores rather than definitive evidence that the underlying latent constructs differ without measurement error. This distinction is particularly important for dimensions with sub-threshold AVE or relatively weak indicator loadings.

Methodological Considerations

Several methodological considerations should be taken into account when interpreting the findings. First, the cross-sectional design provides information about group differences at one point in time and therefore cannot establish developmental trajectories or causal relationships. Second, the use of purposive sampling and participants drawn from a geographically bounded population in Cirebon Regency limits the generalizability of the findings to broader elementary-school populations. Third, both dependent variables were obtained through self-report questionnaires, which may be subject to response and social-desirability biases. Fourth, the measurement assessment identified several weak indicator loadings and sub-threshold AVE values, indicating that construct validity was not equally strong across all dimensions and grade groups. Finally, the inclusion of test anxiety within the mathematics learning motivation measure creates conceptual proximity to test-related negative academic emotions. Although the two constructs were operationally maintained as separate dimensions, this potential overlap warrants caution when interpreting the distinction between the two dependent variables. These limitations were considered when drawing conclusions from the multivariate analyses.

RESULT

Descriptive Results

Descriptive statistics were examined to identify general patterns in mathematics learning motivation and negative academic emotions across grade level, age, and gender. Mathematics learning motivation scores were relatively stable across student groups, whereas negative academic emotion scores showed greater descriptive variation, particularly across grade levels and age groups. The descriptive statistics are presented in Table 5.

Table 5. Descriptive Statistics of Mathematics Learning Motivation and Negative Academic Emotions by Student Characteristics

Characteristic	Group	N	Motivation M	SD	Negative Academic Emotions M	SD
Grade level	Grade 3	66	57.42	8.12	20.82	6.21
	Grade 4	101	56.91	8.35	23.47	6.48
	Grade 5	93	57.19	8.27	26.08	6.72
Age	8 years	10	57.80	7.64	19.80	5.91
	9 years	54	57.39	8.05	21.31	6.09
	10 years	91	56.95	8.31	23.38	6.37
	11 years	82	57.02	8.44	25.07	6.68
	12 years	23	57.30	8.17	26.00	6.73
Gender	Male	139	57.12	8.30	23.72	6.71
	Female	121	57.01	8.22	23.31	6.55
Overall	Total	260	57.07	8.25	23.53	6.63

As shown in Table 5, mathematics learning motivation was relatively similar across grade levels, with mean scores ranging from 56.91 to 57.42. Comparable stability was observed across age and gender groups. In contrast, negative academic emotion scores showed a clearer grade-level pattern, increasing from Grade 3 ($M = 20.82$, $SD = 6.21$) to Grade 4 ($M = 23.47$, $SD = 6.48$) and Grade 5 ($M = 26.08$, $SD = 6.72$). A descriptively similar pattern was observed across age groups, with mean negative academic emotion scores increasing from 19.80 among 8-year-old students to 26.00 among 12-year-old students. Male and female students showed relatively comparable mean scores. These descriptive patterns were subsequently examined using multivariate inferential analysis. The grade-level pattern of negative academic emotions is illustrated in Figure 2.

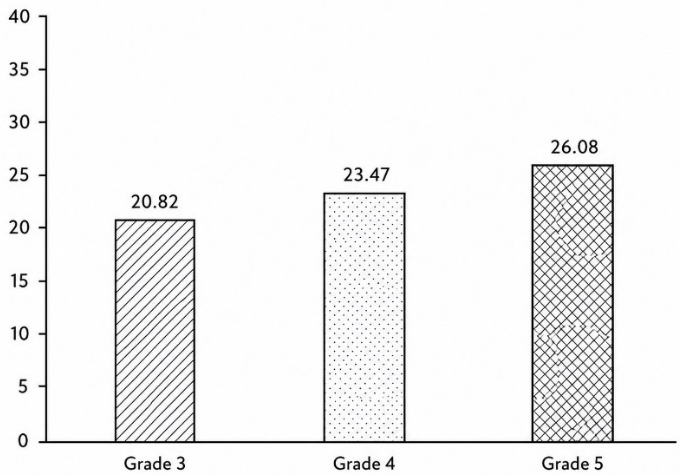

Figure 2. Mean Negative Academic Emotion Scores Across Grade Levels

As illustrated in Figure 2, mean negative academic emotion scores increased progressively across the three grade levels. Grade 5 students demonstrated the highest mean score ($M = 26.08$), followed by Grade 4 ($M = 23.47$) and Grade 3 students ($M = 20.82$). Because higher scores represent greater intensity of the negative academic emotional responses measured by the instrument, this descriptive pattern indicates stronger negative academic emotional experiences among students in the higher grades. Statistical significance was determined through the subsequent multivariate and follow-up analyses.

MANOVA Assumption Testing

Before conducting MANOVA, the relevant statistical assumptions were examined. The distributions of the dependent variables and potential multivariate outliers were screened prior to analysis. Homogeneity of covariance matrices was assessed using Box's M test, whereas equality of error variances was examined using Levene's test. The results are presented in Table 6.

Table 6. Results of MANOVA Assumption Tests

Assumption	Test/Variable	Statistic	df	p	Interpretation
Homogeneity of covariance matrices	Box's M	45.18	—	< .001	Violated
Equality of error variance	Motivation	F = 0.48	8, 251	.870	Met
Equality of error variance	Negative academic emotions	F = 6.04	8, 251	< .001	Violated

As presented in Table 6, Box's M test was statistically significant ($p < .001$), indicating that the assumption of homogeneous covariance matrices was not fully satisfied. Levene's test was nonsignificant for mathematics learning motivation ($p = .870$), indicating homogeneous error variance, but significant for negative academic emotions ($p < .001$), indicating heterogeneity of variance. Given these assumption violations, Pillai's Trace was used as the principal multivariate statistic because it is relatively robust when covariance and variance assumptions are not fully satisfied.

MANOVA Results

A MANOVA was conducted to examine whether mathematics learning motivation and negative academic emotions differed simultaneously according to grade level, age, and gender. The multivariate results based on Pillai's Trace are presented in Table 7.

Table 7. Multivariate Effects of Grade Level, Age, and Gender

Effect	Pillai's Trace	F	df	Error df	p	Partial η^2
Grade level	.108	7.15	4	500	< .001	.054
Age	.074	2.40	8	502	.015	.037
Gender	.006	0.75	2	249	.474	.006

As shown in Table 7, grade level demonstrated a statistically significant multivariate difference in the combined dependent variables, Pillai's Trace = .108, $F(4, 500) = 7.15$, $p < .001$, partial $\eta^2 = .054$. Age also demonstrated a significant multivariate difference, Pillai's Trace = .074, $F(8, 502) = 2.40$, $p = .015$, partial $\eta^2 = .037$. In contrast, the multivariate difference according to gender was not statistically significant, Pillai's Trace = .006, $F(2, 249) = 0.75$, $p = .474$, partial $\eta^2 = .006$. Thus, the combined pattern of mathematics learning motivation and negative academic emotions differed significantly according to grade level and age, but not gender.

Univariate Follow-Up Results

Following the significant multivariate results for grade level and age, univariate between-subject tests were examined to identify which dependent variable contributed to these differences. The results are presented in Table 8.

Table 8. Tests of Between-Subjects Effects

Source	Dependent Variable	F	df	p	Partial η^2
Grade level	Motivation	0.42	2, 251	.657	.003
	Negative academic emotions	15.62	2, 251	< .001	.111
Age	Motivation	0.71	4, 251	.586	.011
	Negative academic emotions	4.19	4, 251	.003	.063
Gender	Motivation	0.18	1, 251	.671	.001
	Negative academic emotions	0.96	1, 251	.328	.004

As presented in Table 8, mathematics learning motivation did not differ significantly across grade levels, $F(2, 251) = 0.42$, $p = .657$, partial $\eta^2 = .003$. In contrast, negative academic emotions differed significantly across grade levels, $F(2, 251) = 15.62$, $p < .001$, partial $\eta^2 = .111$. Thus, grade level accounted for approximately 11.1% of the variance in the observed negative academic emotion scores. A similar pattern was found for age. Mathematics learning motivation did not differ significantly across age groups, $F(4, 251) = 0.71$, $p = .586$, partial $\eta^2 = .011$, whereas negative academic emotions differed significantly according to age, $F(4, 251) = 4.19$, $p = .003$, partial $\eta^2 = .063$. Thus, the age-related multivariate effect was also attributable to differences in negative academic emotions rather than mathematics learning motivation.

The significant omnibus age effect indicates that at least some age groups differed in their observed negative academic emotion scores; however, the present analysis does not identify the specific pairwise age-group differences. Gender did not demonstrate significant differences in either mathematics learning motivation, $F(1, 251) = 0.18$, $p = .671$, partial $\eta^2 = .001$, or negative academic emotions, $F(1, 251) = 0.96$, $p = .328$, partial $\eta^2 = .004$. Overall, these findings indicate that the significant multivariate differences associated with grade level and age were primarily attributable to variation in negative academic emotions, whereas mathematics learning motivation remained comparatively stable across grade level, age, and gender.

Pairwise Comparisons

Because grade level showed a significant univariate difference in negative academic emotions, pairwise comparisons with Bonferroni adjustment were conducted to identify the specific grade-level differences. The results are presented in Table 9.

Table 9. Pairwise Comparisons of Negative Academic Emotion Scores Across Grade Levels

Comparison	Mean Difference	SE	p	95% CI
Grade 3 vs. Grade 4	-2.65	1.01	.027	[-5.04, -0.26]
Grade 3 vs. Grade 5	-5.26	1.04	< .001	[-7.72, -2.80]
Grade 4 vs. Grade 5	-2.61	0.91	.014	[-4.77, -0.45]

As shown in Table 9, Grade 5 students reported significantly higher negative academic emotion scores than Grade 3 students ($MD = 5.26$, $p < .001$) and Grade 4 students ($MD = 2.61$, $p = .014$). Grade 4 students also reported significantly higher negative academic emotion scores than Grade 3 students ($MD = 2.65$, $p = .027$). These pairwise comparisons confirm that the observed grade-level difference followed a consistent increasing pattern from Grade 3 to Grade 5.

Hypothesis Testing

The multivariate and follow-up analyses were subsequently evaluated in relation to the three research hypotheses. A summary of the findings is provided in Table 10.

Table 10. Summary of Hypothesis Testing

Hypothesis	Statistical Finding	Decision
H1: Mathematics learning motivation and negative academic emotions differ simultaneously across grade levels	Significant multivariate difference; negative academic emotions differed significantly, whereas mathematics learning motivation did not	Supported
H2: Mathematics learning motivation and negative academic emotions differ simultaneously across age groups	Significant multivariate difference; negative academic emotions differed significantly, whereas mathematics learning motivation did not	Supported
H3: Mathematics learning motivation and negative academic emotions differ simultaneously by gender	Multivariate difference was not significant	Not supported

As summarized in Table 10, H1 and H2 were supported, indicating significant multivariate differences according to grade level and age. The follow-up analyses further showed that these multivariate differences were driven primarily by negative academic emotions rather than mathematics learning motivation. In contrast, H3 was not supported, as the combined pattern of mathematics learning motivation and negative academic emotions did not differ significantly between male and female students.

Overall, the results indicate that grade-level and age-group differences were more evident in students' negative academic emotional experiences than in their overall mathematics learning motivation. The absence of significant univariate differences in mathematics learning motivation across grade level, age, and gender suggests that the significant multivariate effects were not attributable to broad differences in the motivation composite measure. These findings should nevertheless be interpreted in light of the measurement limitations identified in the psychometric assessment, particularly the weaker indicators and sub-threshold AVE values observed for some dimensions.

DISCUSSION

The present study indicates that grade level and age are relevant sources of variation in the combined pattern of mathematics learning motivation and negative academic emotions among elementary school students, whereas gender does not produce a comparable multivariate difference. Importantly, the significant grade- and age-related effects are primarily attributable to negative academic emotions, while overall mathematics learning motivation remains comparatively stable across the groups examined. Previous evidence suggests that several motivational and engagement components, including learning focus, persistence, planning, and adaptive motivation, can vary across educational levels in primary mathematics contexts (Xia et al., 2022). Differences across grade levels have also been reported for mathematics-related beliefs among Indonesian students, indicating that students' non-cognitive experiences of mathematics may vary according to their educational level (Hidayatullah & Csíkos, 2023). Thus, the present findings provide a more differentiated picture by indicating that, within Grades 3–5 in this sample, grade-related variation is more visible in negative academic emotional experiences than in the overall level of mathematics learning motivation.

The grade-level pattern in negative academic emotions deserves particular attention because students in the higher grades showed higher descriptive scores on the negative emotions assessed across classroom, learning, and testing contexts. This pattern should not be interpreted as evidence that advancing through school causes negative academic emotions, but it suggests that students in different grades may experience the emotional demands of mathematics differently. Negative achievement emotions such as anger, anxiety, boredom, hopelessness, and embarrassment have meaningful associations with mathematics learning outcomes, although the magnitude of these associations differs across particular emotions (Zulkarnaen & Nur, 2024). Positive and negative achievement emotions are also recognized as important components of mathematics learning, although their relationships with academic experiences and outcomes are not necessarily uniform across contexts (Juandi & Suparman, 2024). Accordingly, the present finding is educationally relevant because it identifies negative academic emotions as a dimension that may warrant greater attention across elementary grade levels without implying that these emotions necessarily produce poorer mathematics achievement in the current sample.

One practical interpretation of these findings is that mathematics instruction should attend not only to what students understand but also to how they experience classroom activities, learning tasks, and assessment situations. Positive emotional conditions have been shown to improve mathematical task efficiency under particular instructional conditions among young primary school students, illustrating the potential relevance of students' emotional states during learning (Saccardo et al., 2024). Contextual mathematics learning involving real objects and active student participation has also been associated with improvements in motivation and learning participation among Indonesian elementary students, although the small classroom-action-research sample limits direct generalization to the present population (Rahayu & Firdaus, 2025). These studies do not establish which particular strategy would reduce the negative academic emotions identified in the present study, but they illustrate feasible approaches for creating mathematics learning experiences that are more engaging and emotionally supportive. Teachers may therefore benefit from monitoring signs of boredom, tension, anxiety, or hopelessness while providing meaningful tasks, appropriate challenge, constructive feedback, and opportunities for active participation.

Age produced a broadly similar pattern to grade level because the combined motivational-emotional outcomes differed across age groups, while the follow-up analysis suggested that the difference was mainly attributable to negative academic emotions rather than mathematics learning motivation. Although the descriptive results indicate higher negative academic emotion scores among older age groups, the absence of pairwise age comparisons means that it would be inappropriate to conclude that every successive year of age corresponds to a statistically significant increase. Different configurations of general, test, and mathematics anxiety have been observed between younger and older school-aged groups, indicating that students' emotional experiences may differ across age groups (Williams et al., 2025). Anxiety-related experiences have also been associated with mathematics outcomes even before children enter formal primary education, suggesting that affective factors relevant to mathematics may have relatively early origins (Svraka et al., 2024). The present findings therefore reinforce the importance of considering age when examining students' negative academic emotional experiences, while longitudinal evidence would be necessary to determine whether the observed between-age differences actually represent developmental change.

In contrast to negative academic emotions, overall mathematics learning motivation did not differ significantly according to either grade level or age, suggesting relative stability in the aggregate motivational score within the range of students investigated. This finding should not be interpreted as evidence that motivation is unimportant because mathematics motivation has been positively associated with self-efficacy and behavioral engagement among Indonesian primary school students (Hidayatullah et al., 2024). Contemporary research also emphasizes that affective experiences in mathematics are multidimensional and may involve cognitive, emotional, social, and contextual factors that cannot necessarily be represented by a single general motivational score (Uğraş, 2025). The relative stability found in this study may therefore indicate that the overall mathematics motivation measure was less sensitive to grade- and age-related distinctions at the aggregate level used in this study. It is also possible that meaningful differences exist within specific motivational dimensions, such as intrinsic value, self-efficacy, self-regulation, utility value, or test anxiety, but become less visible when these components are represented through an aggregate score. This interpretation is important because the measurement assessment showed that the strength of the individual motivational dimensions was not uniform across grade groups, and therefore stability in the composite score should not be interpreted as evidence that all underlying motivational components were equally stable.

The absence of a significant gender effect is also noteworthy because boys and girls in this sample did not differ reliably in the combined pattern of mathematics learning motivation and negative academic emotions. This finding does not imply that gender differences never occur in primary mathematics because differences in mathematics anxiety, subject preference, and some aspects of task performance have been reported among primary school children in other contexts (Lennon-Maslin & Quaiser-Pohl, 2024). Large-scale longitudinal evidence has further shown that boys and girls may begin formal schooling with very similar mathematics performance before a performance gap emerges during subsequent schooling, although that research examined mathematics achievement rather than the motivational-emotional outcomes assessed in the present study (Martinot et al., 2025). These contrasting findings indicate that gender differences may depend on the particular psychological or academic outcome measured, the students' educational stage, assessment conditions, and sociocultural context. Therefore, the nonsignificant gender result in the current study is best understood as evidence that gender did not meaningfully differentiate the two examined outcomes in this specific sample rather than as evidence that gender is irrelevant to mathematics education.

Taken together, the findings contribute to mathematics education by demonstrating that mathematics learning motivation and negative academic emotions do not necessarily show identical patterns of variation across student characteristics, even when both constructs are examined simultaneously. Different pathways involving teacher support, teacher–student relationships, mathematics self-efficacy, and mathematics anxiety indicate that students' emotional experiences may emerge from interactions between individual and classroom factors rather than demographic characteristics alone (Wang et al., 2024). The growing literature on primary mathematics anxiety also highlights connections among gender stereotypes, mathematical perceptions, affective responses, and educational experiences, supporting the need to consider emotional processes as part of mathematics learning rather than as peripheral factors (Sagarduy et al., 2024). Emotional support and interventions may therefore represent useful components of mathematics instruction, although existing evidence indicates that emotional treatments do not produce uniformly consistent effects across all types of achievement emotions and instructional conditions (Juandi & Suparman, 2024). The present findings therefore support the view that motivational and emotional dimensions should be examined jointly but should not be assumed to follow the same pattern across student characteristics.

The findings should also be interpreted in light of measurement and methodological limitations. The measurement assessment indicated that the strength of some constructs was not uniform across grade groups, so observed differences in composite scores should be interpreted cautiously. The conceptual proximity between test anxiety within the mathematics learning motivation measure and test-related negative academic emotions should also be acknowledged. In addition, the cross-sectional design, purposive sampling within Cirebon Regency, and use of self-report questionnaires limit causal interpretation and generalizability. Taken together, the findings do not indicate that mathematics learning motivation and negative academic emotions change uniformly across elementary schooling. Rather, grade level and age were more clearly associated with negative academic emotional experiences than with overall mathematics learning motivation, while gender did not produce a significant multivariate difference. Future longitudinal research with broader samples and more detailed analyses of individual motivational and emotional dimensions is needed to clarify these patterns.

CONCLUSION

This study concludes that mathematics learning motivation and negative academic emotions do not exhibit identical patterns of variation across elementary students' characteristics. Differences related to grade level and age were more clearly reflected in negative academic emotions than in overall mathematics learning motivation, whereas gender did not meaningfully differentiate the combined outcomes in this sample. These findings highlight the importance of considering negative emotional experiences alongside motivation when understanding students' psychological experiences in mathematics learning, particularly across different grade and age groups. The study contributes to mathematics education by providing multivariate evidence that grade- and age-related differences may be more evident in negative academic emotions than in overall learning motivation, supporting the need for learning environments that attend to students' emotional as well as motivational needs. Future research should employ longitudinal designs, broader and more representative samples, and more detailed analyses of specific motivational and emotional dimensions to clarify these patterns across educational contexts.

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