

“I Know What You Think About Math, Now Tell Me What You Feel”: The Mediating Role of Emotions in the Relation Between Motivational Beliefs and Students’ Achievement

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Abstract. To better understand the motivational mechanisms underlying students’ academic success, this study examined the mediating role of emotions in the relationship between academic motivation and mathematics achievement, while controlling for prior achievement. Academic motivation was conceptualized within *Expectancy–Value Theory* and operationalized through motivational beliefs in mathematics, including expectancies for success, three value dimensions (interest, utility, and attainment value), and four cost dimensions (effort, opportunity, emotional,

Received: 2026-02-03. **Accepted:** 2026-02-20.

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and ego cost). As value reflects positively and cost reflects negatively valenced appraisals of learning situations, we focused on the mediating role of positive and negative classroom-related emotions. The study used data from the longitudinal research project *“Towards Effective Learning: Analysis of the Psychological Mechanisms of Obstacles to Learning Mathematics”*. The sample comprised 1,430 ninth-grade students ($M_{age} = 15.26$) from across Lithuania, who completed questionnaires assessing motivational beliefs and classroom-related emotions, while mathematics achievement was obtained from school records. SEM-based mediation analysis revealed that positive emotions consistently served as mediators in the relationships between value and cost dimensions and mathematics achievement, whereas negative emotions played a more limited mediating role, as mediation through negative emotions was observed only for utility value and ego cost. Notably, ego cost exhibited a pattern distinctive from other costs: a higher ego cost was associated with stronger positive emotions, which in turn predicted higher mathematics achievement, while also being associated with stronger negative emotions, which predicted lower achievement. These findings highlight the importance of considering emotions as mediators in the relationships between motivational beliefs and achievement within the Expectancy–Value framework.

Keywords: motivational beliefs, emotions, mathematics achievement, Expectancy–value theory.

„Žinau, ką galvoji apie matematiką, dabar pasakyk, kaip jautiesi“: emocijos kaip mokinių motyvuojančių įsitikinimų ir pasiekimų ryšio mediatorius

Santrauka. Siekiant geriau suprasti mokinių akademinę sėkmę grindžiantį motyvacijos mechanizmą, šiame tyrime analizuojama emocijų reikšmė mokymosi motyvacijos ir matematikos pasiekimų ryšiui, kontroliuojant ankstesnius pasiekimus. Mokymosi motyvacija buvo konceptualizuojama remiantis lūkesčio ir vertės teorija, išskiriant motyvuojančius įsitikinimus: sėkmės lūkestį, tris vertės dimensijas (vidinę, naudos ir pasiekimų vertę) bei keturias kainos dimensijas (pastangų, prarastų galimybių, emocijų ir ego kainą). Vertė atspindi teigiamą, o kaina – neigiamą mokymosi situacijų vertinimą, todėl analizuotas teigiamų ir neigiamų emocijų, patiriamų matematikos pamokose, mediacinis vaidmuo. Šiame tyrime naudoti tęstinio tyrimo „Veiksmingo mokymo(si) paieška: klūčių mokytis matematikos psichologinio mechanizmo analizė“ duomenys. Tyrimo imtį sudarė 1430 devintos klasės mokinių (amžiaus vidurkis 15,26 metų) iš įvairių Lietuvos vietovių. Mokiniai pildė klausimynus apie savo motyvuojančius įsitikinimus ir pamokose patiriamas emocijas. Informaciją apie mokinių matematikos pasiekimus suteikė mokyklų administracija. Struktūrinių lygčių modeliavimu (SEM) paremta mediacinė analizė atskleidė, jog teigiamos emocijos tarpininkavo vertės ir kainos dimensijų ryšiui su matematikos pasiekimais, o neigiamos emocijos – tik naudos vertės ir ego kainos ryšiui su pasiekimais. Nustatyta, kad ego kaina veikė kitaip nei kitos kainos dimensijos: didesnė ego kaina buvo susijusi tiek su stipresnėmis teigiamomis emocijomis, kurios prognozavo geresnius matematikos pasiekimus, tiek su stipresnėmis neigiamomis emocijomis, kurios prognozavo prastesnius pasiekimus. Tyrimo rezultatai pabrėžia emocijų svarbą aiškinant mokinių motyvuojančių įsitikinimų ir pasiekimų sąsajas lūkesčio ir vertės teorijos kontekste.

Pagrindiniai žodžiai: motyvuojantys įsitikinimai, emocijos, matematikos pasiekimai, lūkesčio ir vertės teorija.

Introduction

A STEM-proficient workforce is increasingly viewed as critical to national economic growth and societal development in a technology-driven world (OECD, 2024). Because mathematics forms an essential foundation for success in science, technology, engineering, and related fields, it is widely regarded as a gateway to STEM education and careers. Given this central role, it is concerning that students' mathematics achievement remains low in many countries. Recent reports, for example, indicate that approximately 30% of students in the European Union do not reach the minimum proficiency level required by national curricula (European Commission, 2024). These patterns have intensified ongoing discussions about the factors that shape students' learning outcomes in mathematics. Among the various influences identified in the extensive literature on academic achievement, situational personal variables, such as students' motivation and emotions,

are considered important contributors to students' learning processes and performance in mathematics (Costa et al., 2024). Rather than operating independently, motivation and emotional experiences are closely intertwined during learning. Building on this perspective, the present study examines the role of emotions in linking students' motivation to their mathematics achievement.

Students' motivation for learning mathematics can be examined through several theoretical perspectives, with *Expectancy-Value Theory* (EVT) among the most widely applied frameworks. Developed by Eccles and colleagues (Eccles et al., 1983; Wigfield & Eccles, 2000), EVT proposes that students' engagement, persistence, and performance in mathematics are shaped by two categories of beliefs: (1) their expectancies for success in mathematics (i.e., how well they believe they can do in the subject), and (2) the subjective value they assign to learning mathematics. Subjective value is conceptualized as comprising four distinct components: intrinsic value, utility value, attainment value, and cost. Intrinsic value refers to the enjoyment or interest students derive from engaging in mathematical content; utility value captures the perceived usefulness of mathematics for achieving current or future goals; whereas, attainment value reflects the personal importance that students place on performing well in mathematics (Eccles & Wigfield, 2020). In contrast to these three positive aspects of value, cost denotes the perceived negative aspects of studying mathematics (Eccles et al., 1983; Eccles & Wigfield, 2020).

The conceptualization and measurement of cost in EVT research have been inconsistent, particularly regarding its multidimensional structure (Barron & Hulleman, 2015). Although cost has been conceptualized as comprising multiple facets, earlier studies frequently combined these into a single composite score (e.g., Battle & Wigfield, 2003; Chiang et al., 2011; Luttrell et al., 2010), and even when separate components were examined, their definitions and operationalizations varied across studies. This was particularly evident in the psychological cost domain, where anticipated negative emotions and threats to self-worth were frequently conflated (e.g., Greene et al., 2023; Part et al., 2020; Perez et al., 2014; Perez et al., 2019), resulting in heterogeneous operationalizations and mixed empirical findings. Addressing these ambiguities, more recent work has advanced a four-dimensional framework of perceived cost that distinguishes among effort, opportunity, emotional, and ego cost (Jiang, 2015; Jiang et al., 2020). Within the context of studying mathematics, effort cost refers to the excessively high and not worthwhile effort which students anticipate investing in the subject; opportunity cost involves the perception that one must sacrifice other valued activities to do well in mathematics; emotional cost captures the negative feelings such as anxiety or annoyance anticipated when working on mathematics; and ego cost denotes the threat that potential failure poses to one's self-concept or self-worth (Jiang, 2015; Jiang et al., 2020). Evidence supporting the distinctiveness of these four facets has begun to accumulate across cultural contexts, including findings from a Lithuanian adolescent sample, demonstrating their empirical separability and differential associations with academic outcomes (Jiang et al., 2020; Raižienė et al., 2025).

Empirical evidence indicates that, among the motivational beliefs postulated within EVT, expectancies for success are most strongly and consistently positively related to

mathematics achievement. Intrinsic, attainment, and utility values also show positive associations with achievement, although these relations tend to be weaker (Eccles & Wigfield, 2020). As a negative aspect of motivation, cost is expected to be negatively related to academic achievement, which is a pattern repeatedly confirmed in studies using composite cost scores (e.g., Jiang et al., 2018; Jiang & Rosenzweig, 2021; Trautwein et al., 2012). In contrast, relations between the four distinct cost facets and mathematics achievement have been examined in only a limited number of studies, and they reveal a more complex pattern. Effort and emotional cost have consistently been found to relate negatively to achievement (Jiang et al., 2020; Raiziene et al., 2025). Opportunity cost, however, has shown negative (Raiziene et al., 2025), positive (Greene et al., 2023), and nonsignificant associations with achievement across different samples (Jiang et al., 2020; Greene et al., 2023). Ego cost has demonstrated an even more distinctive pattern, showing positive relations with achievement in a Lithuanian sample (Raiziene et al., 2025) but no significant association in a Korean sample (Jiang et al., 2020). Taken together, these findings suggest that the four cost facets may relate to mathematics achievement in qualitatively distinct ways, underscoring the need for further research examining their unique roles.

It is worth noting that much research within the EVT framework has focused on direct associations between motivational beliefs and academic achievement. However, cognitive approaches to emotion suggest that the influence of our thoughts and beliefs on behavior is often indirect, operating through cognitive appraisal of the situation and the emotions it evokes (Lazarus, 1991). From this perspective, students' beliefs about mathematics and learning mathematics, that is, their motivational beliefs, may shape how they feel in learning situations, which, in turn, affects their engagement and, ultimately, their achievement. This interplay between cognitions, emotions, and academic behavior is explicitly articulated in Pekrun's control–value theory of achievement emotions (Pekrun, 2006, 2024). According to this theory, appraisals of control over learning activities and outcomes, together with the value attributed to these activities and outcomes, function as proximal antecedents of achievement emotions, which subsequently influence academic performance. Consequently, it is reasonable to assume that motivational beliefs, as conceptualized within EVT, may be related to mathematics achievement not only directly but also indirectly, through students' emotional experiences.

Despite the theoretical plausibility of this assumption, empirical evidence remains limited. While research within the control–value framework provides strong support for associations between cognitive appraisals and emotions on the one hand, and between emotions and achievement on the other, studies explicitly testing the mediating role of emotions in the relationship between cognitions and achievement are still scarce (e.g., Tze et al., 2023; Putwain et al., 2021; Yu et al., 2024). Moreover, although the key cognitive constructs in Pekrun's theory (control and value appraisals) and EVT (expectancies and values) derive from a shared theoretical background (i.e., classic expectancy–value theories), they are not conceptually identical. Expectancies in EVT largely correspond to components of control appraisals, particularly academic self-concept and self-efficacy. However, expectancies in EVT represent only the evaluation of one's abilities and the

probability of success, whereas control appraisals in Pekrun's framework additionally incorporate attribution-related elements, such as perceived controllability, which are not included in EVT expectancies (Pekrun & Perry, 2014). Additionally, unlike EVT, value in control–value theory is not clearly specified or consistently operationalized as a multidimensional construct, even though it is often measured by using indicators of intrinsic, utility, or attainment value. Importantly, control–value theory conceptualizes value exclusively in terms of positive aspects of learning and achievement, thereby neglecting negative aspects such as perceived costs, which play an important role in EVT. Therefore, the interrelations among costs, emotions, and achievement have not been studied before.

Against this background, the present study aims to examine the mediating role of emotions in the relationship between motivational beliefs as conceptualized within EVT, namely, expectancies for success, three value dimensions, and four cost dimensions, and mathematics achievement. Within this framework, Jiang et al. (2020) argue that value reflects positively valenced appraisals of learning situations, whereas cost reflects negatively valenced appraisals. Therefore, in this study, emotions are operationalized as students' positive and negative affective experiences in mathematics classes. Accordingly, we hypothesize that both positive and negative classroom-related emotions will mediate the relationships between motivational beliefs and mathematics achievement. Specifically, we expect that positive emotions will mediate the associations between motivational beliefs and achievement, such that higher expectancies for success and value components and lower perceived cost will be associated with higher levels of positive emotions, which, in turn, will relate to higher mathematics achievement. In contrast, we hypothesize that negative emotions will mediate these associations in the opposite direction, such that lower expectancies and values and higher perceived cost will be associated with higher levels of negative emotions, which, in turn, will relate to lower mathematics achievement.

Methods

Participants and Procedure

The present study is part of a longitudinal research project titled "*Towards Effective Learning: Analysis of the Psychological Mechanisms of Obstacles to Learning Mathematics*", which examines students' motivational beliefs and learning experiences in mathematics from the beginning of Grade 9 over two years until the completion of basic education. Although the project follows students over time, the present study focuses on predicting mathematics achievement measured at the second measurement occasion (T2; spring 2024), while controlling for prior achievement assessed at the first measurement occasion (T1; autumn 2023).

The original sample of the longitudinal study consisted of 1,649 students (recruitment rate: 69%), drawn from 89 classes in 24 public schools across Lithuania. Quota sampling was used to ensure representation of schools located in urban, town, and rural areas. At T2, 1,459 students participated (88.8% retention from the original sample). The present

analyses include 1,430 students who had available data on prior achievement measured at T1, which was used as a control variable in the analytic model.

The final analytic sample comprised 802 girls and 620 boys (8 participants did not specify their gender), with a mean age of 15.26 years ($SD = 0.46$). Regarding school location, 610 students attended schools in urban areas, 606 in towns, and 214 in rural areas. This distribution closely approximates the national distribution of students in upper secondary grades according to school location.

Participation in the study was voluntary. Only students for whom written informed parental consent had been obtained were invited to participate, and all students provided their own assent prior to completing the questionnaires. Self-report data were collected during regular classroom hours by trained research assistants. With parental consent, schools provided students' final mathematics grades from the semester preceding the questionnaire administration (autumn 2023), which served as an indicator of prior achievement, as well as the students' final mathematics grades from the semester during which the questionnaire data were collected. The study procedures were approved by the Committee on Research Ethics of the Institute of Psychology at Vilnius University (protocol code 20/(1.13 E) 250000-KT-161, 02-10-2023).

Measures

Motivational beliefs

The instruments to measure motivational beliefs (i.e., expectancies for success, values, and costs) were developed by the authors of this study. The items were adapted from prior studies (Wigfield & Eccles, 2000; Luttrell et al., 2010; Conley, 2012; Trautwein et al., 2012; Flake et al., 2015; Kosovich et al., 2015; Perez et al., 2019; Jiang et al., 2020; Lee et al., 2022; Gaspard et al., 2020; Lee et al., 2022), complemented by self-developed items. All items were written in Lithuanian and focused on the subject of mathematics. Students were asked to rate all items on a 5-point Likert-type scale ranging from 1 (completely disagree) to 5 (completely agree).

Expectancies for success were measured by 6 items in total, comprising students' evaluations of their mathematical abilities (four items; e.g., "I am good at math") and their expectations of succeeding in mathematics during the current school year (two items; e.g., "I think I will do well in math this year"). Confirmatory factor analysis indicated that a one-factor model provided a good fit to the data, $\chi^2(8) = 26.45$, $p < 0.001$, CFI = 0.996, TLI = 0.993, RMSEA = 0.04. Standardized factor loadings ranged from 0.775 to 0.906.

Mathematics value beliefs were assessed by using 17 items capturing three value components. Intrinsic value (five items) reflected the students' perceived interest and enjoyment in mathematics (e.g., "I like math"). Utility value (seven items) assessed the students' perceptions of the usefulness of mathematics for everyday life, future goals, and career aspirations (e.g., "I will often need math in my life"). Attainment value (five items) captured the personal importance of being good at mathematics and performing well in the subject (e.g., "It is important for me to be someone who is good at solving

math problems"). Confirmatory factor analysis supported a three-factor model corresponding to intrinsic, utility, and attainment value, $\chi^2(111) = 794.92$, $p < 0.001$, CFI = 0.943, TLI = 0.931, RMSEA = 0.065. Standardized factor loadings ranged from 0.582 to 0.902.

Mathematics cost beliefs were assessed by using 18 items reflecting four cost dimensions: effort cost, opportunity cost, emotional cost, and ego cost. Effort cost (three items) captured perceptions of an excessive effort and energy required to study mathematics (e.g., "I have to put in too much effort to do well in math"). Opportunity cost (five items) reflected perceived sacrifices associated with studying mathematics, such as giving up other valued activities or time with peers (e.g., "Studying math just makes me have no time for other activities I like"). Emotional cost (five items) assessed anticipated negative emotional experiences related to learning mathematics, including stress, anxiety, and annoyance (e.g., "Studying math is very stressful for me"). Ego cost (five items) captured perceived threats to self-worth associated with potential failure in mathematics, including feelings of disappointment in oneself, embarrassment, and fear of being perceived as lacking ability by others (e.g., "I would be disappointed in myself if I didn't understand math"). Confirmatory factor analysis supported a four-factor model corresponding to the proposed cost dimensions, $\chi^2(128) = 692.97$, $p < 0.001$, CFI = 0.959, TLI = 0.951, RMSEA = 0.055. Standardized factor loadings ranged from 0.553 to 0.914.

Classroom-related emotions

Items measuring classroom-related emotions were developed by the authors of this study in Lithuanian and referred specifically to emotions experienced during mathematics classes. Students responded to all items by using a 5-point Likert-type scale ranging from '1' (does not apply) to '5' (fully applies).

Positive emotions were measured by using four items capturing positive emotions experienced during mathematics classes, such as enjoyment and enthusiasm (e.g., "I feel enthusiastic during math class"). Confirmatory factor analysis supported a one-factor model for positive emotions, $\chi^2(1) = 5.878$, $p < .01$, CFI = 0.996, TLI = 0.976, RMSEA = 0.058. Standardized factor loadings ranged from 0.578 to 0.799.

Whereas, *negative emotions* were measured by using five items referring to unpleasant emotional experiences during mathematics classes, including anxiety, frustration, and hopelessness (e.g., "I feel hopeless during math class"). Confirmatory factor analysis indicated a good fit of a one-factor model, $\chi^2(4) = 24.433$, $p < .01$, CFI = 0.991, TLI = 0.977, RMSEA = 0.059. Standardized factor loadings ranged from 0.711 to 0.841.

Internal consistency of all composite self-report measures was good to excellent, with Cronbach's α values ranging from .81 to .93 (see Table 1).

Mathematics achievement

Mathematics achievement was operationalized using students' final mathematics grades obtained from official school records. For each student, one final grade from the autumn (previous) semester and one final grade from the spring (current) semester were used.

Grades were awarded on a 10-point scale, where 10 is the highest grade, which is the standard grading system in Lithuania.

Data Analysis

Data analysis was conducted in two stages. First, a preliminary analysis was conducted in SPSS version 31. We examined the associations among study variables by using Pearson correlation coefficients and compared experienced positive and negative emotions in mathematics classes by using a *t-test*.

Second, mediation models were tested by using Mplus 8.8 (Muthén & Muthén, 2017) to estimate direct and indirect effects of motivational beliefs on mathematics achievement via positive and negative emotions. Sixteen mediation models were specified, one for each motivational belief (expectancy for success, three value components, and four cost facets), with positive and negative emotions as mediators. In all models, the prior achievement was controlled by regressing each variable in the model on it. Motivational beliefs and emotions were specified as latent variables to account for measurement error.

Models were estimated by using the robust Maximum Likelihood Estimator (MLR). The COMPLEX option was applied to account for the nesting of students within classes. Model fit was evaluated using standard indices: the chi-square test of model fit (χ^2), the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), the Tucker–Lewis Index (TLI), and the Standardized Root Mean Square Residual (SRMR). Good model fit was indicated by a nonsignificant χ^2 test, RMSEA values below 0.06, CFI and TLI values above 0.95, and SRMR values below 0.08 (Hu & Bentler, 1999). In the present study, χ^2 tests were significant for all models, likely due to the large sample size.

Mediation was evaluated within a structural equation modeling framework utilizing 5000 bootstrap samples to estimate indirect effects. Because bootstrapping cannot be used simultaneously with the MLR and the COMPLEX commands, indirect effects were estimated by using Maximum Likelihood (ML) with bootstrapping. The statistical significance of indirect effects was determined using 95% confidence intervals (CIs); effects were considered significant when the confidence interval did not include zero. Direct effects are reported for completeness but were not used to establish mediation.

Results

Descriptive Statistics and Correlations

Table 1 presents descriptive statistics and correlations among mathematics motivational beliefs (expectancies for success, value, and cost dimensions), positive and negative emotions experienced in mathematics classrooms, and mathematics achievement in the preceding semester and the semester under study. The results indicate that scores on both the motivational beliefs and emotions scales ranged from 1 to 5, which is consistent with the scales' theoretical ranges. In addition, students reported experiencing significantly more positive than negative emotions during mathematics classes ($t(1451) = 8.54, p < 0.001$).

Table 1.
Descriptive Statistics and Correlations Among Motivational Beliefs, Emotions and Mathematics Achievement

	ExS	InV	UtV	AtV	EfC	OpC	EmC	EgC	PoEm	NeEm	PrAch	Ach
Expectancy for success (ExS)	-	0.72**	0.41**	0.46**	-0.69**	-0.56**	-0.67**	0.16**	0.60**	-0.59**	0.62**	0.64**
Intrinsic value (InV)		-	0.57**	0.57**	-0.49**	-0.47**	-0.56**	0.28**	0.77**	-0.51**	0.43**	0.46**
Utility value (UtV)			-	0.61**	-0.25**	-0.28**	-0.29**	0.33**	0.44**	-0.30**	0.30**	0.34**
Attainment value (AtV)				-	-0.18**	-0.15**	-0.15**	0.70**	0.43**	-0.15**	0.40**	0.42**
Effort cost (EfC)					-	0.75**	0.75**	0.04	-0.43**	0.62**	-0.48**	-0.49**
Opportunity cost (OpC)						-	0.72**	0.09*	-0.42**	0.64**	-0.40**	-0.41**
Emotional cost (EmC)							-	0.18**	-0.51**	0.82**	-0.40**	-0.40**
Ego cost (EgC)								-	0.14**	0.16**	0.23**	0.27**
Positive emotions (PoEm)									-	-0.51**	0.31**	0.32**
Negative emotions (NeEm)										-	-0.34**	-0.33**
Prior Achievement (PrAch)											-	0.83**
Achievement (Ach)												-
M (SD)	2.52 (0.99)	2.65 (0.96)	3.30 (0.79)	3.23 (0.82)	3.41 (1.05)	2.86 (1.13)	3.24 (1.05)	3.15 (0.93)	2.98 (1.04)	2.61 (0.86)	6.38 (2.09)	6.40 (1.99)
Range	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 5	1 – 10	2 – 10
Cronbach's α	0.93	0.91	0.89	0.85	0.88	0.93	0.89	0.87	0.81	0.89	-	-

Note. * $p < 0.01$, ** $p < 0.001$.

The pattern of correlations between motivational beliefs, emotions, and achievement largely aligned with our expectations. Students who reported higher expectancies for success, greater value in mathematics, and more positive emotions during math classes tended to achieve at higher levels. In contrast, students who perceived higher costs in learning mathematics and experienced more negative emotions generally demonstrated lower achievement. Notably, ego cost was an exception, showing a positive association with achievement. These associations remained consistent regardless of whether achievement was measured for the semester under study or for the preceding semester. Notably, among all the motivational beliefs, expectancy for success was most strongly correlated with achievement.

Positive Emotions as Mediators in the Associations between Motivational Beliefs and Achievement

We tested eight mediation models (M1–M8; Table 2) to examine whether positive emotions mediated the relations between motivational beliefs and mathematics achievement, controlling for prior achievement. Model fit was acceptable to excellent across all models ($CFI > 0.956$, $TLI > 0.936$, $RMSEA < 0.068$, and $SRMR < 0.057$).

Results are summarized in Figure 1. Across models, motivational beliefs showed significant direct effects on both achievement and positive emotions, largely in line with theoretical expectations. Expectancy for success and value beliefs were positively associated with achievement and positive emotions, whereas cost facets were generally negatively associated. The only exception was ego cost, which exhibited positive direct effects on both achievement and positive emotions.

Turning to the effects of positive emotions on achievement, these paths were positive and statistically significant in most models. Two exceptions emerged. In the expectancy for success model (M1), positive emotions did not significantly predict achievement. In the intrinsic value model (M2), contrary to expectations, positive emotions were found to be negatively related to achievement.

Regarding indirect effects, bootstrap analyses revealed significant mediation in seven of the eight models (Table 2). Expectancy for success (M1) showed a strong positive association with positive emotions; however, the indirect effect via positive emotions was not statistically significant, which indicates that mediation was not supported in this model.

Significant indirect effects were observed for utility value (M3), attainment value (M4), effort cost (M5), opportunity cost (M6), emotional cost (M7), and ego cost (M8). In these models, motivational beliefs were indirectly associated with mathematics achievement through positive emotions. Specifically, higher utility and attainment values were associated with higher achievement via increased positive emotions, whereas higher effort, opportunity, and emotional costs were associated with lower achievement via reduced positive emotions. Ego cost showed a positive indirect association with achievement through positive emotions, diverging from the pattern observed for the other cost facets.

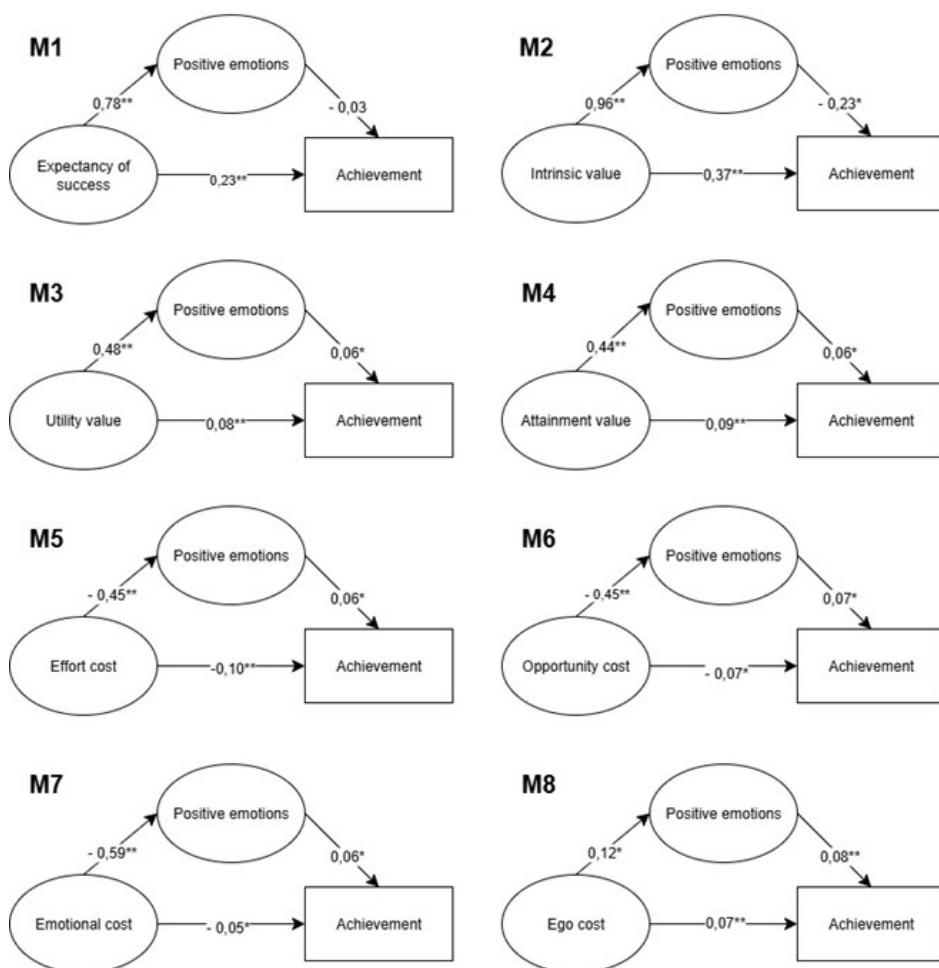
Negative Emotions as Mediators in the Associations between Motivational Beliefs and Achievement

As in the analysis of positive emotions, we examined the mediating role of negative emotions in the relations between motivational beliefs and mathematics achievement by estimating eight structural equation models (M9–M16; Table 2). Model fit was acceptable to excellent across all models ($CFI > 0.949$, $TLI > 0.932$, $RMSEA < 0.072$, $SRMR < 0.068$).

Results are presented in Figure 2. Consistent with the results of the positive emotion models (M1–M8), motivational beliefs in models M9–M16 showed significant direct

Figure 1.

Mediation Analyses Examining the Indirect Effects of Motivational Beliefs on Mathematics Achievement through Positive Emotions



Note. * $p < 0.05$, ** $p < 0.001$.

Table 2.

Fit Indices and Indirect Effects for Models Examining the Mediation Effect of Positive and Negative Emotions on the Relations between Motivational Beliefs and Mathematics Achievement

	Indirect path	χ^2	df	CFI	TLI	RMSEA (90% CI)	SRMR	Indirect Effect (β)	95% CI
M1	ExS→ PoEm→Ach	224.97***	48	0.980	0.973	0.051 [0.044; 0.058]	0.028	-0.025	[-0.072; 0.017]
M2	InV→ PoEm→Ach	179.30***	38	0.983	0.975	0.051 [0.044; 0.059]	0.030	-0.216	[-0.394; -0.099]
M3	UtV→ PoEm→Ach	257.63***	58	0.973	0.963	0.049 [0.043; 0.055]	0.034	0.026	[0.007; 0.049]
M4	AtV→ PoEm→Ach	288.03***	38	0.956	0.936	0.068 [0.061; 0.075]	0.046	0.025	[0.008; 0.045]
M5	EfC→ PoEm→Ach	108.31***	22	0.983	0.971	0.052 [0.043; 0.062]	0.030	-0.025	[-0.044; -0.005]
M6	OpC→ PoEm→Ach	174.22***	39	0.982	0.975	0.049 [0.042; 0.057]	0.034	-0.029	[-0.050; -0.009]
M7	EmC→ PoEm→Ach	195.53***	39	0.975	0.965	0.053 [0.046; 0.060]	0.036	-0.037	[-0.067; -0.010]
M8	EgC→ PoEm→Ach	264.57***	38	0.961	0.943	0.065 [0.057; 0.072]	0.057	0.010	[0.004; 0.018]
M9	ExS→ NeEm→Ach	274.07***	59	0.979	0.972	0.050 [0.045; 0.057]	0.031	-0.032	[-0.069; 0.001]
M10	InV→ NeEm→Ach	144.42***	48	0.989	0.985	0.037 [0.031; 0.045]	0.031	-0.008	[-0.034; 0.016]
M11	UtV→ NeEm→Ach	285.28***	70	0.975	0.967	0.046 [0.041; 0.052]	0.038	0.012	[0.001; 0.025]
M12	AtV→ NeEm→Ach	261.82***	48	0.968	0.956	0.056 [0.049; 0.063]	0.046	0.002	[-0.003; 0.008]
M13	EfC→ NeEm→Ach	130.74***	30	0.984	0.976	0.048 [0.040; 0.057]	0.025	0.005	[-0.023; 0.039]
M14	OpC→ NeEm→Ach	168.63***	49	0.987	0.982	0.041 [0.035; 0.048]	0.023	-0.009	[-0.046; 0.027]
M15	EmC→ NeEm→Ach	215.07***	49	0.979	0.972	0.049 [0.042; 0.055]	0.027	0.045	[-0.059; 0.159]
M16	EgC→ NeEm→Ach	408.00***	49	0.949	0.932	0.072 [0.065; 0.078]	0.068	-0.024	[-0.037; -0.012]

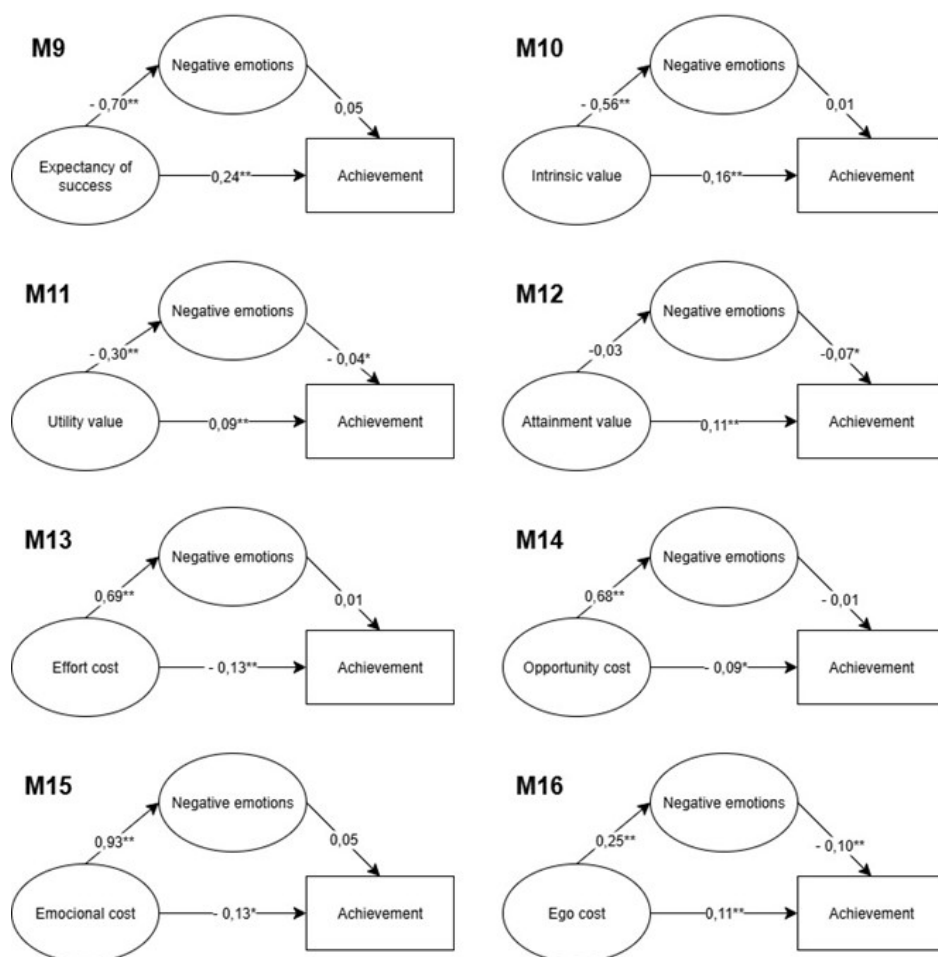
Note. *** $p < 0.001$. Significant indirect effects are highlighted in bold. Exs – Expectancy for Success, InV – Intrinsic Value, UtV – Utility value, AtV – Attainment value, EfC – Effort Cost, OpC – Opportunity Cost, EmC – Emotional Cost, EgC – Ego Cost, PoEm – Positive Emotions, NeEm – Negative Emotions, Ach – Achievement.

effects on achievement. Specifically, expectancy for success and value beliefs were positively associated with achievement, whereas cost facets were negatively associated with achievement, except for ego cost, which showed a positive direct effect on achievement.

In contrast to the positive emotion models, motivational beliefs generally showed opposite direct effects on negative emotions. Expectancy for success and value beliefs were negatively associated with negative emotions, whereas cost facets were positively associated with negative emotions. Ego cost followed this general cost pattern and showed a positive direct association with negative emotions. One exception was attainment value, which did not show a significant direct effect on negative emotions.

Figure 2.

Mediation Analyses Examining the Indirect Effects of Motivational Beliefs on Mathematics Achievement through Negative Emotions



Note. * $p < 0.05$, ** $p < 0.001$.

A somewhat different pattern emerged when examining the direct effects of negative emotions on achievement, as compared with those of positive emotions. Specifically, a significant negative association between negative emotions and achievement was observed only in models M11, M12, and M16.

Regarding indirect effects, significant indirect effects via negative emotions were observed only for utility value (M11) and ego cost (M16), with utility value showing a positive indirect association with mathematics achievement through reduced negative emotions, and ego cost showing a negative indirect association through increased negative emotions.

Among the negative emotion models (M9–M16), statistically significant indirect effects are observed only in Model M11 (utility value → negative emotions → achievement) and Model M16 (ego cost → negative emotions → achievement). The remaining negative emotion models do not show statistically significant indirect effects.]

Discussion

The present study examined the role of emotions in the relation between students' motivational beliefs about mathematics, as conceptualized within Expectancy–Value Theory, and mathematics achievement, while controlling for prior achievement. This study contributes to the existing literature in two important ways. First, the present study extends the traditional EVT-based discussion of the relation between motivational beliefs and achievement by incorporating students' classroom-related emotions as mediators. In doing so, it draws on insights from control–value theory (Pekrun, 2006, 2024), which highlights the importance of emotions for academic achievement, while maintaining EVT as the primary conceptual framework. Second, in examining associations between motivational beliefs and achievement, perceived cost was conceptualized as a four-dimensional construct, allowing for a more fine-grained analysis of the distinct mechanisms through which different aspects of cost may relate to students' learning outcomes.

With regard to our hypotheses, the results provided partial support for the proposed mediation model. As expected, positive classroom-related emotions consistently mediated the associations between most motivational beliefs and mathematics achievement. Higher values and lower costs were generally associated with higher levels of positive emotions, which, in turn, related to higher achievement. In contrast, negative emotions played a more limited mediating role, supporting the hypotheses only in a subset of relationships. Furthermore, ego cost demonstrated a distinct and more complex mediational pattern compared to other cost dimensions.

First, we consider the pattern of direct associations among the study variables. Correlation analyses revealed that expectancies for success were positively associated with mathematics achievement, with this relationship being strong and the strongest among all motivational beliefs examined. Thus, students who were more confident in their ability to succeed achieved higher in mathematics. The associations between value components (perceived interest in mathematics, its usefulness, and personal importance) and achieve-

ment were also positive and of moderate strength. These findings are fully consistent with theoretical assumptions of Expectancy–Value Theory as well as with prior empirical research demonstrating positive links between expectancies, values, and academic achievement (Eccles & Wigfield, 2020).

Regarding perceived costs, three cost dimensions (effort cost, opportunity cost, and emotional cost) were negatively associated with mathematics achievement. This pattern aligns with the general EVT assumption that cost represents a negative motivational force that undermines academic behavior and outcomes (Eccles & Wigfield, 2020) and is consistent with previous studies explicitly examining the four-dimensional cost framework (Jiang et al., 2020; Raižienė et al., 2025). However, ego cost displayed a distinct pattern: although its association with achievement was weaker than that of the other cost dimensions, it was positive rather than negative. At present, this finding can be interpreted only to a limited extent in relation to prior research, as empirical evidence on the association between ego cost and achievement remains scarce (e.g., Jiang et al., 2020). This scarcity is largely due to the way ego cost has been treated in earlier studies: ego cost, defined as the perceived threat that potential failure poses to one's self-concept, has long been conflated with emotional cost (e.g., Perez et al., 2014; Greene et al., 2023; Part et al., 2020; Perez et al., 2019) or omitted altogether from empirical investigations (e.g., Fadda et al., 2020; Gaspard et al., 2015). Notably, a positive association between ego cost and mathematics achievement was identified in a previous study using data from the same longitudinal project as the present research but based on an earlier measurement occasion (Raižienė et al., 2025).

The distinctive functioning of ego cost is also reflected in its associations with emotions experienced during mathematics classes. Unlike other cost dimensions, which were negatively associated with positive emotions, ego cost was positively associated with them. At the same time, its relationship with negative emotions followed the same pattern as the other cost facets, being positively associated with negative classroom-related emotions. Taken together, this pattern of associations points to a more ambiguous role of ego cost compared to the other cost facets. Accordingly, incorporating emotions into the analysis may provide important insights into the mechanisms underlying the relationship between ego cost and mathematics achievement.

The mediation analyses revealed that neither positive nor negative emotions mediated the relationship between expectancies for success and mathematics achievement. This finding contrasts with prior research suggesting that emotions play a role in the association between expectancies and achievement (e.g., Tze et al., 2023; Putwain et al., 2021); however, their findings have also been mixed. For example, in the study by Putwain et al. (2021), only some of the examined emotions were involved in this relationship, whereas in a large-scale international study by Tze et al. (2023), such effects were observed only in a subset of participating countries. One possible interpretation of the absence of indirect effects via emotions in the present study is that both expectancies for success and mathematics achievement are strongly influenced by a common underlying factor,

namely, students' actual abilities. As a result, the direct association between expectancies and achievement may be more pronounced than pathways operating through emotions.

As expected, positive emotions emerged as mediators of the relations between both values and costs and mathematics achievement. Regarding task values, all three value components demonstrated significant indirect links to achievement through students' positive emotions. A similar pattern was reported by Putwain et al. (2021), who identified enjoyment as a specific positive emotion that mediated the relationship between task values and achievement. Our results suggest that students who perceived mathematics as more useful for their current and/or future goals and as more personally important reported higher levels of positive emotions, which, in turn, were associated with higher mathematics achievement. Thus, consistent with our expectations, perceiving mathematics as valuable appears to foster positive emotional experiences in the classroom. These positive emotions are likely to promote greater engagement, effort, and persistence, which may support deeper learning and, consequently, be reflected in higher achievement. Importantly, these indirect associations were observed even after controlling for prior achievement.

Although an association of an unexpected direction was observed for intrinsic value, this finding warrants cautious interpretation. While intrinsic value was strongly and positively associated with positive emotions, the resulting indirect effect on mathematics achievement was negative due to a negative association between positive emotions and achievement in this specific model. This pattern is likely attributable to suppressor or multicollinearity effects among closely related motivational and emotional variables, rather than reflecting a substantively meaningful negative indirect pathway. Accordingly, we suggest that the indirect effect observed for intrinsic value should be interpreted as a methodological artifact of the model rather than as evidence contradicting theoretical assumptions about the role of positive emotions in learning.

Positive emotions mediated the relationships between all cost dimensions except ego cost and mathematics achievement in the expected direction. The findings indicate that students who anticipate investing unrewarding effort, having to sacrifice other valued activities, or experiencing tension and anxiety in mathematics, tend to report lower levels of positive emotions during mathematics classes. These reduced positive emotional experiences, in turn, are associated with lower levels of learning engagement and, consequently, with lower achievement. To date, only a limited number of studies have examined the joint role of costs, emotions, and achievement. In such work, Omer et al. (2023) provided longitudinal evidence of a negative link from cost to positive emotions, which, in turn, positively relates to higher achievement scores.

In contrast, the mediational pattern observed for ego cost more closely resembled that of positive task values than that of the other cost dimensions, as perceiving a threat of failure when learning mathematics was positively associated with the experience of positive emotions, which, in turn, positively predicted achievement. This finding extends the correlational results, which indicated a positive association between ego cost and mathematics achievement, and points to the potential involvement of positive emotions

in this relationship. At the same time, their precise role in linking ego cost to achievement remains unclear.

A somewhat different pattern emerged when considering the mediating role of negative emotions in the relationships between values, costs, and mathematics achievement. Among the three value components, a mediating pathway through negative emotions was observed only for utility value. Specifically, students who perceived mathematics as more useful reported lower levels of negative emotions during mathematics classes, and experiencing fewer negative emotions was, in turn, associated with higher mathematics achievement. A similar pattern was reported by Putwain et al. (2021), who identified an indirect association between utility value and achievement through a specific negative emotion, namely, anxiety.

A mediating pathway through negative emotions was also observed for only one of the cost dimensions. As discussed earlier, both correlational and mediation analyses involving positive emotions indicated that ego cost was positively associated with mathematics achievement, both directly and indirectly, through higher levels of positive emotions. This pattern suggests that ego cost may, under certain conditions, be linked to more adaptive learning outcomes. However, the mediation analyses involving negative emotions point to a contrasting pattern: higher levels of ego cost were also associated with increased negative emotions, which, in turn, were related to lower mathematics achievement. Thus, when operating through negative emotional experiences, ego cost appears to function in a maladaptive way.

Across the mediation analyses, positive emotions accounted for indirect effects in most of the examined relationships, whereas negative emotions were observed as mediators only in a limited number of cases. One possible explanation for this pattern relates to how emotions were operationalized. Based on Jiang et al.'s (2020) argument that value reflects positively valenced appraisals of learning situations, whereas cost reflects negatively valenced appraisals, we distinguished between positive and negative emotions, rather than specific discrete emotions, in this study. This approach aligns with dimensional models of emotion, which typically associate positive emotions with approach-oriented behaviors and negative emotions with avoidance-oriented behaviors (e.g., Russell & Barrett, 1999). When applied to learning contexts, this means that positive emotions would be associated with an increased effort, persistence, and engagement in learning, whereas negative emotions would be associated with withdrawal from learning situations. However, emotional experiences can also be conceptualized by using a discrete emotions approach, which emphasizes that different negative emotions may serve distinct functions (e.g., Russell & Barrett, 1999). For example, math-related fear or anxiety may promote avoidance of test situations, whereas emotions such as anger may energize students to invest effort to improve their test scores. From this perspective, combining different negative emotions into a single composite may obscure their potentially divergent effects on learning and achievement. This interpretation is supported by previous research showing that specific negative emotions, such as anxiety, may act as mediators in the relation between motiva-

tional beliefs and achievement, whereas others, such as boredom, may not (e.g., Putwain et al., 2021).

Several limitations of the present study should be acknowledged. First, the study employed a cross-sectional design, which restricts conclusions about the directionality of the observed relationships among motivational beliefs, emotions, and mathematics achievement. Although prior achievement was controlled for, longitudinal designs are needed to more confidently examine the direction of relationships and causal processes linking motivation, emotions, and achievement.

A second limitation concerns the operationalization of emotions based on their valence. Combining negative emotions into a single composite may have obscured mediating relationships that could emerge when discrete emotions are examined separately. While this dimensional approach to emotions did not prevent the detection of mediation effects for positive emotions, it is important to note that the positive emotions assessed in this study were limited to activating emotions (e.g., enjoyment and enthusiasm; Pekrun, 2006, 2024). Deactivating positive emotions, such as relaxation or contentment, were not included, and therefore, the findings cannot be generalized to all positive emotional experiences. Moreover, emotions were assessed only as classroom-related experiences. Given that patterns of associations between task values and emotions seem to differ slightly across contexts (Peixoto et al., 2017; Goetz et al., 2012), future studies could further explore the mediating role of emotions experienced in other contexts, such as test situations or homework, in the relationship between motivational beliefs and achievement.

Finally, as a first attempt to examine EVT-based motivational beliefs, including expectancies and multiple value and cost dimensions in relation to achievement through emotions, the present study focused on the individual associations of each motivational component. Having identified these relations, future research could build more comprehensive models that simultaneously account for the relative contributions of multiple motivational beliefs.

Despite these limitations, the present study contributes to the still-limited body of research examining the role of emotions in linking cognitive appraisals and academic achievement (e.g., Putwain et al., 2021; Tze et al., 2023). The findings highlight the relevance of considering emotions not only as antecedents of motivational beliefs, but also as mediators in the relationship between motivational beliefs and achievement within the EVT framework. Importantly, the results underscore the need to account for perceived cost in such analyses, rather than focusing exclusively on positive value components, as has often been the case in prior research. In this context, treating cost as a multidimensional construct appears essential, as the present study demonstrates that ego cost relates to achievement through emotional processes in ways that differ from other cost dimensions. The ambiguous role of ego cost observed in the present findings underscores the need for further empirical work to better understand how different forms of cost shape students' emotional experiences and learning outcomes.

Author contributions

Dovilė Butkienė: conceptualization, data curation, investigation, methodology, writing – original draft, writing – review and editing.

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Gintautas Šilinskas: formal analysis, writing – review and editing.

Saulė Raižienė: conceptualization, data curation, funding acquisition, methodology, project administration, writing – original draft, writing – review and editing.

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