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The relationships between parental involvement, teacher support, and mathematics performance: mediating roles of academic self-efficacy and academic buoyancy

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Abstract

Background This study examined how parental involvement (PI) and perceived teacher support (TS) influence middle school students' mathematics performance (MP) through the mediating roles of academic self-efficacy (ASE) and academic buoyancy (AB). Unlike previous research, it simultaneously investigated these dual support systems and their indirect effects on math achievement, providing a comprehensive model that integrates both external support mechanisms with non-cognitive attributes affecting mathematics performance.

Methods Participants were 363 sixth-grade students (51% boys, 49% girls) from middle schools in Türkiye. Data were analyzed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method.

Results The results revealed that PI had a significant positive effect on both ASE and AB, as well as a direct positive effect on MP. Similarly, perceived TS positively influenced both ASE and AB, and had both direct and indirect positive effects on MP. Both ASE and AB mediated the effects of PI and TS on MP.

Conclusions This study reveals that students supported by teachers and parents tend to perform better in mathematics. This effect is related both directly and indirectly through increased ASE and AB. By identifying these dual pathways, the study deepens our understanding by providing important insights into the critical interaction between external supports and non-cognitive attributes in improving mathematics achievement.

Keywords Teacher support, Parental involvement, Academic self-efficacy, Academic buoyancy, Mathematics performance

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Introduction

The issue of enhancing students' mathematical performance (MP) remains a persistent challenge for both educators, policymakers, and parents alike. Despite sustained interest and efforts to improve students' MP, the recent PISA report indicated that between 2018 and 2022 the average performance in mathematics across OECD countries dropped by a record approximately 15 points [82]. Nevertheless, in the four weeks preceding the PISA assessment, an average of 7% of students across the OECD countries reported feeling unsafe in the classroom (Türkiye's average was 13%) and nearly 30% indicated being distracted by digital devices (Türkiye's average was 23%). Prior research has consistently shown that both safety concerns and digital distractions independently contribute to lower mathematics scores [64, 93]. These findings underscore that learning mathematics extends beyond cognitive challenges and involves a complex interplay of emotional, motivational, and social factors [85, 121].

Addressing these challenges in promoting and teaching mathematics learning requires a deeper understanding of how external supports, such as teacher support (TS) and parental involvement (PI) and non-cognitive attributes, including academic self-efficacy (ASE), and academic buoyancy (AB) interact. Non-cognitive factors encompass intrinsic motivations and behaviours that enable students to maximize their potential [12] and are strongly associated with long-term educational outcomes [28]. Empirical evidence indicates that PI positively relates to MP both directly and indirectly via ASE [48, 84, 111], while TS enhances engagement and achievement, primarily through its effects on ASE and behavioral engagement [57, 70, 107, 108]. In addition, previous research suggests that AB may further mediate these relationships, enabling students to cope with daily academic challenges and maintain performance under stress, with social support amplifying these effects [67]. However, most studies have examined these factors in isolation or focused on a single mediator, leaving a gap in understanding how TS and PI jointly interact with ASE and AB to influence middle school students' MP.

Understanding the combined effects of external factors and internal attributes through mediating mechanisms is particularly important for middle school students, a developmental stage marked by increasing academic pressures, more complex mathematical concepts, and heightened expectations from parents and teachers. At this stage, students are expected to engage with teachers, peers, and parents to develop mathematical concepts and skills collaboratively. Despite these expectations, research indicates that between 5 and 8% of school-age students demonstrate mathematical inadequacy, characterized by low ASE and poor AB [32]. Students with such difficulties

are likely to perform poorly in mathematics, which can hinder their acquisition of key skills and cause concern for families [80]. Previous studies have emphasized the importance of ASE and AB in mathematics achievement, but the effects of external support-related factors have been less studied. To address this empirical gap, the present study aims to examine the effects of PI and perceived TS on ASE and AB, their direct effects on MP, and whether ASE and AB serve as mediators in the relationship between these variables and MP. By simultaneously modeling these interactions, the study provides a more nuanced understanding of how external supports (TS and PI) and internal attributes (ASE and AB) jointly influence MP. This integrated approach not only advances theoretical knowledge but also offers practical insights for designing interventions that engage both teachers and parents to enhance students' MP.

Conceptual framework

Academic self-efficacy and mathematics performance

According to the SCT, both external social influences and self-regulatory attributes are crucial in motivating and controlling behaviour [7]. A key self-regulatory factor is self-efficacy, defined as a person's assessment of their capacity to plan and carry out the actions or tasks required to accomplish certain goals [6]. In educational settings, self-efficacy is often conceptualized as ASE [7, 94], which is defined as students' belief in their own ability to succeed in academic tasks [6, 120]. ASE refers to students' perseverance and determination towards their abilities in achieving academic achievement, as well as their beliefs about fulfilling certain academic tasks [6]. Moreover, it includes a person's belief in their ability and confidence when faced with academic challenges [113, 116]. Research shows that ASE significantly influences students' academic behaviours and outcomes. Students with higher ASE are more likely to set challenging goals and demonstrate resilience when facing academic difficulties [99, 119]. Across diverse content areas, stronger ASE has been consistently associated with improved academic performance, highlighting its pivotal role in enhancing achievement and test performance [11, 51, 92, 123]. In mathematics, ASE reflects students' belief in their ability to successfully complete mathematical tasks [108] and their confidence in addressing mathematical challenges [113]. Lera et al. [68] used a multilevel structural equation model and indicated that ASE predicts MP even at the class level, highlighting its role as a robust determinant of achievement. Despite extensive evidence of its direct effect, the mechanisms through which external supports, such as TS and PI, interact with ASE and AB to influence middle school students' MP remain underexplored. Addressing this gap, the present study

hypothesizes that higher ASE positively predicts middle school students' MP.

Academic buoyancy for mathematics performance

AB is the capacity of students' ability to effectively deal with daily academic challenges or difficulties such as low grades, difficult tasks, or classroom distractions [74]. This ability mitigates academic stress, but also fosters persistence, engagement, and a positive attitude towards learning, which is crucial for sustained academic achievement [73]. In mathematics, the curriculum's increasing abstraction and problem-solving demands pose unique challenges that can undermine students' motivation and performance. Students who face setbacks in mathematics, such as failing to solve complex problems or experiencing anxiety may experience decreased overall academic performance. The ability to overcome such mathematical challenges is referred to as academic buoyancy (AB). Strengthening AB in mathematics is crucial for overcoming unexpected challenges (e.g., anxiety, lack of motivation, and unstable academic development), all of which can negatively affect students' MP [4]. By encouraging students' interest and persistence in pursuing goals for the future, AB in mathematics aims to improve achievement and reduce mathematics-related anxiety. Previous studies showed that AB, particularly in mathematics, significantly predicts academic performance and achievement [20, 23] and this relationship is often mediated by ASE [102]. Moreover, recent findings also suggest that AB interacts with other mathematics related cognitive processes, such as number sense and mathematical metacognition among middle school students [2]. It also remains significant even when controlling for gender [67]. Overall, developing AB is crucial for enhancing students' motivation, engagement, and performance in school setting [18, 20] and the present study hypothesizes that students with greater AB are more likely to demonstrate improved MP.

Teacher support in mathematics performance

One important resource that significantly shapes students' academic performance develops is teacher supportive behaviours [59]. TS has been shown to enhance students' academic achievement [34], positively correlate with mathematics self-concept and reduce mathematics anxiety [110]. Research also indicates that TS directly influences three components of mathematics engagement: emotional, behavioural, and cognitive [70]. Positive teacher supportive behaviours not only boost students' autonomy in their mathematics abilities but also enhance their overall engagement, promoting improved academic outcomes [108]. Furthermore, close relationships with teachers positively predict school engagement, while conflictual relationships undermine it [26]. However,

some research suggests that the effects of TS may operate indirectly. For instance, Chang et al. [13] concluded that while TS enhances students' ASE, its influence on actual MP may be mediated by other ASE factors and varies across different demographic groups. Building on this evidence, the present study hypothesizes that TS directly and positively predicts middle school students' MP.

Parental involvement in students' mathematics performance

Given its multifaceted role in fostering students' academic outcomes, PI remains a critical area of investigation in educational research. It not only complements teacher efforts but also enhances academic engagement, and ASE among students, both of which are key predictors of MP [27, 49]. Ginsburg et al. [33] identified three types of PI in mathematics: (1) PI in completing homework assignments, (2) parent reengagement with mathematics learning, and (3) mathematics talks during mathematics activities. These practices directly contribute to students' academic progress by fostering a supportive learning environment at home [35, 49]. Previous research indicates that PI strengthens their children's interests and efforts and it is associated with increased positive academic outcomes, including higher academic achievement and better school attendance [56]. Recent experimental evidence also confirms that students who have received parental support tend to demonstrate higher MP than those who have not [1]. However, some research suggests that sustaining this positive effect requires consistent involvement and high-quality parent-child interactions [71, 81]. Moreover, not all kinds of involvement are positively related to academic achievements, and the effects may vary across different ethnicities [9]. Especially in mathematics education, PI can have both benefits and drawbacks, particularly when parents experience mathematics anxiety, which can inadvertently hinder students' learning [72, 83]. Building on these findings, the present study investigates the direct association between PI and MP. Furthermore, PI may also indirectly influence MP by enhancing non-cognitive factors such as students' AB and ASE, highlighting the importance of examining these constructs together within an integrated framework.

Mediating role of academic self-efficacy

In challenging subjects like mathematics, the notion of ASE is one of the strongest predictors of performance and school functionality [41]. According to Martin and Rimm-Kaufman's [76], students' self-efficacy has a direct effect on their mathematics learning process and significantly shapes their general academic achievement. ASE is not solely an individual characteristic, it is significantly influenced by the social support that students receive from their environment [6]. Among the various sources

of social support, parents and teachers represent the two most influential figures in shaping children's ASE, given their central roles in both home and school contexts. Parents who are actively involved in their children's studies foster greater engagement in the educational process. Such PI in children's education fosters positive outcomes, including academic achievement. Research indicates that PI serves as a key source of external support, enhancing students' ASE in mathematics [17]. As Fan & Williams [27] noted, parental support often begins early in a child's education, as parents are typically their first educators, shaping their aspirations and expectations [77]. This is because high-quality parent-child relationships foster positive educational outcomes, including enhanced self-efficacy and academic engagement [27]. Moreover, support from parents contributes to students' MP by motivating them to overcome challenges in mathematics and by promoting their autonomy.

Additionally, TS plays a crucial role in fostering students' ASE. When teachers provide structure by managing student-centred activities and provide positive feedback that improves students' self-efficacy perceptions, they positively influence their students' academic performance. Kim et al. [59] found that students who received more support from their teachers had a stronger sense of ASE, which in turn, led to improved overall achievement. Collie et al. [19] concluded that high-quality relationships with teachers and parents—characterised by positive interactions, fair treatment, and a sense of belonging—often result in students with high self-efficacy and greater academic engagement. ASE can serve as a mediator in the relationships between PI, TS, and MP. When parents and teachers are actively involved in mathematics learning, they provide essential support that enhances students' ASE, which in turn boosts students' confidence and motivation, ultimately leading to improved performance in mathematics. In conclusion, ASE may function as a non-cognitive mediator linking PI and TS to students' MP, emphasizing the importance of examining these external supports together.

Mediating role of academic buoyancy

Students who overcome minor academic difficulties and challenges with AB demonstrate school satisfaction and effective classroom behaviours [50]. Evidence from previous research suggests that AB contributes positively to students' performance in the classroom [23, 75, 115]. AB encourages students to adopt effective learning strategies [19] and supports both their emotional and behavioural engagement in school settings [22], self-regulation, and higher academic achievement [78]. AB is influenced by an individual's social environment, as environmental factors significantly affect students' thoughts and actions [74]. For students to cultivate AB, appropriate support

is essential. Supportive and structured guidance from teachers, along with active parental engagement, can strengthen students' capacity to cope with daily academic challenges [14, 52]. Hejazi and Abbasi [45] noted that students' AB can be enhanced when teachers guide them toward optimal personal goals and parents provide a supportive family environment. Building on this evidence, the present study hypothesizes that AB may function as a mediator linking PI and TS to students' MP, underscoring the value of examining the interplay between external supports and internal self-sources.

The current study

Previous research has highlighted the impact of non-cognitive attributes, such as ASE and AB on middle school students' MP [52, 66, 70]. Similarly, external attributes such as PI and TS have been shown to significantly influence students' mathematics outcomes [87, 95]. A review of 137 studies on children aged 6–16 years concluded that most of the indicators of PI are related to children's mathematical achievement, performance, and skills. In addition, a positive generalization about PI has the potential to erroneously hide negative aspects [29]. Moreover, the effect of PI can vary across ethnic and cultural groups [9]. Despite these findings, little attention has been given to exploring how these factors interact through mediating variables, particularly among middle-school students [102]. This gap is noteworthy, as AB and ASE are likely to play a particularly significant role in shaping MP during the middle school years for several developmental and contextual reasons. First, this period may be largely due to encountering formal examinations, which can create new academic pressures for the first time at the school, especially in Türkiye [8]. Second, middle school is characterized by a grading system that brings increased performance pressures, often accompanied by higher expectations from both parents and teachers [42]. Third, students begin to encounter increasingly complex and abstract mathematical concepts during these years [24, 32]. Finally, this period often coincides with developmental changes, including the transition to high school and adolescence [3]. These combined challenges can lead to declines in students' MP. Although cognitive factors have been the main focus of many studies in the existing literature, researchers emphasize the need to consider motivational, emotional and social factors alongside cognitive factors to gain a comprehensive understanding of mathematics achievement [88, 102, 122].

To address a notable gap in the literature, the present study investigates a multifaceted mediation model that examines how external factors (i.e., PI and perceived TS) are associated with middle school students' MP both directly and indirectly through the mediating roles of AB and ASE which function as internal attributes. By

modeling these associations simultaneously, the study captures the interrelations between external supports and non-cognitive attributes in relation to students' MP. Specifically, the contribution of the study is twofold: (1) it advances theoretical understanding by offering a more nuanced account of external factors and internal attributes jointly relate to MP in middle school, thereby enriching perspectives of students' learning process; and (2) it provides applied insights for future intervention research by delineating the roles of external support and non-cognitive attributes, thus informing the design of evidence-based and contextually responsive practices to strengthen students' mathematics learning and achievement.

Theoretical framework of the study

This study is grounded in Bandura's [5, 6] social cognitive theory (SCT), which highlights the role of ASE in students' motivation and achievement, and on Martin and Marsh's [74] concept of AB, which captures students' capacity to cope with everyday academic challenges. According to SCT, individuals' behaviors are influenced not only by non-cognitive factors but also by socio-demographic characteristics and the surrounding environment. In this framework, environmental factors may influence individual behaviours and performance not directly but through their effects on perceptions. Therefore, internal attributes can play a critical mediating role in the relationship between objective built environmental factors and behaviors of individuals.

Grounded in this theoretical framework and supported by related empirical findings, the conceptual model of this study was developed (see Fig. 1). In this model, perceived environmental support (e.g., parental, teacher support) may directly affect students' mathematics performance (MP). At the same time, it is assumed that parental involvement (PI) and perceived teacher support (TS) also create indirect effects on performance by strengthening students' perceptions of academic

self-efficacy (ASE) and academic buoyancy (AB). In other words, internal attributes such as self-efficacy and buoyancy are considered key mediators linking external support factors to mathematics achievement. Furthermore, the model suggests that there is a reciprocal feedback mechanism between environmental support and MP, indicating that students' performance levels may, in turn, reshape their perceptions of ASE.

The hypotheses

This study focuses specifically on the relationships between perceived TS, PI, and MP, with a particular emphasis on the mediating roles of ASE and AB. For this purpose, the following hypotheses (H) were formulated:

- H1. TS directly and positively predicts middle school students' MP.
- H2. PI directly and positively predicts middle school students' MP.
- H3. ASE positively predicts middle school students' MP.
- H4. AB positively predicts middle school students' MP.
- H5. ASE mediates the relationship between perceived TS and MP.
- H6. ASE mediates the relationship between PI and MP.
- H7. AB mediates the relationship between perceived TS and MP.
- H8. AB mediates the relationship between PI and MP.

Methods

Participants

This study employed a cross-sectional quantitative research design. A convenience sampling technique was used to select participants, as it enabled data collection from an easily accessible population and provided useful information to address the research questions and

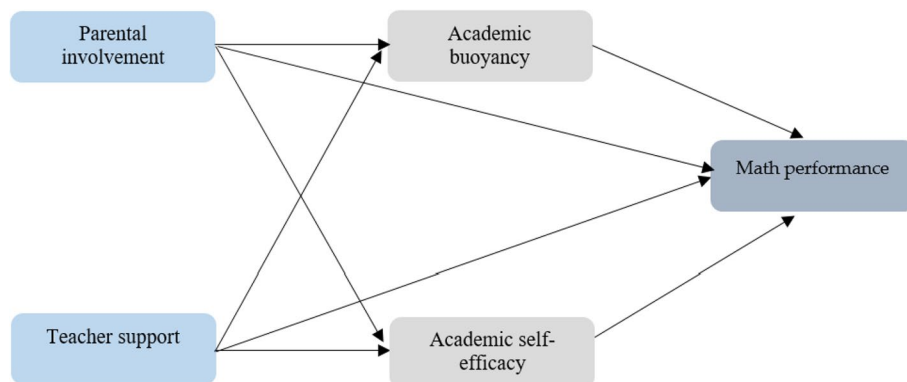


Fig. 1 Proposed model of study

hypotheses [79]. Although this non-probability method does not offer the same level of representativeness as probability-based techniques, it has been widely used in educational research due to its feasibility, reduced costs, and suitability for exploratory and hypothesis-testing studies [96]. To strengthen representativeness, participants were recruited from multiple middle schools located in a mid-sized city in Türkiye, ensuring that the sample reflected diverse school contexts rather than a single institution. Initially, 400 sixth-grade students were invited to participate; however, 37 questionnaires were excluded because they contained more than 20% missing responses, which was established as the threshold for insufficient data quality. After data cleaning, the final sample consisted of 363 students, including 185 boys (51.0%) and 178 girls (49.0%), with ages ranging from 11 to 12 years. Sixth-grade students were specifically selected because they participated in the national mathematics examination administered by the Turkish Ministry of National Education during the spring term of the 2023–2024 school year.

Measures

The measurement scales utilized in this study included the Interpersonal Behaviors Questionnaire, Academic Self-Efficacy Scale (ASES), Parental Involvement Scale (PIS), and Academic Buoyancy Scale (ABS). To ensure reliable and valid measures for assessing the relationships between ASE, AB, and PI, some measuring instruments were adapted to the Turkish language to better fit the context of the study. Therefore, ASES, PIS, and ABS were translated into Turkish by linguistic experts proficient in both Turkish and English, including a linguist specializing in Turkish. A rigorous back-translation procedure was then applied to verify accuracy and cultural appropriateness. Expert reviewers in translation and applied linguistics examined both the translated and back-translated versions, making necessary adjustments to ensure semantic, conceptual, and idiomatic equivalence.

The study authors subsequently analyzed the items for ambiguity and inconsistency, and an additional review by a Turkish language expert ensured compliance with Turkish linguistic structures. A pilot test with 50 middle school students was conducted to assess the clarity, cultural compatibility, and reliability of the items. Based on the feedback, revisions were made to align the items with Turkish cultural norms and to ensure accurate representation of the constructs. Following this, a preliminary study was carried out with 200 middle school students not included in the main sample to examine the psychometric properties of the finalized Turkish versions of the scales. Throughout the adaptation process, the procedures recommended by Borsa et al. [10] were followed to ensure cross-cultural equivalence. Reliability was

assessed using Cronbach's alpha and Composite reliability (CR), while construct validity was evaluated through factor loadings and average variance extracted (AVE). A detailed description of the study variables is presented below.

Interpersonal behaviours questionnaire

Originally developed by Rocchi et al. [90] and translated into Turkish by İlter [54], this questionnaire measures participants' perceptions of teacher supportive behaviours. The scale consists of three subscales—competence support, autonomy support, and relatedness support—with a total of 12 items. Responses were rated on a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). Higher scores indicate greater perceived TS. Sample items include: (1) "My mathematics teacher gives me the freedom to make my own choices." (2) "My mathematics teacher supports me in developing my skills." The scale demonstrated high consistency in this study, with a Cronbach's alpha of 0.93.

Academic self-efficacy scale

Originally developed by Lee et al. [65], the scale was adapted from the self-efficacy dimension of the Motivational Strategies for Learning Questionnaire and consists of nine items. For the purposes of this study, the items were specifically adapted to the mathematics context. Sample items include: (1) "Compared to other students in this class, I think I know more about mathematics topics," and (2) "Compared to other students in this class, I think I am a good student in mathematics." Items were rated on a 5-point Likert scale (1 = not at all true for me, 5 = very true for me), with higher scores indicating greater ASE in mathematics. In this study, confirmatory factor analysis (CFA) conducted with AMOS 22.0 for the ASES-Turkish version supported a one-factor model comprising six items, demonstrating acceptable construct validity. The model yielded the following goodness of fit indices: $\chi^2/df=2.408$, GFI=0.96, TLI=0.95, CFI=0.96 and RMSEA=0.064. Factor loadings of all items ranged between 0.48 and 0.82. Further reliability analyses yielded a Cronbach's alpha of 0.87, AVE of 0.58, and a CR of 0.84 for the scale, demonstrating satisfactory internal consistency and construct reliability [38].

Parental involvement scale

Originally developed by Cheung and Pomerantz [17], was used to measure students' perceptions of their parents' involvement in mathematics learning. The scale is unidimensional and consistent of ten items, covering a range of PI practices in mathematics. For this study, some of the original items were adapted to reflect mathematics-related activities and mathematics learning. Sample items include: (1) "My parents are in contact with my

mathematics teacher at school” and (2) “My parents buy extra mathematics workbooks or supplementary materials for me.” Students responded on a 5-point Likert scale ranging from 1 (not at all true) to 5 (very true). High scores indicate higher perceived PI in students’ mathematics learning. For PIS-Turkish version, CFA was performed to evaluate the goodness-of-fit of the model, yielding good indices ($\chi^2/df=2.67$, RMSEA=0.048, GFI=0.95, CFI=0.96 and TLI=0.94). Factor loadings for the items ranged from 0.62 to 0.74. The Cronbach’s alpha for this scale was 0.89, and AVE and CR values were 0.56 and 0.82, respectively.

Academic buoyancy scale

Originally developed by Martin and Marsh [74], was used to measure participants’ AB in mathematics. The scale consists of 4 items, rated on a 5-point Likert scale (1=strongly disagree, 5=strongly agree). Sample items include (1) “I am good at dealing with setbacks in math class (e.g., poor grades, negative feedback, getting a question wrong), (2) “I don’t let a bad grade in math affect my self-confidence.” For this study, the original items were adapted into Turkish by the researchers to reflect mathematics learning. The four items evaluate students’ ability to cope with setbacks, challenges, and stress related to mathematics. Higher scores indicate greater AB in mathematics. CFA results for the ABS-Turkish version showed a good fit ($\chi^2/df=3.71$, RMSEA=0.061, GFI=0.93, CFI=0.94 and, TLI=0.93). Factor loadings for each item were all above 0.40, with items loading strongly onto their respective factors. Reliability analysis yielded a Cronbach’s alpha of 0.91 for the ABS-Turkish version. Additionally, the AVE was 0.57, and the CR was 0.83, supporting the scale’s convergent validity and internal consistency.

Mathematics performance

MP was measured using students’ scores from the standardized national common mathematics exam administered by the Turkish Ministry of National Education during the 2023–2024 school year. Exam scores were collected from participants’ official school records concurrent with survey administration. Participants’ mathematics exam scores ranged from 8 to 100 ($M=68.55$, $SD=26.03$). A higher exam score indicates higher levels of mathematics achievement. Previous research has shown that standardized mathematics test scores provide a reliable indicator of students’ MP [108].

Data collection

Ethical approval for this study was obtained from the Social and Human Sciences Ethics Committee (Protocol number: E-97105791–050.04–57875). Following ethical approval, as the participants were middle

school students, parental or legal guardian consent was required. A “Parental Consent Form” was used to obtain this permission, which included information about the study’s purpose, voluntary participation, the possibility of withdrawal at any time, and assurance that withdrawal would incur no consequences. Students are asked to submit the consent form to the school administration within two days of receiving it. Parents who approved their child’s participation provided their full name, date, and signature on the designated section of the form. Students who did not bring the parental consent form or whose form was not approved were not included in the study. Data collection took place on March 28 and April 30, 2024, in classrooms designated by school administrators, during times when students were available. During survey administration, the second author clarified that the instruments were not mathematics tests or exams, emphasized that there were no right or wrong answers, and assured students that their responses would not affect their mathematics course grades. Participants were encouraged to respond honestly and were informed that their responses would remain confidential, would only be used by the researchers, and would be analyzed collectively. It was also explicitly stated that their teachers would not have access to individual responses. The data-collection instruments were anonymous and did not contain any information that could identify a participant. Surveys were completed in approximately 30 min.

Data analysis

Descriptive statistics and Pearson correlations were computed using SPSS 22.0. Confirmatory factor analysis (CFA) was performed to verify the factorial structures of the instruments. The hypothesized model was tested using SmartPLS 3.0 with the partial least squares structural equation modeling (PLS-SEM) approach. PLS-SEM is particularly suited for analysing complex models with relatively small sample sizes and is less restrictive regarding data normality assumptions [39, 89]. The PLS-SEM procedure follows a two-step process [47]. First, the measurement model is evaluated to assess the reliability and validity of the constructs, and second, the structural model is examined to determine support for the hypothesized relationships.

The validity and reliability of the measurement model were evaluated by examining outer loadings, CR, CA, and AVE coefficients. The results confirmed that the measurement model was reliable and valid, as indicated by Composite Reliability (CR) and Cronbach’s alpha (CA) values exceeding 0.7 and Average Variance Extracted (AVE) values higher than 0.5 [38]. Structural equation modeling (SEM) was used to investigate the direct effects of PI and TS on MP as well as the indirect effects through ASE and AB. To examine the hypothesized indirect effect

of mediating variables, bias-corrected bootstrap analysis with a 95% confidence interval using 5000 bootstrap resamples was used. The absence of zero between the lower and upper limits of the 95% CIs was interpreted as indicative of the statistical significance of the observed effects [43]. Gender and age were included as covariates in the proposed model for the hypotheses analyses. To test the normality of the data, skewness and kurtosis coefficients were examined [97]. A significance level of $p < 0.05$ was accepted statistically significant.

Results

Descriptive statistics and correlation analysis

Table 1 presents the descriptive statistics (means and standard deviations), skewness, kurtosis, and bivariate correlations among all the study variables. The results showed that perceived TS was significantly and positively correlated with ASE ($r = 0.457, p < 0.001$), AB ($r = 0.382, p < 0.001$), and MP ($r = 0.402, p < 0.001$). Similarly, PI was positively associated with ASE ($r = 0.448, p < 0.001$), AB ($r = 0.349, p < 0.001$), and MP ($r = 0.332, p < 0.001$). Furthermore, both ASE ($r = 0.570, p < 0.001$) and AB ($r = 0.554, p < 0.001$) showed significant and positive correlations with MP. Finally, there was a positive correlation between PI and TS ($r = 0.359, p < 0.001$). Regarding data distribution, skewness values ranged from -0.737 to 0.912 , kurtosis values ranged from -1.576 to 0.79 , indicating that the data for the main variables met the assumption of normal distribution within acceptable limits (± 2) for parametric analyses [97].

Measurement model

The measurement model (Table 2) was tested to verify the appropriateness of the proposed framework. To validate the model, reliability indices—including Cronbach’s alpha (CA), composite reliability (CR), and rho_A—were assessed alongside measures of convergent and discriminant validity. Factor loadings were examined to determine item-level reliability and validity. Convergent

validity was assessed using the average variance extracted (AVE), with a threshold of 0.50 or higher. Discriminant validity was assessed using both the Heterotrait-Monotrait ratio (HTMT) and the Fornell-Larcker criterion [91]. Factor loadings of 0.70 or higher and AVE values above 0.50 indicate an acceptable level of convergent validity [39].

As shown in Table 2, an initial analysis was conducted to identify any items that had factor loadings below the threshold of 0.70. All factor loadings within the measurement model were above 0.70, ranging from 0.709 to 0.833. The CA values ranged from 0.786 to 0.831, while the CR ranged from 0.785 to 0.855. Both CA and CR coefficients surpassed the recommended threshold of 0.70, indicating robust reliability for all latent constructs [39] and demonstrating good internal consistency. The AVE for all constructs ranged from 0.547 to 0.601, providing evidence of convergent validity for all constructs [40]. Overall, these results demonstrate that the measurement model satisfied the established reliability and validity criteria.

To assess the reliability of the constructs, rho_A values were examined. As seen in Table 2, the rho_A values ranged from 0.823 to 0.932, exceeding the 0.70 threshold and indicating reliable constructs [38]. For discriminant validity, the HTMT values for all constructs ranged from 0.403 to 0.736, remaining well below the recommended threshold of 0.85 [46].

Furthermore, discriminant validity was evaluated using the Fornell–Larcker criterion [25]. According to Fornell and Larcker [30], the square root of the average variance extracted (AVE) for each latent construct should exceed its highest correlation with any other construct in the model. As shown in Table 3, the square root of AVE values (ranging from 0.740 to 0.812) was greater than the correlations with all other constructs, thereby satisfying the Fornell–Larcker criterion. These results provide additional support for the discriminant validity of the measurement model.

Difference analysis

Differences in mathematics learning and performance between boys and girls have been widely documented in the literature (Jacobs et al., 2004). Previous research suggests that students’ gender may influence ASE and AB in mathematics achievement, making these variables relevant to the present study [53, 74, 102, 109, 114, 117]. Jacobs and Bleeker [55] argued that children’s interests in mathematics and reading vary by gender, therefore, gender was included in the proposed model as a covariate. Age was also controlled, as evidence shows that children’s interest in mathematics and reading tends to decline with age [31]. To examine group differences, independent-samples t tests and one-way ANOVA were conducted.

Table 1 Descriptive statistics and correlations between the study variables

	1	2	3	4	5
1. TS		0.359**	0.457**	0.382**	0.402**
2. PI			0.448**	0.349**	0.332**
3. ASE				0.570**	0.554**
4. AB					0.484**
5. MP					
M	5.13	3.53	3.58	3.35	68.55
SD	1.45	0.768	0.823	0.813	26.03
Skewness	-0.737	-0.325	-0.481	-0.338	0.912
Kurtosis	-1.284	-1.176	-1.576	-0.876	0.795

Abbreviations: TS Teacher support, PI Parental involvement, ASE Academic self-efficacy, AB Academic buoyancy, MP Mathematics performance

** $p < 0.001$

Table 2 Outer loadings, internal consistency and average variance extracted

Constructs	Items	Loadings	rho_A	CA	CR	AVE
Academic buoyancy (AB)	AB1	0.723	0.823	0.787	0.785	0.551
	AB2	0.759				
	AB3	0.745				
	AB4	0.728				
Teacher Support (TS)	TS1	0.734	0.832	0.789	0.823	0.601
	TS2	0.789				
	TS3	0.712				
	TS4	0.778				
	TS5	0.796				
	TS6	0.709				
	TS7	0.733				
	TS8	0.745				
	TS9	0.751				
	TS10	0.833				
	TS11	0.744				
	TS12	0.777				
Academic self-efficacy (ASE)	ASE1	0.708	0.886	0.786	0.855	0.578
	ASE2	0.765				
	ASE3	0.807				
	ASE4	0.711				
	ASE5	0.745				
	ASE6	0.766				
	ASE7	0.823				
	ASE8	0.755				
	ASE9	0.788				
Parental involvement (PI)	PI1	0.724	0.932	0.831	0.804	0.547
	PI2	0.745				
	PI3	0.767				
	PI4	0.786				
	PI5	0.790				
	PI6	0.733				
	PI7	0.790				
	PI8	0.821				
	PI9	0.713				
	PI10	0.747				

Table 3 Discriminant validity (Fornell–Larcker criterion and heterotrait–monotrait ratio)

	AB	ASE	MP	PI	TS
AB	0.743				
ASE	0.461	0.760			
MP	0.406	0.493	0.812		
PI	0.487	0.509	0.491	0.740	
TS	0.437	0.480	0.454	0.456	0.775

The square roots of the AVE are bolded and oriented diagonally

Abbreviations: TS Teacher support, PI Parental involvement, ASE Academic self-efficacy, AB Academic buoyancy, MP Mathematics performance

Results revealed no significant difference in MP by gender ($t=0.776, p>0.05$). However, significant gender differences emerged for ASE ($t=2.501, p<0.001$) and AB ($t=3.069, p<0.001$). One-way ANOVA across age groups showed no significant differences in the main study

variables ($F=1.73, p>0.05$). Based on these results, and in line with prior literature, both gender and age were incorporated as control variables in the proposed model to enhance explanatory power and account for potential confounding effects.

Common method bias

Common method bias (CMB) refers to artificial differences between variables caused by the same subjects or data sources, measurement context, project context, or project characteristics [100]. In this study, since all data were collected through self-report measures from participants at the same time, the following analyses were conducted to minimize the potential impact of common method bias on the research findings [60]. Harman’s single-factor test was conducted by subjecting all measurement items to an unrotated exploratory factor analysis.

The results yielded seven factors with eigenvalues greater than 1, with the first factor accounting for 38.45% of the total variance. As this percentage is well below the 50% threshold, CMB was not considered a significant threat to the validity of the proposed model.

Structural model

After confirming the validity and reliability of the measurement model, the structural model was evaluated. A multicollinearity test was conducted to determine whether there was multicollinearity in the proposed model. According to the general rule, variance inflation factor (VIF) values below the critical threshold of 3.3 for all variables indicate the absence of multicollinearity [40]. The analysis revealed that the VIF values ranged between 1.256 and 2.411 for all variables, indicating no multicollinearity issue [38]. In PLS-SEM, the R-square value shows the amount of variance explained, and a higher value indicates a better fit. R² values range between 0 and 1 and are used to measure predictive accuracy; 0.750 is considered substantial, 0.500 moderate, and 0.250 weak [37]. In this study, the R² value of the structural model was found to be 0.533, which indicates a moderate level of fit.

Hypotheses testing results

Hypothesis testing was performed in SmartPLS 3.0 to examine the mediating roles of ASE and AB in the relationships between perceived TS, PI, and MP. In the model, TS and PI were specified as independent variables, ASE and AB as mediators, and MP as the dependent variable. The magnitude and significance of the path coefficients were assessed using the PLS 5,000 bootstrap resamples. Following the evaluation of the measurement model, the PLS algorithm was applied to test the hypothesized structural model. As shown in Table 4, the path coefficients (β values) supported the proposed hypotheses. Analysis of the control variables (gender and age) indicated no statistically significant effects (p > 0.05). For clarity, gender and age were controlled for but not

displayed in the structural model. The results of the hypothesis testing are summarized in Table 4.

Direct effects

After controlling for gender and age, the analysis revealed the results showed that both perceived TS (β = 0.151, p < 0.001) and PI (β = 0.093, p < 0.04) had positive and significant direct effects on MP, thereby supporting hypotheses H1 and H2. Moreover, TS significantly and positively predicted both ASE (β = 0.333, p < 0.001) and AB (β = 0.324, p < 0.001), while PI also significantly predicted ASE (β = 0.380, p < 0.001) and AB (β = 0.294, p < 0.000). Both ASE (β = 0.252, p < 0.001) and AB (β = 0.334, p < 0.000) had significant positive effects on MP, providing support for hypotheses H3 and H4.

Indirect effects

The mediation analysis further examined how ASE and AB mediated the relationships between PI, TS, and MP. The results of the bootstrap analysis (see Table 4) indicated that ASE served as a significant mediator in the relationship between TS and MP (β = 0.084, p < 0.000), as well as between PI and MP (β = 0.096, p < 0.001), thereby supporting hypotheses H5 and H6. Moreover, AB significantly mediated the relationship between TS and MP (β = 0.108, p < 0.000), and between PI and MP (β = 0.098, p < 0.000), confirming hypotheses H7 and H8. These findings indicate that both ASE and the AB served a partial mediating role in these pathways.

Overall, the model demonstrated that TS and PI have a positive effect on MP not only through direct pathways but also indirectly through the mediating roles of ASE and AB. These findings suggest that TS and PI significantly enhance MP, and that both ASE and AB play substantial roles in strengthening this relationship. Figure 2 presents the proposed model, displaying the estimated standardized path coefficients, indicator loadings, and statistical significance levels.

Table 4 Hypotheses test results

Relationships	Original sample	Sample mean	t-value	p	Decision
Direct effect					
H1 TS → MP	0.151	0.152	3.342	0.001	Supported
H2 PI → MP	0.093	0.096	2.059	0.040	Supported
H3 ASE → MP	0.252	0.252	4.067	0.000	Supported
H4 AB → MP	0.334	0.332	5.975	0.000	Supported
Indirect effect					
H5 TS → ASE → MP	0.084	0.022	3.853	0.000	Supported
H6 PI → ASE → MP	0.096	0.098	3.498	0.001	Supported
H7 TS → AB → MP	0.108	0.107	4.790	0.000	Supported
H8 PI → AB → MP	0.098	0.100	3.723	0.000	Supported

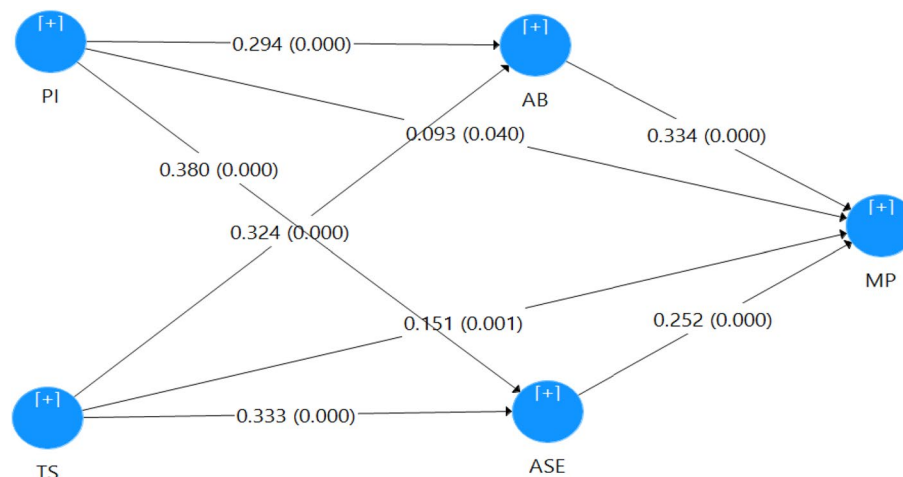


Fig. 2 Hypothesized model results. Abbreviations: TS– Teacher support, PI – Parental involvement, ASE – Academic self-efficacy , AB – Academic buoyancy, MP – Mathematics performance

Discussion

The present study aimed to investigate the associations between perceived teacher support (TS) and parental involvement (PI) on mathematics performance (MP), both directly and indirectly through academic self-efficacy (ASE), and academic buoyancy (AB) among middle school students.

Prior research has consistently emphasized the central role of supportive teacher-student relationships in fostering students' academic engagement and achievement, particularly in challenging subjects such as mathematics [16, 104]. Middle school students, who face increasing academic pressure and a more abstract mathematics curriculum, may particularly benefit from emotionally responsive and academically supportive teachers [107]. Consistent with this literature, the present study found that perceived TS directly predicted students' MP. This suggests that students who perceive their teachers as supporting autonomy, competence, and emotional well-being tend to perform and achieve better outcomes in mathematics [57, 112]. Beyond this direct effect, TS also indirectly predicted MP via both ASE and AB, suggesting TS not only contributes to students' MP by offering instructional support, but also by enhancing their ASE in mathematics—that is, their belief in their ability to succeed in mathematics—and by fostering their AB, or their capacity to recover from routine academic setbacks encountered in mathematics learning. This aligns with Bandura's [6] socio-cognitive perspective, which posits that supportive social contexts enhance students' motivational beliefs and academic performance. Specifically, students who receive more social support from their teachers are more likely to acquire mathematical knowledge, build self-confidence, develop an interest in mathematics [106], form positive evaluations of the value of mathematics [86]. Such support also helps students

perceive mistakes as learning opportunities rather than as sources of judgment, thereby reducing mathematics anxiety. TS thus not only motivates students to engage with learning but also increases their self-efficacy beliefs [70], which in turn reduces setbacks or challenges encountered in mathematics learning [69]. These findings indicate that TS serves as a dual mechanism, encompassing both the instructional quality provided by teachers and relational and motivational support that foster students' ASE and AB, which in turn contribute positively to their MP.

The present study extends existing literature on the role of PI on students' MP. Active PI is associated with improved children's learning and classroom performance [56]. A recent meta-analysis also confirmed the significantly positive influence of PI on students' MP [101]. When parents actively engage in their children's learning processes, students are more likely to achieve higher levels of achievement in mathematics [29]. At the middle-school level, where the mathematics curriculum becomes increasingly abstract and includes more specialized topics requiring advanced reasoning and problem-solving skills, PI may provide students with the emotional support and structured guidance needed to persist through academic challenges. Consistent with this body of research, the present findings revealed that PI not only directly supports students' MP but also has an indirect effect on MP through its positive associations with ASE and AB. Several studies indicate that higher levels of PI enhance students' ASE, which in turn contributes to improved academic performance [103, 111]. Similarly, encouraging active and supportive PI can significantly enhance AB, which fosters students' ability to cope with everyday academic setbacks and challenges and thus support their MP [14]. Parents who demonstrate consistent involvement in their children's education may reinforce students'

confidence in their academic capabilities and promote a resilient attitude toward learning challenges [36, 81]. In this context, PI can serve as an external resource that creates a positive impact on students' MP by increasing their self-efficacy beliefs in mathematics and helping them cope with math anxiety or typical difficulties. Because emotional and autonomy support from parents can create an environment that enables them to guide students to pursue mathematical challenges, take risks, and strive for learning and performance with increased self-confidence, ultimately increasing mathematics achievement [83]. These findings underscore the multifaceted role of PI in supporting MP, both directly and through ASE and AB, and suggest that fostering meaningful and sustained PI may therefore be an effective strategy for increasing students' ASE and AB in mathematics. Importantly, this support must be perceived by students themselves, as their sense of being supported plays a critical role in the development of ASE and AB.

PI and TS in students' learning processes, as well as children's reactions to these processes, are shaped within cultural contexts [44, 98]. In the Turkish context, traditional cultural values emphasise interconnectedness [58]. Parents develop strong emotional bonds with their children, while teachers also cultivate close relationships with their students, often perceiving them as their own children [61]. Both parents and teachers demonstrate a deep concern for children's success and well-being, thereby fostering participation and support that contribute to enhanced student achievement. Nevertheless, evidence from studies [16, 101] and the present study indicates that PI and TS positively influence students' MP irrespective of cultural background. Thus, the evidence points to a culturally independent and universally valid association between PI, TS, and students' MP.

As with external factors, the present study also highlights the internal attributes including ASE and AB, in relation to middle school students' MP, revealing both significant direct and mediated effects. This finding aligns with established theoretical perspectives. Students with higher ASE, characterized by strong confidence in their ability and effort to succeed, tend to achieve better MP, consistent with Bandura's [6] assertion that self-efficacy is a key determinant of academic success. Similarly, students with higher AB are better able to cope with everyday academic setbacks, pressures, and daily challenges and tend to maintain engagement and persistence, leading to improved performance in demanding subjects such as mathematics and science [20, 62, 74, 102]. Children's developmental trajectories are influenced by recurrent interactions with key figures in their immediate environment, such as parents and teachers. [118]. Students can alleviate the emotional stress they may experience in coping with uncertainty through emotional support

from their parents [105]. When children receive effective parental academic involvement, the high expectations of parents help students sustain their mathematics self-efficacy and prevent them from avoiding challenges when encountering difficulties in mathematics [63]. Moreover, by increasing the likelihood that students perceive themselves as competent in the subject, PI contributes to the development of a stronger mathematical identity [21]. Such support enables students to recover from setbacks and to adjust their cognitive and behavioral capacities in order to better adapt to unforeseen challenges or changes in their mathematics learning [15]. Likewise, students with low mathematics achievement tend to experience higher levels of mathematics anxiety, exhibit lower ASE and classroom participation, and perceive less support from their mathematics teachers. Moreover, the interaction between contextual factors (e.g., PI or TS) and personal factors (e.g., ASE and mathematics anxiety) significantly shapes the classroom engagement of these students. Owing to their weak academic performance, they frequently receive limited attention from teachers during the learning process, which increases their susceptibility to negative emotions such as learned helplessness and anxiety. Insufficient TS further exacerbates their learning difficulties relative to peers and fosters avoidance of mathematics-related learning situations [118]. The literature consistently underscores that TS assumes a critical and transformative role in the learning trajectories of students with low academic achievement, with the quality of this support emerging as a decisive determinant of MP. Beyond their direct contributions, both ASE and AB served as mediators between external support (TS and PI) and students' MP. This suggests that supportive environments foster students' confidence in their academic abilities and their buoyancy in everyday academic challenges. When students perceive encouragement and involvement from teachers and parents, they are more likely to believe in their capabilities and persist through academic difficulties. Thus, ASE and AB function as a key psychological mechanism, which translates external support into sustained engagement and improved academic performance in mathematics.

Theoretical implications

The present study provides several theoretical insights regarding the factors influencing middle school students' MP. First, it highlights the dynamic interplay between internal attributes (e.g., ASE and AB) and external factors (e.g., PI and TS), emphasizing that students' achievement cannot be fully understood without considering how these dimensions mutually influence each other. Second, the findings underscore the significance of repeated interactions with key figures in students' immediate environment, demonstrating that both PI and TS

serve as critical mechanisms for fostering ASE and AB. Third, the study draws attention to the vulnerabilities of low-achieving students, who tend to perceive lower levels of TS and exhibit diminished academic engagement and self-efficacy, suggesting that theoretical models of student achievement should account for the differential effects of environmental support based on performance levels. Overall, these insights contribute to a more comprehensive understanding of the mechanisms underlying students' mathematics learning, reinforcing the importance of integrating both intrinsic motivational processes and external supportive factors within theoretical frameworks.

Practical implications

This study offers practical insights for teachers and parents aiming to improve middle school students' MP. Teachers are encouraged to provide opportunities for student decision-making, support their choices, and show genuine interest, as these practices can positively strengthen students' perceptions of TS and boost their performance. Additionally, parents can enhance their involvement by maintaining regular communication with mathematics teachers to monitor their children's progress and engage in meaningful conversations with them about math-related challenges and achievements. Supporting students' self-efficacy and AB in mathematics is essential, as these internal resources play a critical role in enhancing students' learning experiences and enabling them to overcome the difficulties inherent in challenging subjects such as mathematics. Feeling supported in coping with such challenges can motivate students to persist and succeed in mathematics and increase their success. Ultimately, coordinated efforts between parents and teachers—characterized by consistent encouragement, targeted support, and open communication—can foster students' AB, strengthen their self-efficacy, and improve their overall MP.

Limitations and future research implications

This study has some limitations. First, our understanding regarding students' parental involvement and perceptions about their teachers' support is based solely on their self-reported. This may not fully capture the extent of support provided by parents and teachers. Future studies may incorporate multi-sources approaches, including data collected from parents, teachers, and direct observations, to provide a more comprehensive understanding. Second, the sample size was relatively small and drawn from a single urban region Türkiye. Findings may not be generalizable to broader, more diverse populations. Future research should include larger and more diverse samples to improve the external validity. Third, the use of a cross-sectional design restricts the ability to establish causal

relationships among the variables. Longitudinal designs are recommended to explore how these relationships evolve and influence MP over time. Finally, although the reliability and validity of the measures used were supported, there is a possibility that the responses were influenced by social desirability bias. Future research should benefit from using multiple data sources and qualitative methods (e.g., interviews, observations) in addition to quantitative surveys, providing more in-depth insights.

Conclusions

This study contributes to our understanding of the complex relationships between performance in mathematics and their perceived contextual factors and non-cognitive attributes among middle school students. Findings indicate that TS and PI are positively associated with MP, both directly and indirectly, through ASE and AB. The findings also show that students who receive more support from their teachers and parents in their mathematics learning have increased levels of ASE and AB. This combined effect leads to significant increases in MP. The study sheds light on the interaction between internal and external factors affecting MP. Taken together, these findings provide evidence for the importance of considering external support mechanisms, such as PI alongside TS, ASE, and AB in relation to MP. Overall, the study emphasizes the necessity of comprehensively addressing both contextual support and intrinsic motivational and psychological resources in mathematics education, and reveals how these factors interact dynamically to shape performance in mathematics courses. In conclusion, this study not only provides important methodological insights for researchers examining MP and serves as a guide for educators developing practices to improve middle school students' mathematics achievement.

Abbreviations

TS	Teacher Support
PI	Parental Involvement
ASE	Academic Self-Efficacy
AB	Academic Buoyancy
MP	Mathematics Performance
PLS	Partial Least Squares
SEM	Structural Equation Modelling
OECD	Organisation for Economic Co-Operation and Development
ASES	Academic Self-Efficacy Scale
PIS	Parental Involvement Scale
ABS	Academic Buoyancy Scale
PLS-SEM	Partial Least Squares Structural Equation Modelling
CR	Composite Reliability
AVE	Average Variance Extracted
HTMT	Heterotrait-Monotrait Ratio
VIF	Variance Inflation Factor

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Authors' contributions

İİ, NCA, and MC: Writing, Review & Editing. İİ: Resources, conceptualization, methodology, investigation, visualization and analysis. NCA: Resources,

conceptualization, data collection, investigation, MC: Writing- original draft preparation, conceptualization. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in Türkiye with the participation of middle school students. Ethical approval was obtained from the Ethics Committee of Hasan Kalyoncu University (Approval No: E-97105791–050.04–57875). All legal and ethical requirements were fulfilled, and written informed consent was obtained from parents or legal guardians in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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