

Promoting Academic Interaction: The Role of Classroom Social Environment in Predicting Student Engagement in Upper Elementary Mathematics

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Abstract. Student engagement plays a crucial role in fostering meaningful mathematics learning in elementary school and is strongly influenced by the classroom's social environment. However, limited research has examined how classroom social environments predict student engagement in upper elementary mathematics learning and whether this relationship differs by gender. This study aimed to examine the predictive role of the classroom social environment in student engagement in mathematics learning among upper elementary students. A quantitative ex post facto design was employed involving 316 students in Grades IV-VI. Data were collected using validated and reliable Guttman-scale instruments measuring classroom social environment and student engagement in mathematics learning. A normality test with Kolmogorov Smirnov Test indicated that the data were not normally distributed, therefore, nonparametric statistical analyses were applied, including Spearman rank correlation, coefficients of determination, and Mann-Whitney U tests. The results showed a positive and significant relationship between classroom social environment and student engagement in mathematics learning, explaining 24.01% of the variance in engagement, which falls within the moderate category. Female students reported higher perceptions of classroom social environment and engagement, whereas the predictive contribution of the classroom social environment to student engagement in mathematics learning was stronger among male students. Among the dimensions of the classroom social environment, promoting academic interaction emerged as the strongest predictor. These findings highlight the importance of supportive and interactive classroom environments in strengthening engagement in elementary mathematics learning.

Keywords: Classroom Social Environment; Elementary School; Gender; Mathematics Learning; Student Engagement.

1. Introduction

Student engagement has been widely recognized as a key construct in educational research, as it functions as a primary mechanism linking learning experiences to academic outcomes (Li & Xue, 2023; Maamin et al., 2022; Qudwatullathifah et al., 2025; Wong et al., 2024; Xu et al., 2023). Student engagement reflects the extent to which students are actively involved in the learning process through behavioral, cognitive, emotional, agentic, and social dimensions (Kulik, 2023; Riana Bagaskorowati et al., 2023; Sen, 2022; Xu et al., 2023). High levels of engagement are associated with deeper conceptual understanding, learning persistence, and positive attitudes toward learning, whereas low engagement is often linked to passivity, learning difficulties, and lower academic achievement.

In the context of mathematics learning, student engagement becomes increasingly important due to the nature of mathematics, which requires higher-order cognitive activity, persistence, and the willingness to express ideas and problem-solving strategies (Agbata et al., 2024; Salami & Spangenberg, 2025). Meaningful mathematics learning depends not only on conceptual mastery but also on the extent to which students actively participate in discussion, idea exploration, and reflection on their thinking processes (Koskinen & Pitkäniemi, 2022). Low levels

of student engagement in mathematics learning are frequently associated with mathematics anxiety, negative attitudes toward mathematics, and reduced continuity of learning interest at subsequent educational levels (Li & Xue, 2023; Salami & Spangenberg, 2025; Wong et al., 2024).

Student engagement is not formed solely at the individual level but is shaped through interactions between student characteristics and the learning context (Ghbari et al., 2024; Li & Xue, 2023b; Martins et al., 2022). One of the learning contexts most closely related to students' daily learning experiences is the classroom social environment (Gutierrez Jr. & Doronio, 2024; Martins et al., 2022). The classroom social environment encompasses the quality of teacher-student interactions and peer relationships, including social and emotional support, as well as the classroom climate established through norms and instructional practices (Aroh et al., 2025; Gutierrez Jr. & Doronio, 2024). A supportive and inclusive classroom social environment enables students to feel psychologically safe to participate, express ideas, and learn from mistakes, thereby strengthening student engagement in learning, including mathematics learning (Gutierrez Jr. & Doronio, 2024; Hanaysha et al., 2023; Liang et al., 2025; Niu et al., 2022).

1.1. Problem Statement

Based on preliminary classroom observations conducted prior to this study during mathematics lessons in upper elementary classes at an elementary school in the Ngluwar sub-district, variations in student engagement appeared to be related to the dynamics of the classroom social environment. Students demonstrate greater willingness to answer questions when teachers provide explicit support or trust, such as through positive greetings or verbal encouragement that creates opportunities to try. In contrast, differences in student attitudes emerge when peer responses are negative, such as laughter or comments following incorrect answers, which can make students feel embarrassed and afraid. During group discussion activities, students appear more active when they receive support from teachers and group members, whereas engagement decreases when social support is limited, with some students choosing to remain silent or delegate tasks to other members. In addition, the learning atmosphere also varies according to teachers' emotional conditions. When teachers appear cheerful and enthusiastic, students tend to be more focused and actively participate. Conversely, when teachers seem tired or less motivated, the classroom atmosphere becomes more passive and students are less responsive.

Previous studies have consistently highlighted the importance of the classroom social environment in shaping student engagement. Supportive teacher-student interactions, positive peer relationships, and a constructive classroom climate have been shown to contribute to students' cognitive, emotional, and social engagement in mathematics learning (Gutierrez Jr. & Doronio, 2024; Liang et al., 2025; Niu et al., 2022). However, existing research prior research primarily focuses on secondary and higher education levels (Gutierrez Jr. & Doronio, 2024; Liang et al., 2025; Maamin et al., 2022) or have positioned student engagement primarily as a mediating variable for academic achievement (Niu et al., 2022), while empirical investigations at the elementary school level particularly in upper elementary mathematics classrooms are still scarce. In addition, prior research often treats the classroom social environment as a global construct, without systematically examining the relative contribution of specific dimensions such as promoting academic interaction, emotional and academic support, and a climate of mutual respect. Furthermore, the role of gender in shaping the relationship between classroom social environments and student engagement has not been consistently explored, despite evidence suggesting gender-based differences in engagement patterns (Gutierrez Jr. & Doronio, 2024). These gaps indicate the need for further investigation to deepen understanding of how classroom social environments support student engagement in upper elementary mathematics learning across specific dimensions and gender differences.

1.2. Related Research

Gutierrez Jr. & Doronio (2024) reported through a correlational study that the quality of the classroom social environment is significantly associated with students' emotional, social, and cognitive engagement in mathematics learning, highlighting the important role of classroom social interactions in shaping student engagement. Consistent with these findings, Liang et al.

(2025) demonstrated that the classroom social climate is a necessary condition for the emergence of student engagement during the learning process, positioning the social environment as a fundamental factor in learning engagement. In the context of mathematics instruction, Niu et al. (2022) found that socially and academically supportive learning environments positively influence students' cognitive engagement and self-confidence, which subsequently affect mathematics achievement. These results are supported by Alrajeh & Shindel (2020), who showed that mathematics teacher support plays a significant role in enhancing student engagement. Furthermore, Maamin et al. (2022) identified a significant relationship between student engagement and mathematics achievement, reinforcing the close connection between affective-social aspects and academic outcomes. From a theoretical perspective, Berhanu & Semela (2025) on Self-Determination Theory, explained that classroom environments that satisfy students' needs for autonomy, competence, and social relatedness can enhance engagement and learning outcomes.

In addition to classroom environmental factors, individual student characteristics may also contribute to variations in learning engagement. Prasky Hartono et al. (2019) reported differences in student engagement based on gender. Gender is considered a psychosocial characteristic associated with differences in socio-emotional functioning, motivation, and self-regulation (Meece & Painter, 2012; Romer et al., 2011). Previous studies have also reported variations in patterns of self-regulation between male and female students (Rimm-Kaufman et al., 2015; Sáez-Delgado et al., 2022; Xia et al., 2022), suggesting that gender differences may influence how students regulate their learning and respond to classroom interactions and learning environments. These differences suggest that male and female students may respond differently to the classroom social environment and student engagement during the mathematics learning process.

However, previous studies have generally examined the classroom social environment as a global construct without analyzing the contribution of its specific dimensions to student engagement. Gutierrez Jr. & Dronio (2024) examined the classroom social environment as a global construct without analyzing the contribution of its specific dimensions to student engagement in mathematics learning and conducted their study at the secondary school level. Liang et al. (2025) analyzed correlations between dimensions of classroom social climate and dimensions of student engagement, but their research focused on higher education contexts. Meanwhile, Niu et al. (2022) examined supportive learning environments in elementary mathematics learning without specifically analyzing the contribution of each dimension of the classroom social environment. In fact, each dimension of the classroom social environment such as emotional and academic support from teachers and peers, academic interaction, and mutual respect may influence students' learning experiences in different ways. Moreover, studies that consider gender differences in the relationship between classroom social environment and student engagement mathematics learning remain limited. Therefore, this study examines the contribution of each dimension of the classroom social environment to student engagement in upper elementary mathematics learning and explores potential differences based on gender.

1.3. Research Objectives

Based on the identified research gaps, this study aims to examine the role of the classroom social environment in shaping student engagement in upper elementary mathematics learning. The study evaluates the extent to which the classroom social environment contributes to student engagement in mathematics learning. It also investigates gender-based differences and analyzes the relative influence of each dimension of the classroom social environment in supporting student engagement in mathematics learning.

Through the achievement of these objectives, this study is expected to provide an empirical mapping of the contribution of the classroom social environment to student engagement in mathematics learning, including variations in contribution by gender and the relative role of each classroom social environment dimension. The findings are expected to enrich the literature in educational psychology and mathematics education by extending the understanding of contextual mechanisms that shape student engagement at the elementary

education level. In addition, this study offers practical implications for the development of pedagogical practices that emphasize the creation of supportive, interactive, and socially oriented classroom environments to enhance student engagement in mathematics learning.

2. Theoretical Framework

2.1. Social Constructivist Perspective

From a social constructivist perspective, learning is fundamentally a social process shaped through interaction with others and engagement in shared activities (Mishra, 2023; Saleem et al., 2021; Syah et al., 2026). Lev Vygotsky proposed that cognitive development occurs through social interaction, where knowledge is constructed collaboratively rather than acquired individually (Potrac et al., 2016). Within this framework, the classroom becomes a social space in which students develop understanding through dialogue, collaboration, and guided participation with teachers and peers. Vygotsky's concept of the zone of proximal development emphasizes that learners can achieve higher levels of understanding when supported by more capable others through scaffolding and meaningful interaction (Rahman, 2024).

In mathematics learning, such social processes are particularly important because students often develop conceptual understanding by discussing strategies, explaining reasoning, and negotiating meaning with peers and teachers (Voigt, 2013). A classroom social environment characterized by mutual respect, supportive teacher guidance, and opportunities for academic interaction therefore provides essential conditions for students to actively participate in mathematical discourse (Demirci & Baki, 2023). Through these interactions, students not only construct mathematical knowledge but also develop confidence and willingness to engage in problem-solving activities.

2.2. Classroom Social Environment

The classroom social environment constitutes a central component of learning dynamics, referring to the social climate formed through teacher-student interactions and peer relationships within the classroom. It reflects students' perceptions of social support, norms, rules, and the quality of interpersonal relationships established by both teachers and peers (Patrick & Anderman, 2002; Patrick & Ryan, 2005; A. M. Ryan & Patrick, 2001). This environment is commonly conceptualized through several key dimensions, including teacher support, promotion of academic interaction, mutual respect, and performance orientation. In mathematics learning contexts, a supportive classroom social environment provides opportunities for students to share ideas and strategies without fear of ridicule, while minimizing excessive performance comparison that may heighten anxiety. Such conditions foster a sense of psychological safety, cooperation, and mutual respect, enabling students to engage more confidently in mathematical problem solving.

Teachers play a pivotal role in shaping this social context by constructing classroom norms, guiding interaction patterns, and conveying implicit messages about how students are expected to relate to one another. Communication practices that promoting interaction and mutual respect tend to promote collaborative and supportive classroom climates, whereas an emphasis on performance orientation may generate competitive atmospheres. From students' perspectives, classroom social environments encompass emotional and academic support from teachers, emotional and academic support from peers or student, as well as broader social processes that promote academic interaction and mutual respect (Patrick et al., 2007). Together, these dimensions form a social learning context that not only facilitates academic participation but also supports students' social and emotional adjustment, particularly in mathematics learning where openness to discussion and strategic thinking is essential.

2.3. Student Engagement in Mathematics Learning

Student engagement in mathematics learning is understood as a multidimensional construct encompassing social, emotional, cognitive, and behavioral engagement in classroom activities. Within the Responsive Classroom framework, engagement emerges through

students' active participation in social interactions, emotional connections to learning tasks, and cognitive investment in problem solving (Rimm-Kaufman et al., 2015). Social engagement is reflected in positive peer interactions and collaborative discussions during mathematical tasks; emotional engagement involves feelings of interest, enjoyment, and security while learning mathematical concepts; cognitive engagement refers to reflective thinking and the use of learning strategies, such as applying algorithms or exploring alternative solution paths. Behavioral engagement, often observed by teachers, includes students' on-task behavior, attention, and persistence in completing academic work. Collectively, these dimensions highlight that engagement in mathematics is not merely individual effort but a dynamic process shaped by classroom relationships and learning contexts.

2.4. Self-Determination Theory

The relationship between the classroom social environment and student engagement can be explained through motivational frameworks. According to Self-Determination Theory, students' engagement increases when the basic psychological needs of autonomy, competence, and relatedness are fulfilled (Deci et al., 2017; R. M. Ryan & Deci, 2024). In classroom contexts, these needs are supported through opportunities to express ideas, constructive feedback, and positive relationships with teachers and peers, which can enhance students' intrinsic motivation and participation in learning activities (Bayraktari et al., 2023; Chiu, 2023; Hannah et al., 2024). Complementing this perspective, the Integrated Model of Student Engagement explains that engagement emerges from interactions among social, psychological, and institutional factors, including teacher support, peer relationships, and a sense of belonging (Kahu & Nelson, 2018). Therefore, classroom environments characterized by support, interaction, and mutual respect provide important conditions for meaningful student engagement in mathematics learning.

2.5. Framework

This study is grounded in the perspective that the classroom social environment serves as an important external factor shaping students' responses and engagement in learning. A positive classroom social environment creates a safe, supportive, and conducive atmosphere that encourages students to participate actively in learning activities, including mathematics learning. In this study, the classroom social environment is conceptualized through six dimensions: teacher emotional support, teacher academic support, promoting academic interaction, promoting mutual respect, student emotional support, and student academic support, which together represent the quality of interpersonal relationships and social interactions within the classroom. Psychologically, such an environment contributes to fulfilling students' basic psychological needs for autonomy, competence, and relatedness, which in turn fosters intrinsic motivation and engagement in learning. Student engagement itself is viewed as a multidimensional construct consisting of cognitive, emotional, and social engagement, reflected in students' effort to understand mathematical concepts, positive attitudes toward learning, and active participation in collaborative learning activities. Therefore, both the overall classroom social environment and its specific dimensions are theoretically expected to contribute to enhancing student engagement in mathematics learning. In addition, this study considers gender as a moderating perspective to examine possible differences in how male and female students respond to the classroom social environment and student engagement in mathematics learning. Accordingly, this study analyzes the contribution of the classroom social environment and each of its dimensions to student engagement in mathematics learning and explores whether these contributions vary by gender among upper elementary students. This research framework can be illustrated in Figure 1.

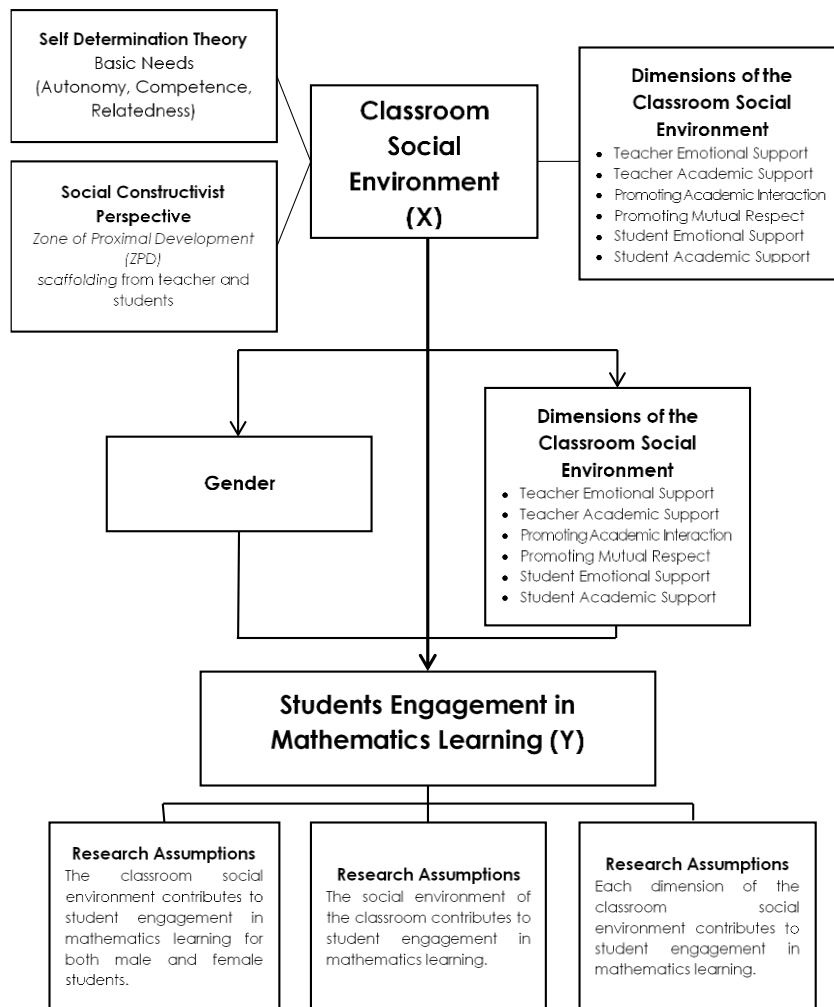


Figure 1. Framework

3. Method

3.1. Research Design

This study employed a quantitative approach with an ex post facto design. This design was selected because the study aimed to analyze relationships and the contribution of variables without manipulating any treatments applied to the research subjects. The focus of the study was to examine the contribution of the classroom social environment to student engagement in mathematics learning, both overall, by gender, and across each dimension of the classroom social environment.

3.2. Participant

The participants comprised 316 students enrolled in Grades IV, V, and VI from six public elementary schools located in Ngluwar district in Central Java Province, Indonesia (Table 1). The sample represented upper elementary students within the typical age range for these grade levels and included both male and female participants. Total sampling was applied, whereby all students from the selected schools who met the inclusion criteria were involved in the study. This approach was chosen to obtain a comprehensive representation of the target population and to minimize sampling bias, as the size of the population was manageable and accessible. Consequently, the sample accurately reflects the characteristics of upper elementary students in the participating schools.

Table 1. Characteristics Participant

Characteristics	Category	Frequency	Percentage
Gender	Male	175	55.38%
	Female	141	44.62%

3.3. Data Collection

Data were collected using Guttman scale instruments to measure the classroom social environment and student engagement in mathematics learning from students' perspectives. The classroom social environment instrument was adapted from Patrick et al. (2007), entitled "Early Adolescents' Perceptions of the Classroom Social Environment, Motivational Beliefs, and Engagement". This instrument consisted of 23 closed-ended items distributed across six dimensions of the classroom social environment, namely teacher emotional support, teacher academic support, student emotional support, student academic support, promoting academic interaction, and promoting mutual respect. The student engagement in mathematics learning instrument was adapted from Rimm-Kaufman et al. (2015), entitled "To What Extent Do Teacher-Student Interaction Quality and Student Gender Contribute to Fifth Graders' Engagement in Mathematics Learning?" This instrument comprised 15 closed-ended items distributed across three dimensions, namely emotional engagement, cognitive engagement, and social engagement (Table 2).

The adaptation process involved translating the items into Indonesian while maintaining conceptual equivalence and the measurement objectives of each item. Subsequently, the instrument format was modified into a Guttman scale with two response options, Yes and No, to accommodate the characteristics of elementary school students. Data collection was conducted directly with students, accompanied by classroom teachers and the researcher to ensure optimal completion of the instruments. The use of dichotomous responses was selected because it was considered easier for students to understand and helped produce more consistent responses (Ekawati et al., 2025; Sari et al., 2025). Thus, although the response format was simplified, the constructs, dimensions, and measurement indicators of both instruments remained grounded in strong theoretical and empirical foundations.

Table 2. Dimension and Indicator of Scale

Variable	Dimension	Indicator	Number of Item
Classroom Social Environment	Teacher Emotional Support	Empathy, emotional understanding, availability of teacher support	4
	Teacher Academic Support	Teacher concern for learning progress and academic effort	4
	Promoting Interaction	Opportunities for discussion and peer academic interaction	3
	Promoting Mutual Respect	Classroom norms that prevent ridicule and promote respect	4
	Student Emotional Support	Peer care, acceptance, and emotional concern	4
	Student Academic Support	Peer encouragement for academic success	4
Student Engagement	Cognitive Engagement	Effort, persistence, and focus in learning mathematics	6

Variable	Dimension	Indicator	Number of Item
in Mathematics Learning	Emotional Engagement	Interest, enjoyment, and affect toward mathematics	5
	Social Engagement	Peer collaboration and communication in mathematics learning	4

3.4. Data Analysis

Data analysis was conducted to address the objectives of the quantitative ex post facto study, namely to examine the contribution of the classroom social environment to student engagement in mathematics learning, both overall, by gender, and across each dimension of the classroom social environment. Data were obtained using Guttman scale instruments and analyzed using SPSS version 25 with a significance level of $\alpha = 0.05$. Prior to hypothesis testing, the Kolmogorov-Smirnov normality test was performed to determine the appropriate analytical techniques. As the data were not normally distributed ($p < 0.05$, $p_{x,y} = 0.000$), nonparametric statistical analyses were employed. The first and third hypotheses were tested using Spearman's rank correlation with data interpretation through the Guilford correlation interpretation table to determine the direction and strength of the relationships between variables, both overall and for each dimension of the classroom social environment. The magnitude of the contribution was calculated using the coefficient of determination (R^2), obtained by squaring Spearman's correlation coefficient. The second hypothesis was analyzed using the Mann-Whitney U test to identify gender-based differences. Subsequently, Spearman's rank correlation was conducted separately for male and female students to compare the strength of the relationships and the magnitude of the classroom social environment's contribution to student engagement within each group.

3.5. Validity and Reliability

This study employed two Guttman scale instruments (Yes-No responses) to measure the classroom social environment and student engagement in mathematics learning. Prior to implementation, both instruments underwent content validation through expert judgment to assess the appropriateness of wording, meaning, and alignment of items with the theoretical constructs. The validation results indicated that the instruments were suitable for use with minor revisions to wording.

Item validity testing was conducted with 50 students in Grades IV-VI from a public elementary school outside the main study sample using Pearson's Product Moment correlation with the assistance of SPSS version 25. All items on both instruments showed calculated r values greater than the critical r value (0.279), ranging from $r = 0.302$ to $r = 0.683$, with significance values below 0.05 (see Table 3). Therefore, all items were deemed valid and retained for data collection. Instrument reliability was analyzed using Cronbach's alpha. The reliability test results showed alpha values of 0.763 for the classroom social environment instrument and 0.718 for the student engagement in mathematics learning instrument, both exceeding the minimum threshold of 0.60. Accordingly, both instruments were considered to exhibit good internal consistency and were deemed reliable for use in this study (Table 3).

Table 3. Validity Item

Variable	Item	r values	Sig (2-tailed)	Interpretation
Classroom Social Environment	X01	0,349	0,013	Valid
	X02	0,331	0,019	Valid
	X03	0,302	0,033	Valid
	X04	0,302	0,033	Valid

Variable	Item	r values	Sig (2-tailed)	Interpretation
	X05	0,315	0,026	Valid
	X06	0,399	0,004	Valid
	X07	0,373	0,008	Valid
	X08	0,374	0,007	Valid
	X09	0,331	0,019	Valid
	X10	0,331	0,019	Valid
	X11	0,359	0,011	Valid
	X12	0,332	0,019	Valid
	X13	0,333	0,018	Valid
	X14	0,394	0,005	Valid
	X15	0,350	0,013	Valid
	X16	0,309	0,029	Valid
	X17	0,595	0,000	Valid
	X18	0,683	0,000	Valid
	X19	0,671	0,000	Valid
	X20	0,309	0,029	Valid
	X21	0,538	0,000	Valid
	X22	0,398	0,004	Valid
	X23	0,509	0,000	Valid
Student Engagement Mathematics Learning	Y01	0,659	0,000	Valid
	Y02	0,419	0,002	Valid
	Y03	0,340	0,016	Valid
	Y04	0,410	0,003	Valid
	Y05	0,384	0,006	Valid
	Y06	0,357	0,011	Valid
	Y07	0,602	0,000	Valid
	Y08	0,537	0,000	Valid
	Y09	0,540	0,000	Valid
	Y10	0,574	0,000	Valid
	Y11	0,447	0,001	Valid
	Y12	0,381	0,006	Valid
	Y13	0,392	0,005	Valid
	Y14	0,365	0,009	Valid
	Y15	0,447	0,001	Valid

4. Findings

4.1. Descriptive Statistics of the Classroom Social Environment and Student Engagement in Mathematics Learning

The results of the descriptive statistical analysis indicated that, overall, the classroom social environment was in the moderate to high category, suggesting that students perceived relatively positive support and social interactions in mathematics learning (Table 4). The variation in scores reflected differences in students' perceptions of the quality of the classroom social environment.

Table 4. Descriptive Statistics of the Classroom Social Environment

Statistic	Result
N	316
Mean	20.06
Std. Deviation	3.015
Minimum	8
Maximum	23

In this study, the classroom social environment was measured across six dimensions, namely teacher emotional support, teacher academic support, promoting academic interaction, promoting mutual respect, student emotional support, and student academic support. Descriptive statistics for each dimension indicated positive tendencies across all dimensions. The results showed that teacher academic support had the highest mean score, whereas promoting academic interaction had the lowest mean score (Table 5).

Table 5. Descriptive Statistics of Classroom Social Environment Dimensions

Dimension	Number of Item	Mean	Std. Deviation	Min	Max
Teachers Emotional Support	4	3.69	0.557	2	4
Teachers Academic Support	4	3.80	0.581	0	4
Promoting Academic Interaction	3	2.45	0.813	0	3
Promoting Mutual Respect	4	3.69	0.657	1	4
Student Emotional Support	4	3.14	1.169	0	4
Student Academic Support	4	3.29	1.010	0	4

The results of the descriptive statistical analysis indicated that overall student engagement was in the moderate to high category (Table 6). This suggests that students were relatively active in participating in mathematics learning, cognitively, socially, and emotionally during instructional activities.

Table 6. Descriptive Statistics of Student Engagement in Mathematics Learning

Statistic	Result
N	316
Mean	12.02
Std. Deviation	2.203
Minimum	5
Maximum	15

Student engagement was measured across three dimensions, namely cognitive, emotional, and social engagement (Table 7). The descriptive statistics showed that the mean scores across the three dimensions were relatively balanced when considering the number of items in each dimension. These results indicate that students were not only affectively engaged but also demonstrated active participation in cognitive processes and social interactions during mathematics learning.

Table 7. Descriptive Statistics of Student Engagement Dimensions in Mathematics Learning

Dimension	Number of Item	Mean	Std. Deviation	Min	Max
Cognitive Engagement	6	4.70	0.961	2	6
Emotional Engagement	5	4.36	1.038	0	5
Social Engagement	4	2.96	1.173	0	4

The results of the descriptive statistical analysis by gender indicated that for both variables, namely the classroom social environment and student engagement in mathematics learning, female students had higher mean scores than male students (Table 8). These findings suggest that female students tended to perceive the classroom social environment more positively and demonstrated higher levels of engagement in mathematics learning. However, these differences were subsequently examined using inferential analysis to determine their statistical significance.

Table 8. Descriptive Statistics of Classroom Social Environment and Student Engagement in Mathematics Learning based on Gender

Variable	Gender	N	Mean	Std. Deviation
Classroom Social Environment	Male	175	19.82	2.973
	Female	141	20.37	3.048
Student Engagement in Mathematics Learning	Male	175	11.81	2.189
	Female	141	12.28	2.201

4.2. Statistical Assumption Test

The statistical assumption test in this study was conducted using the Kolmogorov-Smirnov normality test on the two variables: classroom social environment (X) and student engagement in mathematics learning (Y). Based on the statistical analysis of the Kolmogorov-Smirnov normality test, the significance values for both variables were 0.000 ($0.000 < 0.05$), indicating that the data were not normally distributed (Table 9). Based on the results of the normality test showing that the data were not normally distributed, the hypothesis testing was therefore continued using nonparametric statistical analysis including Spearman rank correlation, coefficients of determination, and Mann-Whitney U tests.

Table 9. Results of the Kolmogorov-Smirnov Normality Test

Variable	Asymp. Sig. (2-tailed)	Description
Classroom Social Environment	0.000	Not Normally Distributed
Student Engagement in Mathematics Learning	0.000	Not Normally Distributed

4.3. Classroom Social Environment and Student Engagement in Mathematics Learning

The Spearman Rank correlation test showed a significance value of 0.000 ($p < 0.05$); therefore, the null hypothesis (H_0) was rejected and the alternative hypothesis (H_{a1}) was accepted (Table 10). These results indicated a significant relationship and influence between the classroom social environment and student engagement in mathematics learning. The correlation coefficient of 0,490 indicated a positive relationship between the two variables, meaning that a better classroom social environment was associated with higher levels of student engagement in mathematics learning. Based on Guilford's guidelines for interpreting correlation coefficients, the strength of this relationship was classified as moderate. Based on the coefficient of determination (R^2), the classroom social environment contributed 24.01% to student engagement in mathematics learning. This finding indicated that the classroom social environment made a meaningful contribution to student engagement, while the remaining variance was influenced by other factors outside the variables examined in this study.

Table 10. Summary of the Results of the First Hypothesis Test

Variable	Sig.	r_s	R^2	Interpretation
Classroom Social Environment Student Engagement in Mathematics Learning	0.000	0.490	24.01%	H_{1a} accepted

4.4. Classroom Social Environment and Student Engagement in Mathematics Learning Based on Student Gender

The Mann-Whitney U test produced an Asymp. Sig. (2-tailed) value of 0.040 ($p < 0.05$), indicating a significant difference in students' perceptions of the classroom social environment based on gender (Table 11). The mean rank for female students was higher than that for male students, suggesting that female students perceived the quality of the classroom social environment more positively. Furthermore, the Mann-Whitney U test for student engagement in mathematics learning also yielded an Asymp. Sig. (2-tailed) value of 0.043 ($p < 0.05$). These results indicated a significant gender difference in student engagement in mathematics learning, with female students demonstrating higher levels of engagement than male students.

Table 11. Summary of Mann-Whitney U Test

Variable	Gender	Mean Rank	Sig.
Classroom Social Environment	Male	149.17	0.040
	Female	170.09	
Student Engagement in Mathematics Learning	Male	149.25	0.043
	Female	169.98	

The Spearman Rank correlation analysis by gender group showed that both male and female students had significance values of 0.000 ($p < 0.05$), indicating significant relationships and effects between the classroom social environment and student engagement in mathematics learning in both groups. The correlation coefficient for male students was 0.504, while for female students it was 0.465. Both coefficients indicated positive relationships with moderate strength. Based on the coefficient of determination, the classroom social environment contributed 25.40% to student engagement in mathematics learning among male students and 21.62% among female students (Table 12). These findings indicate that although female students showed better perspectives of the classroom social environment and higher levels of engagement, the influence of the classroom social environment on engagement in mathematics was relatively stronger for male students.

Table 12. Summary of Second Hypothesis Test Results

Gender	Variabel	Sig.	r_s	R^2	Interpretasi
Male	Classroom Sosial Environment	0.000	0.504	25.40%	H_{a2} accepted
	Student Engagement in Mathematics Learning				
Female	Classroom Sosial Environment	0.000	0.465	21.62%	
	Student Engagement in Mathematics Learning				

4.5. Classroom Social Environment in Each Dimension and Student Engagement in Mathematics Learning

The Spearman Rank correlation analysis further showed that all dimensions of the classroom social environment had significant and positive relationships with student engagement in mathematics learning. All six dimensions yielded significance values of 0.000 ($p < 0.05$), leading to the acceptance of the alternative hypothesis (H_{a3}). Specifically, teacher emotional support had a correlation coefficient of 0.233, teacher academic support 0.299, promoting academic interaction 0.354, promoting mutual respect 0.240, student emotional support 0.338, and student academic support 0.295 (Table 13). According to Guilford's interpretation guidelines,

all relationships were classified as low in strength, yet they consistently demonstrated positive directions.

In terms of contribution, promoting academic interaction provided the largest contribution to student engagement in mathematics learning (12.53%), followed by student emotional support (11.42%), teacher academic support (8.94%), student academic support (8.70%), promoting mutual respect (5.76%), and teacher emotional support (5.43%). These results indicate that promoting academic interaction plays a relatively more dominant role in enhancing student engagement in mathematics learning compared to the other dimensions, even though each dimension contributes to student engagement to varying degrees.

Table 13. Summary of the Results of the Third Hypothesis Test

Dimension	Sig.	r_s	R ²	Interpretation
Teachers Emotional Support	0.000	0.233	5.43%	H _{a3} accepted
Teachers Academic Support	0.000	0.299	8.94%	
Promoting Academic Interaction	0.000	0.354	12.53%	
Promoting Mutual Respect	0.000	0.240	5.76%	
Student Emotional Support	0.000	0.338	11.42%	
Student Academic Support	0.000	0.295	8.70%	

5. Discussion

The results indicate that the classroom social environment has a significant relationship with and contribution to student engagement in mathematics learning in upper elementary grades. A classroom social environment characterized by emotional and academic support, opportunities for academic interaction, and mutually respectful relationships plays an important role in shaping students' cognitive, emotional, and social engagement during mathematics learning. These findings emphasize that student engagement is influenced not only by individual cognitive aspects but is also constructed through the quality of students' social experiences in the classroom. The role of the classroom social environment becomes increasingly important given that mathematics is often perceived as a challenging subject and may elicit learning anxiety.

The relationship between the classroom social environment and student engagement can be explained through the framework of Self-Determination Theory, which has been widely applied in contemporary educational research to understand the emergence of learning engagement. Studies grounded in Self-Determination Theory demonstrate that student engagement increases when learning environments support the fulfillment of basic psychological needs, namely autonomy, competence, and relatedness (Berhanu & Semela, 2025; Gutierrez Jr. & Doronio, 2024; Liang et al., 2025). In the context of mathematics learning, a positive classroom social environment enables students to feel socially accepted and valued, confident in meeting academic demands, and encouraged to take initiative and actively participate in learning activities. Fulfillment of these needs fosters intrinsic motivation, which plays a central role in strengthening student engagement throughout the learning process. This explanation is consistent with prior studies highlighting the importance of support from teachers, peers, and parents, as well as classroom conditions and learning contexts, in promoting student engagement (Hanaysha et al., 2023; Martins et al., 2022).

A growing body of research has reported consistent associations between the classroom social environment and student engagement. The present findings align with Gutierrez Jr. & Doronio (2024), who identified positive relationships between classroom social environment dimensions such as teacher support, mutual respect, task-related interaction, and performance goal orientation and students' emotional, social, and cognitive engagement in secondary mathematics education. In higher education contexts, Liang et al. (2025) similarly emphasized that classroom social climate, as a micro-social learning environment, plays a critical role in enhancing student engagement. At the elementary level, Niu et al. (2022) demonstrated that socially and academically supportive learning environments influence student engagement,

which subsequently affects mathematics achievement. The consistency of findings across educational levels suggests that the quality of classroom social environments constitutes a fundamental factor in fostering student engagement in mathematics learning.

Gender-based analyses revealed that female students reported more positive perceptions of the classroom social environment and higher levels of engagement than male students. This pattern may be understood through differences in social experiences and self-regulation characteristics. Ariyurek & Yurtseven (2024) reported that female students tend to exhibit greater trust in teachers and schools and place higher value on peer relationships. Such positive perceptions of social relations contribute to viewing the classroom as more supportive and secure, which in turn promotes engagement. This finding is consistent with Musso et al. (2022), who observed that female students consistently demonstrate higher levels of school engagement than male students. Furthermore, relatively more adaptive self-regulation and emotion regulation among female students (Sáez-Delgado et al., 2022; Xia et al., 2022) may enable them to respond more effectively to social and academic support, thereby sustaining engagement even when facing learning challenges, including in mathematics. Consequently, more positive perceptions of the classroom social environment and higher engagement among female students appear to be mutually reinforcing in shaping more meaningful learning experiences.

However, the findings reveal a significant association between the classroom social environment and student engagement in mathematics for both male and female students, with a relatively stronger contribution observed among male students. This suggests that although female students tend to report higher engagement and more positive classroom perceptions, male students' engagement is more strongly influenced by variations in classroom social environment quality. This pattern aligns with findings showing that female students more frequently experience classroom climates associated with optimal learning outcomes, whereas male students are more likely to encounter less supportive classroom environments, making their engagement more dependent on available social support and classroom organization (Olivier et al., 2024). In addition, male students are reported to be more sensitive to social contexts and peer motivational cultures, such that changes in classroom social environment quality exert a relatively stronger impact on their engagement compared to female students (Van Houtte, 2024). Thus, while the association between classroom social environment and engagement appears universal, the supportive role of the classroom becomes particularly critical for male students in mathematics learning.

Analysis of individual classroom social environment dimensions revealed that all dimensions were positively and significantly associated with student engagement in mathematics, although their levels of contribution varied. Promoting academic interaction, which includes opportunities to share ideas, engage in discussion, and provide mutual assistance, emerged as the strongest contributor to student engagement. This finding is consistent with Alsebaie (2023), who reported that group work significantly enhances interaction and engagement, particularly when students are given autonomy to collaborate and exchange ideas. Similar results were reported by Rehman et al. (2024), who found that problem-based learning promotes collaborative learning, problem-solving skills, and positive attitudes toward mathematics, thereby strengthening engagement. Moreover, research on flipped learning indicates that students' cognitive, emotional, and behavioral engagement increases when social interaction and academic discussion are effectively designed (Cevikbas & Kaiser, 2022). Conversely, engagement tends to decline when academic interaction is insufficiently facilitated. Overall, these findings underscore that student engagement in mathematics is strongly shaped by the extent to which classroom environments consistently promote active and meaningful academic interaction.

Emotional and academic support from teachers and peers also demonstrated significant influences on student engagement in mathematics learning. Balanced and high-quality support from teachers, peers, and parents has been reported to positively affect overall student engagement at the elementary level (Martins et al., 2022). Zhang et al. (2024) further highlighted the role of teacher and peer support in enhancing engagement across learning contexts, including physical education. Students who perceive strong support exhibit greater

willingness to ask questions, attempt new strategies, and view mistakes as part of the learning process, reflecting stronger behavioral and cognitive engagement (Gutierrez Jr. & Doronio, 2024). Liang et al. (2025) also emphasized that teacher academic support fosters students' initial interest and motivation while strengthening academic competence at moderate levels of engagement, whereas teacher emotional support provides emotional security that sustains ongoing engagement. In addition, teacher and peer support contributes to reducing mathematics anxiety and fostering positive attitudes toward mathematics, which subsequently enhances engagement (Zhuo et al., 2025). The effectiveness of peer support is further reflected in peer tutoring practices, which have been shown to improve conceptual understanding and mathematical problem-solving abilities as indicators of deeper cognitive engagement (Valdez Pasion & Marcelo, 2024).

The dimension of promoting mutual respect plays an important role in fostering student engagement by creating inclusive and supportive classroom environments. Liang et al. (2025) emphasized that promoting mutual respect contributes significantly to establishing classroom social environments that value diversity and promote positive interactions among classroom members. At higher levels of socio-emotional engagement, mutually respectful classroom conditions become particularly influential, reflecting students' increasing reliance on interactive and collaborative learning to deepen mathematical understanding. These findings align with Fitz (2025), who demonstrated that students learn mathematics most effectively when they experience positive relationships with teachers, develop a sense of belonging within the classroom community, and learn in environments that cultivate a growth mindset. Respectful classroom climates also strengthen students' confidence to participate actively and embrace academic challenges, especially when supported by high expectations and consistent teacher guidance, thereby sustaining engagement over time.

Overall, the present findings indicate that student engagement in mathematics learning is not shaped by any single dimension of the classroom social environment in isolation, but rather through an interconnected system of social experiences. Emotional support, academic support, academic interaction, and a climate of mutual respect operate synergistically to fulfill students' psychological needs and strengthen intrinsic motivation. This synthesis highlights that classroom management oriented toward positive social relationships and collaborative learning constitutes a critical foundation for sustaining student engagement, particularly within the context of elementary mathematics education.

6. Conclusion

The classroom social environment was positively and moderately associated with student engagement in mathematics among upper elementary students, indicating a meaningful contribution of classroom social factors to engagement. The classroom social environment explained 24.01% of the variance in students' engagement in mathematics learning, indicating that the quality of social interactions in the classroom makes a moderate contribution to student engagement. Gender-based differences emerged in students' perceptions of the classroom social climate and their engagement in mathematics, with female students reporting more favorable perceptions and higher engagement levels than male students. Despite these differences, the classroom social environment continued to significantly influence engagement for both genders, with a relatively stronger contribution observed among male students. This finding suggests that gender serves as a demographic characteristic that enriches variation in the association rather than functioning as a primary determinant of engagement. All dimensions of the classroom social environment were also positively and significantly related to engagement, with promoting academic interaction emerging as the strongest contributor, followed by emotional and academic support from teachers and peers, as well as a climate of mutual respect.

Limitation

This study is subject to several limitations that should be acknowledged when interpreting the findings. The data were obtained entirely from students' perceptions through scale-based

instruments; therefore, potential subjective response bias could not be avoided. Perspectives from other sources, such as teachers, as well as direct classroom observations, were not included. In addition, the analysis focused on the classroom social environment as the independent variable without examining the dimensions of student engagement (cognitive, emotional, and social) separately. Consequently, the results did not provide a detailed picture of how each engagement dimension responded to specific aspects of the classroom social environment.

Recommendation

Based on the limitations of this study, several recommendations for future research can be proposed. First, future studies are encouraged to incorporate teachers' perspectives to complement students' perceptions in order to obtain a more comprehensive understanding of the classroom social environment and student engagement. Second, researchers may include direct classroom observations to capture actual classroom interactions, which would allow the use of mixed-methods or longitudinal research designs to provide deeper insights into the dynamics of classroom social environment and student engagement in mathematics learning. Third, future studies are recommended to analyze student engagement in mathematics learning by examining its specific dimensions (cognitive, emotional, and social), so that a more detailed understanding of how each dimension responds to the classroom social environment can be obtained.

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Declaration of Generative AI and AI-assisted Technologies

This manuscript was prepared with the assistance of Generative AI ChatGPT. The AI was used to assist in grammar improvement and language translation. All intellectual contributions, critical analyses, and final revisions were conducted by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the content presented in this work.

References

- Agbata, B. C., Obeng-Denteh, W., Kwabi, P. A., Abraham, S., Okpako, S. O., Arivi, S. S., Asante-Mensa, F., & Adu, G. W. K. (2024). Everyday uses of mathematics and the roles of a mathematics teacher. *Science World Journal*, 19(3), 819–827. <https://doi.org/10.4314/swj.v19i3.29>
- Alrajeh, T. S., & Shindel, B. W. (2020). Student engagement and math teachers support. *Journal on Mathematics Education*, 11(2), 167–180. <https://doi.org/10.22342/jme.11.2.10282.167-180>
- Alsebaie, F. Y. (2023). Promoting students' engagement and interaction in class discussions through group work. *Journal of the Association of Arab Universities for Higher Education Research*, 43(4). <https://doi.org/10.36024/1248-043-004-024>
- Ariyurek, E. A., & Yurtseven, N. (2024). School engagement and learning responsibility in middle school students. *International Journal of Curriculum and Instructional Studies*, 14(2), 220–250. <https://doi.org/10.31704/ijocis.1500085>
- Aroh, P. N., Eze, K. O., & Ugwu, V. I. (2025). Correlation between classroom social environment and students' academic interest. *International Journal of Research in Education and Science*, 11(3), 614–623. <https://doi.org/10.46328/ijres.1307>

- Bayraktari, A., Yusuf, I., & Şare, A. (2023). The influence of self-determination theory on student engagement in the classroom. *International Scientific Journal Vision*, 57–78. <https://visionjournal.edu.mk/social/index.php/1/article/view/180>
- Berhanu, A., & Semela, T. (2025). Applying self-determination theory to understand student engagement and achievement in Ethiopian science and mathematics classrooms. <https://doi.org/10.21203/rs.3.rs-7234476/v1>
- Cevikbas, M., & Kaiser, G. (2022). Student engagement in a flipped secondary mathematics classroom. *International Journal of Science and Mathematics Education*, 20(7), 1455–1480. <https://doi.org/10.1007/s10763-021-10213-x>
- Chiu, T. K. F. (2023). Student engagement in K-12 online learning amid COVID-19: A qualitative approach from a self-determination theory perspective. *Interactive Learning Environments*, 31(6), 3326–3339. <https://doi.org/10.1080/10494820.2021.1926289>
- Deci, E. L., Olafsen, A. H., & Ryan, R. M. (2017). Self-determination theory in work organizations: The state of a science. *Annual Review of Organizational Psychology and Organizational Behavior*, 4, 19–43. <https://doi.org/10.1146/annurev-orgpsych-032516-113108>
- Demirci, S. Ç., & Baki, A. (2023). Characterizing mathematical discourse according to teacher and student interactions: The core of mathematical discourse. *Journal of Pedagogical Research*, 7(4), 144–164. <https://doi.org/10.33902/JPR.202321852>
- Ekawati, F. F., Tri Winarti Rahayu, Budhi Satyawana, Ismaryati, Deddy Whinata Kardiyanto, & Bambang Wijanarko. (2025). Motives for physical activity among deaf students: A descriptive analysis. *INKLUSI*, 12(2), 156–167. <https://doi.org/10.14421/ijds.120212>
- Fitz, J. (2025). *Positive conditions for mathematics learning: An overview of the research*. <https://doi.org/10.54300/967.472>
- Ghbari, T. A., Badareen, G. S., Al-Smadi, R. T., Damra, J. K., & Shammout, N. A. (2024). The mediating role of self-efficacy in the relationship between self-determination motive and academic engagement among undergraduate students. *Participatory Educational Research*, 11(3), 43–58. <https://doi.org/10.17275/per.24.33.11.3>
- Gutierrez Jr., A. C., & Doronio, R. G. (2024). Classroom social environment and student engagement in mathematics: A correlational study. *European Journal of Education Studies*, 11(8). <https://doi.org/10.46827/ejes.v11i8.5471>
- Hanaysha, J. R., Shriedeh, F. B., & In'airat, M. (2023). Impact of classroom environment, teacher competency, information and communication technology resources, and university facilities on student engagement and academic performance. *International Journal of Information Management Data Insights*, 3(2). <https://doi.org/10.1016/j.ijime.2023.100188>
- Hannah, S. K., Ng, B. L. L., & Liu, W. C. (2024). Fostering student motivation and engagement through teacher autonomy support: A self-determination theory perspective. *International Journal of Instruction*. <https://hdl.handle.net/10497/27229>
- Kahu, E. R., & Nelson, K. (2018). Student engagement in the educational interface: understanding the mechanisms of student success. *Higher Education Research and Development*, 37(1), 58–71. <https://doi.org/10.1080/07294360.2017.1344197>
- Koskinen, R., & Pitkäniemi, H. (2022). Meaningful learning in mathematics: A research synthesis of teaching approaches. *International Electronic Journal of Mathematics Education*, 17(2), em0679. <https://doi.org/10.29333/iejme/11715>
- Kulik, J. R. (2023). A critical examination of an in class Tabata based physical fitness protocol on student engagement levels in a sixth grade math class. In J. R. <https://scholarcommons.sc.edu/etd>
- Li, J., & Xue, E. (2023). Dynamic interaction between student learning behaviour and learning environment: Meta-analysis of student engagement and its influencing factors. *Behavioral Sciences*, 13(1). <https://doi.org/10.3390/bs13010059>

- Liang, S., Li, Y., & Yang, Y. (2025). Is student engagement without classroom social climate possible? A necessary condition analysis. *Humanities and Social Sciences Communications*, 12(1). <https://doi.org/10.1057/s41599-025-05910-9>
- Maamin, M., Maat, S. M., & Iksan, Z. H. (2022). The influence of student engagement on mathematical achievement among secondary school students. *Mathematics*, 10(1). <https://doi.org/10.3390/math10010041>
- Martins, J., Cunha, J., Lopes, S., Moreira, T., & Rosário, P. (2022). School engagement in elementary school: A systematic review of 35 years of research. *Educational Psychology Review*, 34(2), 793–849. <https://doi.org/10.1007/s10648-021-09642-5>
- Meece, J. L., & Painter, J. (2012). Gender, self-regulation, and motivation. In *Motivation and self-regulated learning* (pp. 339–367). Routledge. <https://www.taylorfrancis.com/chapters/edit/10.4324/9780203831076-14/gender-self-regulation-motivation-judith-meece-jason-painter>
- Mishra, N. R. (2023). Constructivist approach to learning: An analysis of pedagogical models of social constructivist learning theory. *Journal of Research and Development*, 6(01), 22–29. <https://doi.org/10.3126/jrdn.v6i01.55227>
- Musso, P., Ligorio, M. B., Ibe, E., Annese, S., Semeraro, C., & Cassibba, R. (2022). STEM-gender stereotypes: associations with school empowerment and school engagement among Italian and Nigerian adolescents. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.879178>
- Niu, W., Cheng, L., Duan, D., & Zhang, Q. (2022). Impact of perceived supportive learning environment on mathematical achievement: The mediating roles of autonomous self-regulation and creative thinking. *Frontiers in Psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.781594>
- Olivier, E., Morin, A. J. S., Plante, I., Archambault, I., & Dupéré, V. (2024). Classroom learning climate profiles: Combining classroom goal structure and social climate to support student school functioning and behavioral adaptation. *Journal of Educational Psychology*, 116(2), 256. <https://doi.org/https://doi.org/10.1037/edu0000837>
- Patrick, H., & Anderman, L. H. (2002). *Social motivation and the classroom social environment*. <https://www.researchgate.net/publication/257984617>
- Patrick, H., & Ryan, A. M. (2005). Identifying adaptive classrooms: Dimensions of the classroom social environment. In *What Do Children Need to Flourish?* (pp. 271–287). Springer US. https://doi.org/10.1007/0-387-23823-9_17
- Patrick, H., Ryan, A. M., & Kaplan, A. (2007). Early adolescents' perceptions of the classroom social environment, motivational beliefs, and engagement. *Journal of Educational Psychology*, 99(1), 83. <https://doi.org/10.1037/0022-0663.99.1.83>
- Potrac, P., Nelson, L., Groom, R., & Greenough, K. (2016). Lev Vygotsky: Learning through social interaction in coaching. In *Learning in sports coaching* (pp. 101–112). Routledge. <https://doi.org/10.4324/9781315746012>
- Prasky Hartono, F., Umamah, N., & Putri Nirmala Puji, R. (2019). The level of student engagement based on gender and grade on history subject of senior high school students in jember regency. *International Journal Of Scientific & Technology Research*, 8, 8. www.ijstr.org
- Qudwatullathifah, R. N., Maharani, A., & Miftahurrohman, C. (2025). Students' engagement in learning mathematics with the academic performance of elementary school. *Klasikal: Journal of Education, Language Teaching and Science*, 7. <https://doi.org/10.52208/klasikal.v7i2.1304>
- Rahman, L. (2024). Vygotsky's zone of proximal development of teaching and learning in STEM education. *International Journal of Engineering Research & Technology*, 13(8), 389–394. <https://doi.org/10.5281/zenodo.18137951>

- Rehman, N., Huang, X., Mahmood, A., AlGerafi, M. A. M., & Javed, S. (2024). Project-based learning as a catalyst for 21st-Century skills and student engagement in the math classroom. *Heliyon*, 10(23). <https://doi.org/10.1016/j.heliyon.2024.e39988>
- Riana Bagaskorowati, Tresnani, Widiya Alita, Novi Nur Samiadi, & Novriko Burhan. (2023). Upper class elementary school student engagement in math subject merdeka curricula: Post covid study case in Jakarta province Indonesia. *International Journal of Elementary Education*, 7(1), 134–142. <https://doi.org/10.23887/ijee.v7i1.58471>
- Rimm-Kaufman, S. E., Baroody, A. E., Larsen, R. A. A., Curby, T. W., & Abry, T. (2015). To what extent do teacher-student interaction quality and student gender contribute to fifth graders' engagement in mathematics learning? *Journal of Educational Psychology*, 107(1), 170–185. <https://doi.org/10.1037/a0037252>
- Romer, N., Ravitch, N. K., Tom, K., Merrell, K. W., & Wesley, K. L. (2011). Gender differences in positive social-emotional functioning. *Psychology in the Schools*, 48(10), 958–970. <https://doi.org/10.1002/pits.20604>
- Ryan, A. M., & Patrick, H. (2001). The classroom social environment and changes in adolescents' motivation and engagement during middle school. *American Educational Research Journal*, 38(2), 437–460. <https://doi.org/10.3102/00028312038002437>
- Ryan, R. M., & Deci, E. L. (2024). Self-determination theory. In *Encyclopedia of quality of life and well-being research* (pp. 6229–6235). Springer. https://doi.org/10.1007/978-3-031-17299-1_2630
- Sáez-Delgado, F., López-Angulo, Y., Mella-Norambuena, J., Baeza-Sepúlveda, C., Contreras-Saavedra, C., & Lozano-Peña, G. (2022). Teacher self-regulation and its relationship with student self-regulation in secondary education. *Sustainability (Switzerland)*, 14(24). <https://doi.org/10.3390/su142416863>
- Salami, O. O., & Spangenberg, E. D. (2025). The influence of students' engagement in mathematical problem solving activities. *Interdisciplinary Journal of Education Research*, 7(1), a24. <https://doi.org/10.38140/ijer-2025.vol7.1.24>
- Saleem, A., Kausar, H., & Deeba, F. (2021). Social constructivism: A new paradigm in teaching and learning environment. *Perennial Journal of History*, 2(2), 403–421. <https://doi.org/10.52700/pjh.v2i2.86>
- Sari, D. P., Wiyono, K., & Siahaan, S. M. (2025). Integration of Palembang LRT in the e-module for alternating current electricity STEM: A study of validity, practicality, and effectiveness. *Jurnal Penelitian Pendidikan IPA*, 11(11), 944–957. <https://doi.org/10.29303/jppipa.v11i11.13105>
- Sen, E. O. (2022). Middle school students' engagement in mathematics and learning approaches: Structural equation modelling. *Pedagogical Research*, 7(2), em0124. <https://doi.org/10.29333/pr/11908>
- Syah, I., Sukmana, O., & Yumitro, G. (2026). Analysis of Vygotsky's social constructivism theory in collaborative learning based on digital technology. *International Journal of Economics Management and Social Science*, 9(1), 365–376. <https://journal.salewangang.net/ijemss/article/view/53>
- Valdez Pasion, O., & Marcelo, P. I. (2024). Benefits of peer tutoring in enhancing students' academic performance in mathematics. *International Journal of Advanced Multidisciplinary Studies*, IV. <https://www.ijams-bbp.net/archive/vol-4-issue-5-may/benefits-of-peer-tutoring-in-enhancing-students-academic-performance-in-mathematics/>
- Van Houtte, M. (2024). Gender differences in class engagement and disruptive school behaviour: boys' susceptibility to peers' motivation culture. *Gender and Education*, 36(5), 393–412. <https://doi.org/10.1080/09540253.2024.2345061>
- Voigt, J. (2013). Negotiation of mathematical meaning in classroom processes: Social interaction and learning mathematics. In *Theories of mathematical learning* (pp. 21–50). Routledge. <https://doi.org/10.1007/BF01273665>

- Wong, Z. Y., Liem, G. A. D., Chan, M., & Datu, J. A. D. (2024). Student engagement and its association with academic achievement and subjective well-being: A systematic review and meta-analysis. *Journal of Educational Psychology*, 116(1), 48. <https://doi.org/10.1037/edu0000833>
- Xia, Q., Yin, H., Hu, R., Li, X., & Shang, J. (2022). Motivation, engagement, and mathematics achievement: An exploratory study among Chinese primary students. *Sage Open*, 12(4). <https://doi.org/10.1177/21582440221134609>
- Xu, X., Shi, Z., Bos, N. A., & Wu, H. (2023). Student engagement and learning outcomes: an empirical study applying a four-dimensional framework. *Medical Education Online*, 28(1). <https://doi.org/10.1080/10872981.2023.2268347>
- Zhang, T., Zhao, J., & Shen, B. (2024). The influence of perceived teacher and peer support on student engagement in physical education of Chinese middle school students: mediating role of academic self-efficacy and positive emotions. *Current Psychology*, 43(12), 10776–10785. <https://doi.org/10.1007/s12144-023-05200-0>
- Zhuo, X., Wang, Y., Xu, Y., Feng, H., Liu, C., Wang, Y., & Si, J. (2025). How students' math anxiety profiles change in primary school: The roles of teacher support, peer support and math attitudes. *British Journal of Educational Psychology*. <https://doi.org/10.1111/bjep.12758>