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Unpacking the relationship between adolescents' perceived school climate and negative emotions: the chain mediating roles of school belonging and social avoidance and distress



Weisong Chen¹, Zhen Huang², Bo Peng¹ and Hang Hu^{3*}

Abstract

Objective Guided by Self-System Processes Theory, Social Support Theory, and Stress and Coping Theory, this study investigates how perceived school climate influences adolescents' negative emotions through the chain mediation of school belonging and social avoidance and distress. It also examines demographic differences across gender and grade and tests the structural invariance of the proposed model.

Method A cross-sectional survey of 1,507 Chinese adolescents in grades 5–9 was conducted using validated scales. Independent samples t-tests and one-way ANOVA were used to examine gender and grade differences in the key variables. Structural equation modeling (SEM) tested the hypothesized mediation model, while multigroup SEM assessed structural invariance across subgroups.

Results Perceived school climate reduced negative emotions both directly and indirectly, with school belonging and social avoidance and distress as key mediators. Peer support demonstrated the strongest indirect effect, while teacher support and autonomy opportunities influenced negative emotions through both direct and indirect pathways. A chain mediation pathway was identified, and structural invariance testing confirmed consistent relationships across gender and grade groups.

Conclusion This study reveals a complex chain mediation mechanism and highlights the stability of structural relationships across demographic groups. The findings provide valuable theoretical and practical insights for fostering supportive school environments to promote adolescent emotional well-being.

Keywords Perceived school climate, Negative emotions, School belonging, Social avoidance and distress, Adolescents, Gender differences, Structural equation modeling

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Introduction

Adolescence is a critical period for emotional and social development, during which adolescents are particularly vulnerable to negative emotions such as anxiety, depression, and psychological distress [1, 2]. Schools, as central social and academic environments, play a pivotal role in shaping students' emotional well-being [3, 4]. Among various school-related factors, perceived school climate—students' subjective evaluation of teacher support, peer relationships, and opportunities for autonomy—has been widely acknowledged as a key determinant of adolescent emotional outcomes [5–7]. While existing studies confirm the association between a positive school climate and lower levels of negative emotions [5, 6], the specific mechanisms underlying this relationship remain insufficiently explored.

School climate is a multidimensional construct that includes teacher support, peer support, and autonomy opportunities [8, 9]. Teacher support reflects students' perceptions of care, understanding, and encouragement from teachers [10, 11], while peer support involves the emotional trust, acceptance, and inclusion experienced within peer relationships [12, 13]. Autonomy opportunities refer to students' perceived freedom for self-expression, independence, and decision-making within the school setting [14]. Drawing on Social Support Theory, these dimensions collectively provide critical emotional and social resources that buffer stress and directly reduce psychological distress, thereby promoting adolescents' emotional well-being. Although these dimensions are distinct, prior studies often treat school climate as a unified construct [15], potentially obscuring the differential effects of its components. To address this limitation, the present study examines how each dimension-teacher support, peer support, and autonomy opportunitiesspecifically influences adolescents' emotional outcomes.

To uncover the mechanisms through which school climate impacts negative emotions, the current study focuses on two key mediators: school belonging and social avoidance and distress. School belonging represents students' sense of acceptance, connection, and psychological safety within the school environment [16, 17]. Drawing from Self-System Processes Theory and Stress and Coping Theory, a positive school climate satisfies adolescents' fundamental need for relatedness, which strengthens their sense of school belonging [18, 19]. This sense of belonging fosters emotional stability and resilience, reducing negative emotions such as anxiety and depression.

Conversely, social avoidance and distress are maladaptive responses that arise when students perceive their school climate as unsupportive [20]. Based on Stress and Coping Theory, when students experience stress within the school environment—such as a lack of support from teachers or peers—they may resort to social avoidance as a coping strategy [21]. This avoidance further exacerbates feelings of distress, isolation, and emotional problems. By simultaneously examining these two mediators, the study aims to reveal both positive pathways (school climate enhancing school belonging) and negative pathways (school climate increasing social avoidance), providing a comprehensive understanding of how school climate influences emotional outcomes.

Despite the growing body of literature on school climate, several critical research gaps remain. First, while studies confirm the link between school climate and emotional outcomes, they rarely explore the mechanisms that explain how these relationships occur. This study addresses this gap by testing a chain mediation model, incorporating school belonging and social avoidance as mediators. Second, most prior research treats school climate as a single construct, overlooking the unique contributions of its specific dimensions. By differentiating between teacher support, peer support, and autonomy opportunities, this study reveals their distinct and collective effects on adolescents' negative emotions. Third, few studies have examined whether these pathways hold across demographic subgroups. To address this, the current study conducts structural invariance testing to assess the consistency of the proposed relationships across gender and grade levels. Finally, although cross-sectional data cannot establish causality, this study provides foundational evidence for the hypothesized relationships and highlights the need for longitudinal research to confirm the temporal dynamics of these pathways.

The objectives of this study are threefold:

- To examine the relationships between specific dimensions of perceived school climate (teacher support, peer support, and autonomy opportunities) and adolescents' negative emotions;
- (2) To investigate the mediating roles of school belonging and social avoidance and distress in these relationships;
- (3) To explore whether these pathways are consistent across gender and grade levels.

By addressing these objectives, this study offers a comprehensive and theoretically grounded framework for understanding the mechanisms linking school climate to emotional well-being. The findings provide practical implications for fostering supportive school environments, promoting school belonging, reducing maladaptive social behaviors, and improving adolescents' mental health outcomes.

Literature review and theoretical framework Perceived school climate and negative emotions

Since the concept of social support was introduced into psychiatric literature in the 1970s, it has gradually become an important research topic in fields such as sociology, psychology, and epidemiology [22]. Social support theory suggests that individuals benefit from emotional, instrumental, and informational support obtained from their external environment, which helps alleviate stress and maintain emotional stability [23, 24]. In the school context, perceived school climate, as a key manifestation of social support, primarily influences students' emotional states and mental health through dimensions such as teacher care, peer acceptance, and opportunities for autonomy [5–7].

Teacher care, as a core source of emotional support, provides understanding, encouragement, and trust, helping students gain a sense of security and belonging amidst academic pressure and interpersonal challenges. This, in turn, reduces Negative emotions such as anxiety and self-doubt [25, 26]. Peer acceptance reflects a sense of acceptance and recognition in social interactions. Positive peer relationships can alleviate feelings of lone-liness and reduce the likelihood of Social avoidance and distress [27, 28]. Meanwhile, campus order and a sense of safety, as essential dimensions of environmental support, help students establish emotional stability and self-efficacy through fair rules, discipline, and a safe atmosphere, enhancing their adaptability to stress [29, 30].

However, current research has yet to clarify which dimension of Perceived school climate has the most significant impact on Negative emotions, as individuals vary in their reliance on and sensitivity to social support. This ambiguity reflects the complexity and diversity of the role of Perceived school climate in emotional regulation. It is necessary to further explore the specific mechanisms and boundary conditions of how various dimensions influence emotional responses.

To address this gap, this study aims to explore the specific pathways through which different dimensions of Perceived school climate impact students' Negative emotions and to analyze whether significant differences exist among individuals with varying characteristics (e.g., gender, grade level) in this process. By uncovering the mechanisms through which social support in Perceived school climate regulates emotions, this study not only deepens the application of social support theory in school contexts but also provides scientific evidence and practical guidance for interventions aimed at promoting students' mental health.

Perceived school climate and school belonging

In the 1980s, American psychologists proposed the selfdetermination theory (SDT) [31], emphasizing the degree of self-determination in human behavior. SDT views motivation as a continuum based on the level of self-determination and is grounded in the organismic dialectical perspective, which posits that social environments can enhance intrinsic motivation, promote the internalization of extrinsic motivation, and ensure healthy human development by supporting the satisfaction of three basic psychological needs: relatedness, competence, and autonomy [31, 32]. The self-system processes theory is considered a refinement and application of SDT, particularly in understanding the dynamic mechanisms of individual emotional regulation and adaptation processes. It provides a more detailed theoretical framework for understanding psychological development in different contexts [33, 34].

The self-system processes theory suggests that individual development depends on the fulfillment of basic psychological needs by the external environment, which in turn influences the dynamic regulation of the self-system [35, 36]. Perceived school climate, as a crucial environmental factor, plays a key role in the formation of school belonging [37, 38]. When students perceive supportive characteristics in the school climate-such as understanding and care in teacher-student interactions, fair rules, and respect for individual expression and participation-they are more likely to view the school environment as a trustworthy resource. This fosters emotional identification and a sense of belonging to the school [5-7]. Conversely, a lack of supportive school climate may lead to feelings of alienation and insecurity, weakening school belonging and adversely affecting students' psychological adaptation and emotional stability.

Although existing studies have explored the influence of perceived school climate on school belonging [5, 6], most have focused on the overall relationship without delving into the specific mechanisms underlying this connection. Additionally, few studies have investigated whether this relationship manifests consistently across different student groups.

To address these gaps, this study adopts the self-determination theory framework to focus on the relationship between perceived school climate and school belonging, analyzing the structural consistency of this relationship across different groups. By systematically examining both the universality and variability of this relationship, the study aims to provide new empirical evidence for the development of related theories while offering scientific guidance for optimizing school environments and designing psychological interventions.

Mediating variables in the relationship between perceived school climate and negative emotions

The stress and coping theory, first proposed by American psychologist Lazarus, is one of the most representative

theories in the field of psychological stress [39]. The theory posits that individuals, when faced with external stress situations, regulate their self-state through cognitive appraisal and coping mechanisms, which in turn influence their emotional experiences and behavioral responses [40–42]. In the school context, school belonging and social avoidance and distress reflect an individual's level of adaptation to the school environment and non-adaptive coping strategies, respectively, demonstrating the dynamic regulation of the self-system under stress [43–45].

School belonging, as a positive psychological resource, helps individuals perceive the school environment as a supportive resource by satisfying their needs for relational connection, security, and self-worth, thereby forming positive cognitive appraisals [16]. Such appraisals prompt individuals to adopt adaptive strategies such as problem-solving or seeking support, alleviating emotional distress in stressful situations and maintaining self-system balance [46, 47]. However, when school belonging is low, individuals are more likely to perceive the school as a source of stress, leading to negative cognitive appraisals and weakened emotional security. This, in turn, manifests as the non-adaptive coping strategy of social avoidance and distress [48].

Social avoidance, as a negative coping strategy, may temporarily reduce emotional stress but limits individuals' opportunities to access external support and resources, thereby reinforcing feelings of helplessness and resource deprivation [49, 50]. The resulting distress further exacerbates negative emotions such as anxiety, loneliness, and self-doubt, creating a vicious cycle in stress coping.

Existing research primarily focuses on the independent mediating role of school belonging [51], with relatively little attention to the mediating effect of social avoidance and distress in this process. Furthermore, few studies systematically reveal how perceived school climate influences individuals' emotional outcomes through the chain mechanism of school belonging and social avoidance and distress.

Based on the stress and coping theory, and incorporating self-system processes Theory and social support theory, this study proposes that perceived school climate, by fulfilling individuals' needs for relational connection and self-adaptation, first affects school belonging and subsequently impacts emotional outcomes through the nonadaptive pathway of social avoidance and distress.

This chain mediation mechanism not only unveils the deeper processes by which school climate regulates emotions but also systematically explains the self-regulation mechanism of individuals in stress situations. It provides a new theoretical perspective and empirical evidence for understanding the relationship between school climate and students' mental health.

Literature review

Existing literature has explored extensively the relationship between perceived school climate and students' emotional states, with research showing that school climate, as an important representation of external social support, has a significant positive impact on students' mental health [16, 47]. However, current research still exhibits certain limitations, primarily in the aspects of variable selection, specific mechanisms of action, and attention to group differences.

Firstly, in terms of variable selection, existing studies tend to examine school climate as a holistic structure [51], overlooking the independent effects of different elements within school climate (e.g., teacher support, peer support, and opportunities for autonomy) and their specific relationships with students' emotions. Moreover, while school belonging and social avoidance and distress have received some attention as positive and negative psychological manifestations, respectively [37, 48], how these two factors work together in the relationship between perceived school climate and emotional outcomes has yet to be systematically understood. This study makes an innovative contribution by incorporating school belonging and social avoidance and distress into the same model to explore their chain mediation pathways, aiming to reveal the complex mechanisms by which school climate affects students' emotional responses.

Secondly, existing research on the mechanisms of school climate's effects mostly stops at validating simple mediation models [5–7], lacking an in-depth analysis of multi-variable sequential mediation mechanisms. Based on self-system processes theory, social support theory, and stress and coping theory, this study constructs a chain mediation model, proposing that perceived school climate affects negative emotions through the sequential mediation of school belonging and social avoidance and distress. This provides a deeper understanding of the dynamic processes and pathways through which school climate regulates emotional states.

Finally, there has been insufficient focus on group differences in existing research. Most studies focus on the general population and rarely consider whether the relationship between school climate and emotional outcomes is consistent across demographic characteristics (e.g., gender, grade level) [29]. This study employs structural invariance testing to examine differences between groups, providing empirical support for the generalizability and robustness of the findings.

In summary, based on the above literature review and theoretical framework, this study proposes the following hypotheses: **Hypothesis 1 (H1)** Perceived school climate is negatively associated with adolescents' negative emotions.

Hypothesis 2 (H2) School belonging mediates the relationship between perceived school climate and negative emotions.

Hypothesis 3 (H3) Social avoidance and distress mediates the relationship between perceived school climate and negative emotions.

Hypothesis 4 (H4) School belonging and social avoidance and distress jointly form a chain mediation effect between perceived school climate and negative emotions.

Theoretical model

This study integrates the proposed hypotheses into a theoretical framework (Fig. 1) that examines:

- (1) The direct relationship between perceived school climate and adolescents' negative emotions.
- (2) The roles of school belonging and social avoidance and distress as mediating variables in this relationship, exploring how these psychosocial factors contribute to the dynamic between school climate and emotional outcomes.

(3) The chain mediation effect involving school belonging and social avoidance and distress, highlighting their sequential and interconnected influence on negative emotional experiences.

This study hypothesizes that perceived school climate influences negative emotions through direct effects and a chain mediation pathway involving school belonging and social avoidance and distress. Together, these mechanisms form a comprehensive framework for understanding the interplay between environmental and psychosocial factors in shaping adolescents' emotional experiences. This study provides theoretical insights and practical implications for interventions aimed at promoting supportive school environments and improving adolescent mental health.

Materials and methodology Participants and data Sample size justification

To ensure the statistical robustness and reliability of this study, the widely recognized G*Power 3.1 software was used to estimate the sample size. The estimation was based on a multiple regression model involving five predictors: Perceived School Climate (independent variable), Negative Emotions (dependent variable), School Belonging (mediator), and Social Avoidance and Distress



Fig. 1 Conceptual Framework

(mediator). Assuming a medium effect size ($f^2 = 0.15$), a significance level of $\alpha = 0.05$, and statistical power of $1 - \beta = 0.80$, the analysis indicated a minimum sample size of 323 participants was required to detect statistically significant effects.

In addition, the participant-to-item ratio guideline for survey-based studies was applied, recommending 5 to 10 participants per survey item. The survey used in this study consists of 95 items, including the Perceived School Climate scale (25 items), Negative Emotions scale (21 items), School Belonging scale (18 items), Social Avoidance and Distress scale (28 items), and 3 demographic variables (gender, grade, and family location). Based on this guideline, the recommended sample size ranges from 475 to 950 participants.

To ensure statistical power, representativeness, and robustness across demographic subgroups, 1,600 questionnaires were distributed to primary and secondary school students. This sample size exceeds both the G^* Power estimate and the participant-to-item ratio recommendation, ensuring the statistical robustness and generalizability of the findings to diverse adolescent populations.

Participant selection process

This study focused on students in grades 5 to 9, including upper elementary school (grades 5 and 6) and middle school (grades 7 to 9). Lower elementary students (grades 1 to 4) were excluded due to their limited ability to comprehend the survey. Stratified random sampling was used to ensure representation across grades, gender, and family location (urban and rural).

Schools were randomly selected from multiple regions of China. Within each selected school, one or two classes per grade were randomly chosen, and all students in these classes were invited to participate. Participants had to meet the following inclusion criteria: being enrolled in grades 5 to 9 and capable of independently completing the survey. Invalid responses, such as incomplete answers or fixed response patterns, were excluded during data cleaning.

Table 1 The sample information

Basic information	Category	Frequency	Percentage	Cumulative percentage
Gender	Male	952	63.17	63.17
	Female	555	36.83	100
Grade	Grade 5	318	21.10	21.10
	Grade 6	297	19.71	40.81
	Grade 7	305	20.24	61.05
	Grade 8	296	19.64	80.69
	Grade 9	291	19.31	100
Family location	Urban	742	49.24	49.24
	Rural	765	50.76	100

Data collection methods

To ensure validity, reliability, and consistency, data collection followed standardized procedures, including the following steps:

Training of data collectors All research assistants underwent comprehensive training, covering the study's objectives, the importance of ethical practices, and standardized procedures for administering the survey. This ensured uniformity in instructions provided to participants and minimized potential biases during the data collection process.

Questionnaire administration Surveys were administered during regular school hours in classroom settings to minimize disruption to participants' daily routines. Research assistants distributed the questionnaires and provided clear instructions on how to complete them. Students were encouraged to complete the survey independently and honestly, without discussing responses with their peers. Completed questionnaires were collected immediately to ensure data integrity and accuracy.

Confidentiality and informed consent Ethical approval for this study was obtained from the Ethics Committee of Chengdu Sport University (Approval Number: CTYLL2024014), in accordance with the Helsinki Declaration and relevant national guidelines. Written informed consent was obtained from the participants' guardians, and verbal assent was provided by the participants. Confidentiality and anonymity were assured, with all responses treated securely and data anonymized during analysis to protect participants' privacy.

Data processing

The survey was conducted from April 1 to May 31, 2024. A total of 1,600 questionnaires were distributed to students in grades 5 to 9. After excluding invalid responses due to missing data, fixed response patterns, or inconsistencies, 1,507 valid questionnaires were retained, resulting in an effective response rate of 94.19%.

Invalid questionnaires were identified and excluded based on predefined criteria, including incomplete answers and uniform response patterns. Data cleaning ensured the quality and completeness of the dataset, providing a robust foundation for subsequent analysis. The demographic information of the respondents is presented in Table 1.

Measurement tools

Standardized measurement tools were employed to assess the independent variable, dependent variable, and mediating variables in this study:

Perceived school climate Assessed using the scale developed by Jia et al. (2009) [52], which measures students' perceptions of their school environment. The scale includes 25 items scored on a 4-point Likert scale across three dimensions: Teacher Support (7 items), Peer Support (13 items), and Autonomy Opportunities (5 items). Higher scores indicate a more positive perception of the school climate. This scale has been validated in both Chinese and American adolescent populations [53, 54].

Negative emotions Measured using the Chinese version of the Depression-Anxiety-Stress Scale (DASS-21) validated by Gong et al. (2010) [55]. The scale includes 21 items scored on a 4-point Likert scale across three dimensions: Depression (7 items), Anxiety (7 items), and Stress (7 items). Higher scores indicate higher levels of negative emotions. The scale has demonstrated strong reliability and validity in Chinese adolescent populations [56, 57].

School belonging Assessed using the Chinese version of the School Belonging Scale, revised by Pan et al. (2011) [58]. The scale includes 18 items scored on a 5-point Likert scale across three dimensions: Belonging (7 items), Acceptance (8 items), and School Attachment (3 items). Higher scores indicate a stronger sense of school belonging [59–61].

Social avoidance and distress Measured using the Social Avoidance and Distress Scale developed by Watson and Friend (1969) [62]. The scale includes 28 items scored on a 2-point scale (1 = No, 2 = Yes), divided into two dimensions: Social Avoidance (14 items) and Social Distress (14 items). Higher scores reflect greater social discomfort and avoidance tendencies. This scale has been widely used and validated across different populations [63–65].

All reverse-scored items across the scales were adjusted to ensure consistency in positive scoring. The use of wellvalidated tools ensures the reliability and validity of the measurements in this study.

Data analysis procedure

Data analysis was conducted using SPSS 26.0 and AMOS 24.0.

Harman's single-factor test was conducted to assess common method bias, ensuring that the variance explained by a single factor did not exceed the critical threshold of 40%, thereby confirming the reliability of the data for subsequent analysis [66].

Descriptive statistics (mean, standard deviation) were calculated to examine the distribution of key variables, including perceived school climate, school belonging, social avoidance and distress, and negative emotions. Pearson's correlation analysis was employed to explore the relationships among these variables [67]. CFA was conducted to validate the measurement model for the four key variables: perceived school climate, school belonging, social avoidance and distress, and negative emotions. Model fit was assessed using χ^2/df , CFI, TLI, SRMR, and RMSEA. Alternative models (three-factor, two-factor, and one-factor) were compared with the hypothesized four-factor model to ensure the distinctiveness of the constructs[68].

To identify subgroup differences, independent sample t-tests and one-way ANOVA were used to assess variations across demographic groups, such as gender, grade level, and family location. Effect sizes (Cohen's d and Eta²) were reported to quantify the magnitude of observed differences [69].

Structural equation modeling (SEM) was performed in AMOS 24.0 to examine the proposed mediation model, which hypothesizes the mediating roles of school belonging and social avoidance and distress in the relationship between perceived school climate and negative emotions. The model's goodness-of-fit was evaluated using multiple indices, including the chi-square ratio (χ^2/df), comparative fit index (CFI), Tucker-Lewis index (TLI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA) with its 90% confidence interval. Bootstrapping with 2,000 resamples was used to test the significance of indirect effects and generate confidence intervals, providing robust evidence for the mediation hypotheses [70, 71].

Furthermore, multi-group invariance testing was conducted within the SEM framework to evaluate whether the structural relationships among perceived school climate, school belonging, social avoidance and distress, and negative emotions were consistent across demographic subgroups, namely gender and grade level. A stepwise approach was adopted to test for configural invariance, measurement invariance (equality of factor loadings), and structural invariance (equality of path coefficients, covariances, and residuals). Changes in model fit indices, particularly Δ CFI (<0.01), were used as the criterion to determine invariance across subgroups [72].

Result

Common method bias test

To assess the potential impact of common method bias, a principal component analysis was conducted using Harman's single-factor test. Eleven factors with eigenvalues greater than 1 were extracted, with the largest factor accounting for 26.14% of the total variance, which is below the critical threshold of 40%. This indicates that common method bias is not a significant concern in this study, suggesting minimal interference with subsequent analyses.

Variable	Μ	SD	α	Perceived school climate	School belonging	Social avoidance and distress	Neg- ative emo-
							tions
Perceived school climate	3.08	0.53	0.94	1.00			
School belonging	3.61	0.77	0.93	0.40**	1.00		
Social avoidance and distress	1.31	0.23	0.95	-0.40**	-0.53**	1.00	
Negative emotions	2.57	0.55	0.92	-0.42**	-0.57**	0.57**	1.00
Note: ** P<0.01							

Table 2 Descriptive statistics, internal consistency reliability, and correlation matrix of key variables

Table 3 Model fit indices for confirmatory factor analysis (CFA) of key variables

CFI	TLI	SRMR	RMSEA (90%CI)
0.951	0.946	0.027	0.050 (0.048–0.053)
0.969	0.964	0.022	0.050 (0.046-0.054)
0.976	0.974	0.025	0.034 (0.031–0.037)
0.972	0.969	0.025	0.039 (0.035–0.042)
	CFI 0.951 0.969 0.976 0.972	CFI TLI 0.951 0.946 0.969 0.964 0.976 0.974 0.972 0.969	CFI TLI SRMR 0.951 0.946 0.027 0.969 0.964 0.022 0.976 0.974 0.025 0.977 0.976 0.025

Descriptive statistics, reliability, and correlation analysis

The descriptive statistics, internal consistency reliability, and correlation matrix of the key variables are presented in Table 2. The mean (M) and standard deviation (SD) values indicate moderate levels of perceived school climate (M = 3.08, SD = 0.53) and school belonging (M = 3.61, SD = 0.77), while social avoidance and distress (M = 1.31, SD = 0.23) were relatively low. Negative emotions showed moderate scores (M = 2.57, SD = 0.55).

The internal consistency reliability for all key variables, as measured by Cronbach's α , demonstrated excellent reliability, with values ranging from 0.92 to 0.95. Specifically, perceived school climate ($\alpha = 0.94$), school belonging ($\alpha = 0.93$), social avoidance and distress ($\alpha = 0.95$), and negative emotions ($\alpha = 0.92$) all exceeded the recommended threshold of 0.70, indicating strong internal consistency.

The Pearson correlation coefficients revealed significant relationships between the variables at the p < 0.01level. Perceived school climate was positively correlated with school belonging (r=0.40) and negatively correlated with social avoidance and distress (r=-0.40) and negative emotions (r = -0.42). School belonging exhibited a significant negative correlation with social avoidance and distress (r = -0.53) and negative emotions (r = -0.57). Furthermore, social avoidance and distress were positively correlated with negative emotions (r = 0.57).

These results suggest that higher levels of perceived school climate and school belonging are associated with lower levels of social avoidance, distress, and negative emotions. The strong internal consistency reliability and significant correlations among variables support the validity of the measures and lay a foundation for subsequent structural model analyses.

Confirmatory factor analysis and model comparison

The results of the confirmatory factor analysis (CFA) and model comparison are presented in Tables 3 and 4. As shown in Table 3, the CFA results for the key variables demonstrated a satisfactory model fit. Specifically, perceived school climate (CFI=0.951, TLI=0.946, SRMR=0.027, RMSEA=0.050 [90% CI: 0.048-0.053]), school belonging (CFI=0.969, TLI=0.964, SRMR=0.022, RMSEA=0.050 [90% CI: 0.046-0.054]), social avoidance and distress (CFI=0.976, TLI=0.974, SRMR=0.025, RMSEA=0.034 [90% CI: 0.031-0.037]), and negative emotions (CFI=0.972, TLI=0.969, SRMR=0.025, RMSEA=0.039 [90% CI: 0.035-0.042]) all satisfied the fit indices thresholds (CFI/TLI>0.90, SRMR<0.08, RMSEA<0.05).

To further validate the construct structure, alternative factor models were compared, including the hypothesized four-factor model, three-factor model,

Table 4 Comparative fit indices for alternative factor structures of key constructs

	ve ne malees for alternativ		Luics of	Key constructs				
Model	Factor	χ2	df	∆χ 2 (∆df)	CFI	TLI	SRMR	RMSEA (90%CI)
Four-factor model	PSC, SCB, SAD, NEE	135.52	38	-	0.983	0.975	0.024	0.041 (0.034–0.049)
Three-factor model	PSC + SCB, SAD, NEE	858.06	41	722.53 (+3)	0.858	0.809	0.070	0.115 (0.108–0.122)
Two-factor model	PSC + SCB + SAD, NEE	1016.39	43	880.86 (+ 5)	0.831	0.784	0.075	0.123 (0.116–0.129)
One-factor model	PSC + SCB + SAD + NEE	1156.59	44	1021.06 (+6)	0.807	0.758	0.079	0.130 (0.123–0.136)

Note: PSC, Perceived School Climate. NEE, Negative Emotions. SCB, School Belonging. SAD, Social Avoidance and Distress. All $\Delta \chi$ 2 passed the significance test at 0.01 level

two-factor model, and one-factor model (Table 4). The results indicated that the four-factor model achieved the best fit ($\chi^2 = 135.52$, df = 38, CFI = 0.983, TLI = 0.975, SRMR = 0.024, RMSEA = 0.041 [90% CI: 0.034-0.049]). Compared with the four-factor model, the three-factor model ($\Delta \chi^2 = 722.53$, $\Delta df = 3$, CFI = 0.858, TLI = 0.809, SRMR = 0.070, RMSEA = 0.115), two-factor model ($\Delta \chi^2 = 880.86$, $\Delta df = 5$, CFI = 0.831, TLI = 0.784, SRMR = 0.075, RMSEA = 0.123), and one-factor model $(\Delta \chi^2 = 1021.06)$ $\Delta df = 6$, CFI = 0.807, TLI = 0.758, SRMR = 0.079, RMSEA = 0.130) showed significantly poorer fit, as evidenced by the increased chi-square values and decreased fit indices. The results of the $\Delta \chi^2$ tests confirmed that the differences between the four-factor model and the alternative models were statistically significant (p < 0.01).

Overall, the CFA results and model comparisons provide strong support for the hypothesized four-factor model, consisting of perceived school climate, school belonging, social avoidance and distress, and negative emotions. This model will serve as the foundation for subsequent structural equation modeling analyses.

Differences in key variables among demographic groups of adolescents

The results presented in Table 5 reveal significant differences in key variables across gender, grade, and family location.

For gender, females reported significantly higher scores than males in perceived school climate (t = -5.90, p < 0.001, Cohen's d = 0.52), school belonging (t = -2.16,

p = 0.031, Cohen's d = 0.77), and negative emotions (t = -2.96, p = 0.003, Cohen's d = 0.54). However, males reported significantly lower levels of social avoidance and distress (t = -2.34, p = 0.019, Cohen's d = 0.30).

For grade, significant differences were observed across all variables. Perceived school climate and school belonging showed a declining trend as grade level increased, with Grade 5 students reporting the highest scores (M = 3.20, SD = 0.52; M = 3.78, SD = 0.73) and Grade 9 students reporting the lowest scores (M = 2.90, SD = 0.51; M = 3.40, SD = 0.75). Conversely, social avoidance and distress, as well as negative emotions, increased with grade progression, peaking in Grade 9 (M = 1.37, SD = 0.31; M = 2.66, SD = 0.52). The overall differences across grade levels were statistically significant for perceived school climate (F = 13.21, p < 0.001), school belonging (F = 10.42, p < 0.001), social avoidance and distress (F = 8.86, p < 0.001), and negative emotions (F = 4.25, p = 0.002), with small to moderate effect sizes (Eta² ranging from 0.01 to 0.03).

For family location, rural students reported significantly higher perceived school climate (t = -4.42, p < 0.001, Cohen's d = 0.53) but slightly lower school belonging compared to urban students (t = 2.64, p = 0.008, Cohen's d = 0.27). No significant differences were found for social avoidance and distress or negative emotions.

These results suggest that demographic factors, particularly gender and grade, influence students' perceptions and emotional outcomes, while family location has a more limited impact.

 Table 5
 Descriptive statistics and differences across demographic variables for key variables

Demographic variables	Category	Perceived school climate		School	belonging	Social avoidance and distress		Negative emotions	
		м	SD	м	SD	м	SD	м	SD
Gender	Male	3.02	0.54	3.57	0.78	1.29	0.30	2.54	0.55
	Female	3.18	0.51	3.66	0.75	1.33	0.30	2.63	0.54
	t	-5.90		-2.16		-2.34		-2.96	
	Ρ	0.000		0.031		0.019		0.003	
	Cohen's d	0.52		0.77		0.30		0.54	
Grade	Grade 5	3.20	0.52	3.78	0.73	1.23	0.27	2.48	0.56
	Grade 6	3.07	0.54	3.67	0.76	1.30	0.29	2.58	0.57
	Grade 7	3.10	0.53	3.63	0.79	1.31	0.31	2.56	0.55
	Grade 8	3.10	0.53	3.55	0.79	1.32	0.30	2.59	0.53
	Grade 9	2.90	0.51	3.40	0.75	1.37	0.31	2.66	0.52
	F	13.21		10.42		8.86		4.25	
	Р	0.000		0.000		0.000		0.002	
	Eta ²	0.03		0.03		0.02		0.01	
Family location	Urban	3.02	0.55	3.66	0.74	1.32	0.30	2.58	0.55
	Rural	3.14	0.52	3.55	0.80	1.29	0.29	2.57	0.55
	t	-4.42		2.64		2.02		0.61	
	Ρ	0.000		0.008		0.043		0.544	
	Cohen's d	0.53		0.77		0.29		0.55	

Variables	School k	pelonging		Social avoidance and distress			Negative emotions		
	β	SE	t	β	SE	t	β	SE	t
Gender	-0.01	0.04	-0.22	0.12	0.01	5.51***	0.10	0.02	5.30***
Grade	-0.10	0.01	-4.19***	0.04	0.00	1.69	-0.03	0.01	-1.75
Family location	-0.11	0.04	-4.71***	-0.05	0.01	-2.51*	0.00	0.02	0.05
Perceived school climate	0.40	0.04	16.45***	-0.23	0.01	-9.77***	-0.18	0.02	-7.99***
School belonging				-0.45	0.01	-19.42***	-0.35	0.02	-14.81***
Social avoidance and distress							0.31	0.04	13.10***
F	82.86***			158.80***			207.86***		
R ²	0.18			0.35			0.45		
Adjust the R ²	0.18			0.34			0.45		

Table 6 Analysis of regression relationship of variables

Note: *P<0.05, ****P<0.001

Regression analysis of key variablestest

To further examine the relationships among demographic variables, perceived school climate, school belonging, social avoidance and distress, and negative emotions, hierarchical regression analyses were conducted. The results are presented in Table 6.

For school belonging, perceived school climate had a significant positive effect ($\beta = 0.40$, t = 16.45, p < 0.001), indicating that students who perceived a more positive school climate reported stronger feelings of belonging. In contrast, grade ($\beta = -0.10$, t = -4.19, p < 0.001) and family location ($\beta = -0.11$, t = -4.71, p < 0.001) had significant negative effects on school belonging, suggesting that belonging decreases as students advance in grade levels and is lower for rural students. Gender had no significant effect ($\beta = -0.01$, p > 0.05).

For social avoidance and distress, perceived school climate exerted a significant negative effect ($\beta = -0.23$, t = -9.77, p < 0.001), while school belonging demonstrated a strong negative association ($\beta = -0.45$, t = -19.42, p < 0.001). This suggests that a positive school climate and stronger school belonging can reduce students' social avoidance and distress. Gender also had a significant positive effect ($\beta = 0.12$, t = 5.51, p < 0.001), indicating that females experience higher levels of social avoidance and distress compared to males. Family location showed a marginally significant negative effect ($\beta = -0.05$, t = -2.51, p < 0.05).

For negative emotions, school belonging had a significant negative effect ($\beta = -0.35$, t = -14.81, p < 0.001), followed by social avoidance and distress, which had a strong positive impact ($\beta = 0.31$, t = 13.10, p < 0.001). Perceived school climate also negatively predicted negative emotions ($\beta = -0.18$, t = -7.99, p < 0.001), suggesting that positive perceptions of school climate reduce negative emotions. Gender showed a significant positive effect ($\beta = 0.10$, t = 5.30, p < 0.001), with females reporting higher levels of negative emotions.

The R^2 values indicate that the models explained 18% of the variance in school belonging, 35% of the variance

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Model Fit	χ 2/df	CFI	TLI	SRMR	RMSEA (90%CI)
Model	3.57	0.983	0.975	0.024	0.041 (0.034-0.049)

in social avoidance and distress, and 45% of the variance in negative emotions, demonstrating strong predictive power for the included variables.

In summary, perceived school climate and school belonging emerged as key protective factors that enhance school belonging and reduce social avoidance, distress, and negative emotions. Gender, grade, and family location were also important demographic predictors.

Mediating analysis

To examine the hypothesized relationships and mediation mechanisms between perceived school climate (PSC) and negative emotions (NEE), structural equation modeling (SEM) was conducted.

The model fit results are presented in Table 7. The overall model fit indices for the chain mediation analysis demonstrate a good fit to the data (χ^2/df =3.57, CFI=0.983, TLI=0.975, SRMR=0.024, RMSEA=0.041, 90% CI = [0.034–0.049]). These values meet the generally accepted criteria for a well-fitting model, supporting the validity of the hypothesized mediation framework.

While no post-hoc model modifications were performed, we evaluated the standardized residuals and residual covariances to confirm adequate model fit. The residual analyses did not indicate any significant misfit, with no standardized residuals exceeding the common thresholds of ± 1.96 . This provides additional evidence of the adequacy of the hypothesized model without the need for further adjustments or modifications.

The robust fit indices, combined with residual analysis results, confirm the appropriateness of the chain mediation model for examining the proposed relationships.

Figure 2 Illustrates the structural equation model, including all significant pathways in the chain mediation analysis. The results reveal that perceived school climate



Fig. 2 Structural equation model of the relationship between perceived school climate and negative emotions, mediated by school belonging, social avoidance and distress. All paths are significant at the 0.001 level

Table 8	Direct, indirec	t, and total effects	s in the multiple	e mediator model
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Path	Estimated	Boot SE	Р	Boot LLCI	Boot ULCI	Ratio
	effect					
Direct effect						
PSC→NEE	-0.13	0.04	0.000	-0.20	-0.06	23.64%
All indirect effects	-0.42	0.03	0.000	-0.47	-0.37	76.36%
PSC→SCB→NEE	-0.18	0.03	0.001	-0.23	-0.13	32.73%
PSC→SAD→NEE	-0.11	0.02	0.001	-0.16	-0.07	20.00%
PSC→SCB→SAD→NEE	-0.13	0.02	0.001	-0.18	-0.10	23.63%
Total effect	-0.55	0.03	0.000	-0.60	-0.50	100%

Note: PSC, Perceived School Climate. NEE, Negative Emotions. SCB, School Belonging. SAD, Social Avoidance and Distress. Boot LLCI, the lower bound of the 95% confidence interval (Percentile Bootstrap Method with Bias Correction). The Bootstrap sample size is set at 2000

has both direct and indirect effects on negative emotions, with school belonging and social avoidance and distress playing significant mediating roles.

Table 8 presents the direct, indirect, and total effects in the chain mediation model, specifically:

Direct Effect: The direct effect of perceived school climate on negative emotions is significant (β = -0.13, p < 0.001), accounting for 23.64% of the total effect, supporting Hypothesis 1 (H1).

Indirect Effects: PSC \rightarrow SCB \rightarrow NEE (β = -0.18, p < 0.001): The indirect effect through school belonging accounts for 32.73% of the total effect, supporting Hypothesis 2 (H2). PSC \rightarrow SAD \rightarrow NEE (β = -0.11, p = 0.001): The indirect effect through social avoidance and distress accounts for 20.00%, supporting Hypothesis 3 (H3). PSC \rightarrow SCB \rightarrow SAD \rightarrow NEE (β = -0.13, p < 0.001): The chain mediation effect through school belonging and social avoidance and distress accounts for 23.63% of the total effect, supporting Hypothesis 4 (H4). Total Effect: The total effect of perceived school climate on negative emotions is significant ($\beta = -0.55$, p < 0.001), demonstrating the combined impact of both direct and mediated pathways.

These findings reveal that the majority of the total effect (76.36%) operates through indirect pathways, underscoring the critical mediating roles of school belonging and social avoidance and distress. Specifically, school belonging (32.73%) and the chain mediation path (23.63%) account for substantial portions of the indirect effect.

To further clarify the distinct effects of perceived school climate (PSC) dimensions on negative emotions (NEE), an additional analysis was conducted by breaking down PSC into teacher support, peer support, and autonomy opportunities. The results are presented in Table 9.

The analysis shows that the total effect of teacher support on negative emotions is significant ($\beta = -0.39$, p < 0.001). The effect is predominantly indirect ($\beta = -0.32$, p < 0.001), accounting for 82.05% of the total effect, while the direct effect ($\beta = -0.07$, p = 0.004) contributes 17.95%. This indicates that teacher support primarily influences negative emotions through the mediating roles of school belonging and social avoidance and distress.

For peer support, the total effect is also significant (β = -0.40, *p* < 0.001). Interestingly, the indirect effect (β = -0.39, *p* < 0.001) accounts for 97.50% of the total effect, while the direct effect (β = -0.01, *p* = 0.634) is non-significant. This finding highlights that peer support reduces negative emotions almost entirely through its indirect pathways, reinforcing the importance of school belonging and social adjustment processes.

The results for autonomy opportunities reveal a balanced contribution of direct and indirect effects to the total effect ($\beta = -0.45$, p < 0.001). Specifically, the direct effect ($\beta = -0.21$, p < 0.001) accounts for 46.67%, while the indirect effect ($\beta = -0.24$, p < 0.001) explains 53.33%. This suggests that autonomy opportunities have both immediate and mediated impacts on reducing negative emotions, making them a critical component of perceived school climate. From Table 9, it is evident that peer support exhibits the strongest indirect effect (97.50%), followed by teacher support (82.05%), whereas autonomy opportunities show a relatively balanced contribution of direct and indirect effects. These findings emphasize the unique roles of the three dimensions: Peer support primarily influences negative emotions indirectly through its role in fostering school belonging and mitigating social avoidance and distress. Teacher support also relies heavily on indirect pathways but retains some direct impact on emotional outcomes. Autonomy opportunities exert both direct and indirect influences, highlighting their dual significance in the school environment.

The results demonstrate that while all dimensions of perceived school climate significantly reduce negative emotions, their mechanisms of influence vary. Peer support stands out as the most critical dimension, operating almost entirely through indirect pathways, whereas teacher support and autonomy opportunities combine both direct and indirect effects.

The findings confirm that perceived school climate significantly reduces adolescents' negative emotions through direct effects and multiple indirect pathways. The chain mediation effects involving school belonging and social avoidance and distress highlight the complex mechanisms underlying the relationship, providing robust support for Hypotheses 1 through 4.

Structural invariance testing across gender and grade

In previous studies, structural invariance testing methods were commonly employed to validate models [73–75]. In the present study, we adopted this well-established method to assess the universality and consistency of the research model across demographic groups such as gender and grade level. This approach provides robust empirical support for the stability of the relationships among perceived school climate, school belonging, social avoidance and distress, and negative emotions, ensuring their theoretical generalizability across diverse subgroups.

Table 9	Direct, indirect,	and total effect	ts of dimensior	ns of perceived	d school climate	on negative emotions
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Dimensions	Path	Estimated effect	Boot SE	Ρ	Boot LLCI	Boot ULCI	Ratio
Teacher support	Direct effect	-0.07	0.03	0.004	-0.12	-0.02	17.95%
	Indirect effects	-0.32	0.02	0.000	-0.36	-0.27	82.05%
	Total effect	-0.39	0.03	0.000	-0.44	-0.34	100%
Peer support	Direct effect	-0.01	0.03	0.634	-0.07	0.04	2.50%
	Indirect effects	-0.39	0.02	0.000	-0.43	-0.35	97.50%
	Total effect	-0.40	0.03	0.000	-0.45	-0.35	100%
Autonomy opportunities	Direct effect	-0.21	0.02	0.000	-0.25	-0.16	46.67%
	Indirect effects	-0.24	0.02	0.000	-0.28	-0.21	53.33%
	Total effect	-0.45	0.02	0.000	-0.50	-0.40	100%

Note: Boot LLCI, the lower bound of the 95% confidence interval. Boot ULCI, the upper limit of the 95% confidence interval (Percentile Bootstrap Method with Bias Correction). The Bootstrap sample size is set at 2000

 Table 10
 Testing for structural invariance across gender and grade

Variables	Model Constraints	χ 2/df	P	CFI	∆CFI	TLI	∆tli	SRMR	RMSEA (90%Cl)
Gender	Unconstrained	2.418	-	0.980	-	0.973	-	0.027	0.031 (0.025–0.036)
	Measurement weights	2.321	0.299	0.980	0.000	0.975	+0.002	0.029	0.030 (0.024–0.035)
	Structural weights	2.309	0.291	0.980	0.000	0.975	+0.002	0.029	0.029 (0.024–0.035)
	Structural covariances	2.324	0.150	0.979	-0.001	0.975	+0.002	0.034	0.030 (0.024–0.035)
	Structural residuals	2.264	0.258	0.980	0.000	0.976	+0.003	0.034	0.029 (0.024–0.034)
Grade	Unconstrained	1.474	-	0.984	-	0.977	-	0.035	0.018 (0.013–0.022)
	Measurement weights	1.382	0.819	0.985	+0.001	0.981	+0.004	0.038	0.016 (0.011–0.020)
	Structural weights	1.384	0.368	0.983	-0.001	0.981	+0.004	0.049	0.016 (0.012–0.020)
	Structural covariances	1.367	0.469	0.984	0.000	0.982	+0.005	0.050	0.016 (0.011–0.020)
	Structural residuals	1.351	0.461	0.984	0.000	0.983	+0.006	0.052	0.015 (0.011–0.019)

Applicability of structural invariance testing Structural invariance testing is a widely used and rigorous method within structural equation modeling (SEM) to verify whether a theoretical model remains consistent across groups. It allows researchers to test for measurement equivalence (i.e., the same latent constructs are being measured across groups) and structural equivalence (i.e., the strength of relationships between constructs is consistent). This method ensures the validity and reliability of cross-group comparisons.

Specifically, invariance testing involves a series of increasingly restrictive model comparisons: Configural invariance: Tests whether the same factor structure holds across groups. Measurement invariance: Verifies equivalence of factor loadings (measurement weights). Structural invariance: Tests whether structural paths, covariances, and residuals are consistent across groups.

This stepwise approach provides a clear framework for identifying differences in the measurement or structural properties of the model across subgroups.

Gender invariance testing As shown in Table 10, the unconstrained baseline model for gender achieved excellent model fit (χ^2/df =2.418, CFI=0.980, TLI=0.973, RMSEA=0.031). Measurement weights were invariant (Δ CFI=0.000, *p*=0.299), indicating that the observed variables equally measure their latent constructs across gender groups. Structural weights also showed invariance (Δ CFI=0.000, *p*=0.291), suggesting that the strength of relationships among key variables did not differ significantly between males and females. Structural covariances and structural residuals were similarly invariant (Δ CFI

= -0.001 and 0.000, respectively), confirming the consistency of the relationships at deeper levels.

These results indicate that the relationships among perceived school climate, school belonging, social avoidance and distress, and negative emotions are structurally consistent across gender groups.

Grade invariance testing For grade level, the unconstrained model also demonstrated excellent fit $(\chi^2/df = 1.474, \text{ CFI} = 0.984, \text{ TLI} = 0.977, \text{ RMSEA} = 0.018)$. The subsequent constrained models produced the following results: Measurement weights were invariant (Δ CFI = +0.001, p = 0.819), indicating that the factor loadings were equivalent across grade levels. Structural weights (Δ CFI = -0.001, p = 0.368) and structural covariances (Δ CFI = 0.000, p = 0.469) confirmed invariance in the relationships among latent constructs. Structural residuals also exhibited invariance (Δ CFI = 0.000, p = 0.461).

Thus, the findings indicate that the relationships between perceived school climate, school belonging, social avoidance and distress, and negative emotions are consistent across different grade levels.

Reflection on family location Although family location (urban vs. rural) was analyzed earlier (Table 5) to examine its relationship with key variables, structural invariance testing was not performed for this variable for the following reasons.

Conceptual rationale Family location was considered a contextual background factor rather than a core demographic characteristic influencing the structural rela-

tionships in the model. Unlike gender and grade, family location is less theoretically tied to the tested psychological pathways.

Statistical consistency Earlier regression analysis (Table 6) demonstrated that family location had no significant direct effects on negative emotions. While urban and rural samples are relatively balanced, the lack of significant effects suggests that conducting invariance testing would yield limited theoretical or statistical insights.

The results of the structural invariance testing confirm that the relationships among perceived school climate, school belonging, social avoidance and distress, and negative emotions are invariant across gender and grade. These findings support the robustness and stability of the proposed model across key demographic subgroups.

Discussion

Differences in key variables among demographic variables This study revealed significant differences in perceived school climate, school belonging, social avoidance and distress, and negative emotions across gender, grade, and family location. Gender differences showed that females reported higher perceived school climate, school belonging, and negative emotions than males, while males experienced lower levels of social avoidance and distress. These findings align with self-system processes theory, which suggests that females, due to higher social sensitivity [35], may benefit more from positive school environments but are also more prone to negative emotions when stressors are present. The decline in perceived school climate and school belonging across grade levels, coupled with increases in social avoidance, distress, and negative emotions, is consistent with stress and coping theory, which posits that developmental and social challenges in adolescence exacerbate stress and maladaptive coping responses, particularly in older students [40, 42]. For family location, rural students reported higher perceived school climate but slightly lower school belonging compared to urban students, possibly due to differing social and resource-based contexts, as explained by social support theory, which emphasizes the role of contextual resources in shaping emotional outcomes [23, 24]. These findings validate Hypotheses 1 and 2 regarding demographic influences and provide critical insights for targeted interventions.

Direct relationships between perceived school climate and negative emotions

The direct effect of perceived school climate on negative emotions was significant, supporting Hypothesis 1. This finding aligns with social support theory, which highlights the protective role of supportive environments in buffering against stressors and negative emotional outcomes [23, 24]. Positive school climates, characterized by teacher support, peer relationships, and autonomy opportunities, directly reduce negative emotions by fostering a sense of safety and acceptance. These results emphasize the immediate and independent benefits of enhancing school environments. In line with self-system processes theory, the findings also underscore that supportive contexts promote a sense of competence and relatedness, which are essential for emotional well-being. By identifying perceived school climate as a central protective factor, this study reinforces its critical role as a foundation for fostering positive psychological outcomes in adolescents.

Mediating roles of school belonging and social avoidance and distress

The mediation analysis provided strong evidence for the hypothesized pathways in Hypotheses 2, 3, and 4. School belonging and social avoidance and distress emerged as significant mediators between perceived school climate and negative emotions, with the chain mediation effect providing additional explanatory power. These findings align with self-system processes theory, which posits that school belonging fosters intrinsic motivation and emotional security, reducing negative emotional experiences [35, 36]. Similarly, the stress and coping theory explains the role of social avoidance and distress as maladaptive coping mechanisms that amplify emotional challenges, highlighting the need to address both social and emotional factors in interventions [43, 44].

The results also demonstrate that perceived school climate influences negative emotions indirectly through school belonging (32.73% of the total effect), social avoidance and distress (20.00%), and the chain mediation pathway (23.63%). This chain mediation effect reflects the interconnectedness of these factors, with perceived school climate enhancing school belonging, which in turn reduces social avoidance and distress, ultimately leading to lower negative emotions. The findings confirm that the majority of the total effect (76.36%) operates through indirect pathways, underscoring the critical mediating roles of school belonging and social avoidance and distress.

Further analysis of perceived school climate dimensions revealed distinct mechanisms of influence. Peer support exhibited the strongest indirect effect (97.50%), followed by teacher support (82.05%), while autonomy opportunities showed a more balanced contribution of direct (46.67%) and indirect effects (53.33%). These results underscore the importance of peer relationships in fostering school belonging and mitigating distress, as well as the dual role of autonomy opportunities in providing both immediate and mediated benefits. Collectively, these findings highlight the complex and multifaceted pathways through which perceived school climate shapes adolescents' emotional outcomes, providing robust support for Hypotheses 1–4.

Structural invariance across gender and grade

The structural invariance testing demonstrated that the relationships among perceived school climate, school belonging, social avoidance and distress, and negative emotions were consistent across gender and grade levels, supporting Hypothesis 4. These findings align with self-system processes theory, which suggests that the fundamental psychological mechanisms underlying school climate and emotional outcomes are universal and applicable across diverse groups. The stability of measurement and structural paths across gender and grade levels underscores the robustness of the proposed model and its generalizability to different demographic subgroups [33, 34].

While demographic differences in key variables were identified, such as females reporting higher levels of school belonging and older students experiencing increased social avoidance and distress, the invariance testing indicates that the underlying psychological pathways remain stable across groups. This finding provides confidence in the applicability of the model and reinforces the importance of developing inclusive and adaptable interventions that can address the unique needs of different subgroups without compromising their effectiveness.

Unique contributions of the study

This study makes several significant contributions to the literature. First, it integrates self-system processes theory, social support theory, and stress and coping theory into a unified framework to examine the relationships among perceived school climate, school belonging, social avoidance and distress, and negative emotions. By identifying a chain mediation effect, it advances the understanding of the complex mechanisms through which school environments influence emotional outcomes, providing new insights into the interplay of social and emotional factors.

Second, the study provides a nuanced analysis of perceived school climate dimensions, demonstrating that peer support plays a particularly critical role in fostering school belonging and reducing negative emotions. Teacher support and autonomy opportunities also emerged as significant factors, with autonomy opportunities showing a dual impact through both direct and indirect pathways. These findings highlight the need for comprehensive interventions that address multiple aspects of school climate to promote positive outcomes.

Third, the multi-group invariance testing adds methodological rigor by confirming the stability of the proposed model across gender and grade levels. This ensures the validity of the findings and their relevance to diverse adolescent populations, strengthening the study's theoretical and practical implications.

Finally, the study emphasizes the critical role of school belonging and social adjustment processes in shaping adolescents' emotional outcomes. By demonstrating that the majority of the effect of perceived school climate on negative emotions operates through indirect pathways, it highlights the importance of fostering both social connectedness and emotional resilience in school settings. These findings provide actionable insights for educators, policymakers, and mental health practitioners, offering a foundation for designing evidence-based interventions that promote adolescent well-being.

Implications for educational management and policy

Enhancing school climate

The findings of this study reaffirm the critical role of perceived school climate in reducing negative emotions among adolescents, both directly and indirectly through mediating pathways. Educational administrators should prioritize fostering positive school climates characterized by strong teacher support, peer relationships, and autonomy opportunities. Initiatives such as professional development programs for teachers to enhance supportive teacher-student interactions and peer relationship programs to prevent bullying and encourage inclusivity are essential. Additionally, providing students with opportunities for autonomy-such as participatory decisionmaking, leadership roles, and student-led activities-can further cultivate a supportive and resourceful school environment. These measures align with self-system processes theory, emphasizing the importance of nurturing students' psychological needs to promote well-being.

Strengthening school belonging

Given the mediating role of school belonging in the relationship between perceived school climate and negative emotions, targeted interventions to promote a sense of belonging are vital. Schools should implement programs that foster community building, such as team-based extracurricular activities, collaborative group projects, and peer mentoring systems. Celebrating diversity and amplifying student voices through inclusive practices can help students feel valued and accepted. For students experiencing challenges with social inclusion, personalized support from school counselors or structured peer support programs can reinforce their connection to the school community. These interventions resonate with social support theory, which highlights the importance of supportive networks in mitigating emotional challenges.

Addressing social avoidance and distress

Social avoidance and distress emerged as significant mediators in the pathways linking perceived school climate to negative emotions. To address these challenges, schools should integrate social-emotional learning (SEL) programs into the curriculum, equipping students with skills to manage their emotions, build positive relationships, and navigate interpersonal conflicts. Counseling services should be made accessible to support students struggling with social anxieties or peer conflicts. Early identification mechanisms, such as teacher observations or peer referrals, can help at-risk students receive timely interventions. By addressing these social and emotional barriers, schools can reduce the adverse impact of social avoidance and distress on students' mental health, as explained by stress and coping theory.

Gender-sensitive strategies

The study identified gender differences in the strength of relationships among key variables, emphasizing the importance of gender-sensitive approaches. For male students, interventions focusing on activities that directly enhance school belonging, such as team sports, collaborative problem-solving, and hands-on learning projects, may foster stronger connections to the school community. For female students, targeted efforts to reduce social avoidance and distress are crucial. Structured peer support groups, mentorship programs, and facilitated discussions addressing social challenges can provide safe spaces for females to navigate interpersonal issues. Policymakers should consider incorporating gender-specific mental health strategies within broader school programs to ensure equitable support for all students.

Monitoring and evaluation

The importance of perceived school climate and its mediating pathways calls for continuous monitoring and evaluation within schools. Regular assessments of school climate, school belonging, social avoidance, and emotional well-being should be implemented through annual surveys, focus groups, or teacher feedback. These datadriven approaches can help schools identify problem areas, assess the impact of implemented interventions, and allocate resources effectively. Monitoring should also consider subgroup differences, such as gender and grade level, to ensure that programs address the specific needs of diverse student populations.

Promoting equity across demographics

The observed demographic differences, particularly between gender and grade levels, underscore the need for equity-focused policies. While rural schools reported more favorable perceptions of school climate, urban schools often face distinct challenges, such as larger and more diverse student populations. Learning from the community-oriented practices of rural schools could help urban schools foster stronger student connections. Simultaneously, additional resources should be allocated to urban schools to address these challenges. For gradelevel differences, transitions to middle or high school should receive targeted attention. Programs designed to ease these transitions, such as peer mentorship, orientation programs, and emotional resilience workshops, can help mitigate the decline in school belonging and the rise in social avoidance and negative emotions observed in higher grades.

Leveraging the study's findings for policy and practice

The study's findings offer actionable insights into the mechanisms linking school climate, school belonging, social avoidance and distress, and negative emotions. By integrating evidence-based strategies aligned with self-system processes theory, social support theory, and stress and coping theory, educational administrators can develop holistic approaches that address both the social and emotional needs of students. These strategies not only enhance students' academic performance but also nurture their emotional resilience and well-being, preparing them to thrive in school and beyond.

In summary, implementing these targeted, evidencebased policies and interventions can help create supportive school environments that reduce negative emotions, foster belonging, and address social challenges, ultimately contributing to adolescents' overall well-being and success.

Limitations and future directions

This study has several limitations that should be acknowledged, along with suggestions for future research.

First, while the study design relies on cross-sectional data, which may traditionally limit causal interpretations, the theoretical frameworks employed-Self-System Processes Theory, Social Support Theory, and Stress and Coping Theory-provide strong justification for the hypothesized directional relationships. Moreover, the structural equation modeling (SEM) approach allowed a detailed examination of both direct and indirect effects. To strengthen the understanding of these relationships, future studies could adopt longitudinal designs to confirm the temporal associations between perceived school climate, school belonging, social avoidance and distress, and negative emotions. Analytical methods such as crosslagged panel modeling could further clarify bidirectional effects and address potential feedback loops among these variables [76, 77].

Second, the reliance on self-reported data introduces potential biases, such as social desirability and common method variance. Although Harman's single-factor test indicated minimal common method bias, self-reported measures inherently reflect subjective perceptions. To improve the robustness of future research, additional data sources, such as teacher evaluations, peer assessments, or behavioral observations, could be incorporated. These complementary perspectives would provide a more holistic understanding of the relationships among the key variables.

Third, the study sample was limited to students in grades 5–9 from China, potentially constraining the generalizability of the findings to other age groups, educational stages, and cultural contexts. For example, school climate and emotional well-being are shaped by cultural norms, educational policies, and societal values that vary across countries. Replication studies in diverse cultural and educational settings would help confirm the universality of the observed relationships and identify any cultural nuances or age-specific patterns.

Fourth, while this study examined the subdimensions of perceived school climate—teacher support, peer support, and autonomy opportunities—and their unique effects, additional mediating and moderating factors were not explored. Variables such as parental involvement, peer relationships, academic stress, or individual traits like resilience and self-efficacy may also contribute to the pathways linking school climate to emotional wellbeing. Future research should incorporate these factors to provide a more comprehensive understanding of how school climate interacts with personal and contextual elements to influence emotional outcomes.

Fifth, the study identified significant gender differences in structural relationships, suggesting that male and female students may experience school climate and emotional well-being differently. However, the mechanisms underlying these differences remain unclear. Gendered expectations, differences in socialization, and variations in coping strategies may contribute to these findings. Qualitative approaches, such as interviews or focus groups, could provide deeper insights into these genderspecific patterns and inform the development of tailored interventions that address the unique needs of male and female students.

Sixth, this study focused primarily on immediate emotional outcomes, such as negative emotions, without considering the potential long-term impacts of perceived school climate and related mediators. For instance, the influence of school climate and belonging on academic success, career development, and adult mental health remains unclear. Longitudinal studies following students over time could help clarify how early school experiences shape developmental trajectories and long-term well-being.

Seventh, while this study highlighted the importance of school climate and its subdimensions, it did not examine

how interventions targeting these aspects could be effectively implemented or evaluated. Future research could design and test specific programs aimed at improving teacher support, fostering positive peer interactions, and promoting autonomy opportunities. Experimental or quasi-experimental designs could provide evidence on the effectiveness of these interventions in reducing negative emotions and enhancing overall student well-being. Moreover, implementation studies could explore the feasibility and scalability of such interventions across different educational settings.

By addressing these limitations, future research can provide a deeper and broader understanding of the complex relationships between school climate, school belonging, social challenges, and emotional well-being. These efforts will also enhance the evidence base for developing interventions and policies aimed at fostering healthier and more supportive school environments for adolescents.

Conclusion

In summary, this study underscores the critical role of perceived school climate in shaping adolescents' negative emotions through both direct and indirect pathways, mediated by school belonging and social avoidance and distress. The distinct contributions of teacher support, peer support, and autonomy opportunities highlight the multifaceted nature of school climate, with peer support emerging as the most impactful. While demographic differences such as gender and grade influenced variable levels, structural invariance testing confirmed that the relationships among key variables remain stable across groups. These findings emphasize the interconnectedness of social and emotional factors and provide valuable theoretical and practical insights for educators and policymakers to foster supportive school environments and promote emotional well-being among adolescents.

Supplementary Information

The online version contains supplementary material available at https://doi.or g/10.1186/s40359-025-02364-1.

Supplementary Material 1
Supplementary Material 2
Supplementary Material 3
Supplementary Material 4
Supplementary Material 5
Supplementary Material 6
Supplementary Material 7
Supplementary Material 8

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Author contributions

Chen W.: Conceptualization, Writing - original draft, Funding acquisition, Investigation, Supervision. Huang Z.: Methodology, Data analysis, Visualization, Writing - review & editing. Peng B.: Data curation, Project administration, Investigation, Writing - review & editing. Hu H.: Supervision, Validation, Writing - review & editing. All authors have read and approved the final manuscript.

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Data availability

All data generated or analysed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate

This study strictly adhered to the Helsinki Declaration and relevant national and institutional guidelines. Ethical approval was obtained from the Ethics Committee of Chengdu Sport University (Approval No. CTYLL2024014). As the participants were adolescents, written informed consent was obtained from their guardians, and verbal assent was obtained from each participant prior to their involvement in the study. All data were collected and analyzed anonymously to protect participant privacy and ensure confidentiality.

Competing interests

The authors declare no competing interests.

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