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The chain mediating effect of friendship quality and learning engagement on school climate and primary school students' academic resilience

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AbstractAgainst the backdrop of rising focus to the study of academic resilience, there is still a dearth of relevant exploration for rural primary school students. Focusing on the influencing mechanisms of academic resilience in rural students not only helps children grow, but also contributes to narrowing the urban-rural education gap, thereby realizing educational equity. To explore the specific mechanism of school climate on the academic resilience of primary school students, this study investigated 316 primary school students in Gansu Province, China by using the school climate scale, the academic resilience scale, the friendship quality scale and the learning engagement scale. The results indicate that: (1) school climate has a positive predictive effect on the academic resilience of primary school students; (2) Friendship quality and learning engagement are mediating variables between school climate and primary school students' academic resilience, respectively; (3) Friendship quality and learning engagement play a chain mediated role between school climate and primary school students' academic resilience. This study empirically reveals the mechanism by which school climate affects academic resilience, providing theoretical basis and practical reference for promoting the development of academic resilience among rural primary school students.
Keywords: School climate, Academic resilience, Friendship quality, Learning engagement

In today's era of dramatic change and profound uncertainty, resilience has become a key trait for individuals to adapt to change, cope with academic stress, interpersonal tension, family problems, and other challenges, as well as to achieve success[1]. Among the multiple types of resilience, academic resilience is particularly important because it plays a key role at an early stage of an individual's growth[2]. As a positive belief generated in academic challenges, it not only helps students build confidence and achieve academic success[3], but also fosters empathy, emotional regulation, communication skills, and problem-solving abilities—all of which contribute to their overall physical and mental well-being[4]. In the long run, strong academic resilience will also transfer into higher career adaptability and maturity, which will be the key to supporting students' outstanding long-term development in their future careers[5].

Currently, academic resilience has gained a lot of attention from educators[6]. It refers to the ability of students to achieve greater academic results than expected in the face of negative events, complex challenges or adversities, demonstrating the ability to recover and adapt quickly, and consists of two main components: adversity and positive adaptation[7]. Students' academic resiliency in some countries, however, appears to be bleak. Just 11.88%, 5.96%, and 6.45% of students in France, Francophone Belgium, and Malta are academically resilient[8].

In contrast, Chinese students demonstrate strong academic resilience, with students in the underdeveloped rural areas of western China being particularly notable[9]. For example, Huining County, a national-level poor county located in Gansu Province, China, has been drought-stricken for ten years, severe water shortage, lack of resources, and extremely poor natural conditions, which has been evaluated by UNESCO as "unsuitable for human habitation"[10]. Despite its poverty，the county has produced more than 1,500 individuals with doctorate degrees and is celebrated as the "home of top scholars and a cradle of Ph.D.s ."[11] According to China News Service[12], the key for these students to overcome poverty and achieve a successful future may lie in their faith in fate and incredible resilience. What are the key factors that enable rural students to develop academic resilience amid such extreme economic hardship and adverse living conditions?

According to Bronfenbrenner's[13] social ecological system theory, children's development is a complicated process caused by their interactions with numerous layers of ecological surroundings. Although both family and school play indispensable roles in children's growth, when families are in a disadvantaged position, schools become the key place to make up for the lack of academic support from families and play an important role in shaping children's academic resilience[14]. In this context, a positive school climate is particularly important.

Regrettably, there is currently a dearth of research that focuses on primary school students in rural areas. The educational gap between urban and rural areas is made worse by the neglect of this sizable and vulnerable group of rural children, which also makes it more difficult to attain educational equity[15]. Against this backdrop, this study concentrates on rural primary schools, specifically those in impoverished areas of Northwest China. The aim is to explore the impact mechanism of school climate on the academic resilience of rural primary school students, in order to lay the foundation for effective supportive interventions.

It should be mentioned that the term "rural primary schools" in this study refers to public schools located outside of the administrative boundaries of cities and in relatively isolated rural areas, which primarily educate school-age children from local rural registered resident primary schools[16]. In comparison to urban primary schools, these schools lack campus resources (such as land and buildings) and teaching resources (such as teachers, extracurricular reading materials, and equipment), and the regional environmental conditions (such as student density and commuting convenience) are frequently poor, making them disadvantaged[17].

Literature Review and Hypotheses

Effect of school climate on academic resilience

Bronfenbrenner's bioecological theory, specifically the Process-Person-Context-Time (PPCT) model, posits that individual development arises from the ongoing interaction of four elements: process, person, context, and time[18]. Within this framework, "proximal processes"—defined as the enduring, progressively more complex reciprocal interactions between an individual and their immediate environment—serve as the primary driving force of development[19]. As one of the most critical and enduring microsystems during childhood and adolescence, the school and its overall climate constitute the essential context in which these proximal processes can occur with both high quality and regularity. This underscores the need to investigate the

impact of school climate on the development of academic resilience in primary school students.

School climate refers to the quality and characteristics of school life[20], which includes teacher-student relationship, peer relationship, group cohesion, campus environment, campus order, discipline and rules, school security and sense of belonging, teaching resources, teachers' incentives, teachers' expectations and other important aspects[20].

A healthy school climate has been generally demonstrated to have a positive impact on the growth of primary kids[21]. According to research, a self-supporting school climate can stimulate students' stronger autonomy motivation, making them more willing to engage in deep thinking when faced with tasks that interest them, and they often have stronger willpower[22]. A peer-supportive school climate can minimize absenteeism among primary school children by improving satisfaction, as well as promote their passion for communicating with their peers[23].

When facing academic pressure, students may release their emotions, but high-quality teacher-student interaction can successfully alleviate the negative aspects of the overall atmosphere of primary school[24] and help them see difficulties as a way to improve abilities and cultivate their attitude of actively adopting strategies to solve academic problems[25].

In addition, compared to students with weaker adaptability to the school, students who have favorable impression of the school climate show stronger academic resilience[26]. It can be seen that a positive school climate, by regulating risk factors, may have a positive impact on students' academic resilience. Therefore, the research hypothesis H1 is proposed: school climate will be positively associated with the primary school students' academic resilience.

The mediating effect of friendship quality between school climate and academic resilience

According to social support theory, emotional, informational, or material assistance from spouses, siblings, friends, neighbors and other social networks, can help individuals effectively relieve stress[27], enhance health and happiness, and meet challenges[2829,30]. Significant changes in social emotions, peer identity seeking, and participation are hallmarks of adolescence. At this point, students spend a lot of time interacting closely with their peers[31]. Therefore, peer relationships play an important role in the learning and development of teenagers[32,33]. From this perspective, friendship support characterized by emotional care and peer companionship may have an important impact on students' academic resilience[34,35]. An important indicator to assess the quality of friendship is called friendship quality[36], referring to the characteristics of an interdependent relationship formed freely by individuals and friends in order to attain social-emotional goals[37]. Low-quality friendships are characterized by conflict, competitiveness, bullying, aggressive and

destructive behavior, and so on[38]. High-quality friendships are linked to positive interpersonal interactions such as prosocial behavior, intimacy, and loyalty[39].

Research shows that less reciprocal friendship experience may make primary school students have negative self-awareness and lower self-worth perception, and they are more likely to give up when they encounter academic difficulties[40]. However, when completing complex academic tasks, the help provided by good friends through group learning, sharing notes, or one-on-one explanation can help difficult peers build self-confidence, enhance communication skills, and enhance academic resilience[41]. The success of close friends in challenging academic tasks will also make students believe that they also have the ability to succeed[42]. In addition, peer support is not only a rich and direct source of assistance to improve students' problem-solving skills when students have academic difficulties, such as complex problems or concepts that need to be clarified[43,44], but also can help students establish a stable support relationship and promote their long-term mental health[45]. For example, the care, encouragement, support and expectation from friends can help students effectively manage negative emotions to a certain extent, reduce their anxiety in math tasks[46], reduce their academic pressure and academic burnout[47,48], and ultimately improve their academic resilience[49].

The researchers also found that if students live in a good school climate, the intimate relationship between peers will have a greater impact on their success in academic tasks[42]. Therefore, the friendship quality of primary school students may be affected by the school climate. Social identity theory also supports this view. The theory points out that the self social identity defined by individuals in social groups will affect their attitudes[50], behaviors and interactions between groups. Social identity is generated from an individual's association with the group or social category to which he belongs[51]. Identity is the assimilation of group membership into one's self-concept via cognitive and emotional processes. If people care about the groups to which they belong (i.e., inner groups), they will be driven to highlight their uniqueness and seek to preserve, protect, or increase the value of the groups and their members[52].

Primary school students rely heavily on schools for social interaction. A positive school environment fosters kids' sense of group identity by making them feel safe, respected, and protected[53,54]. The drive to create their identity makes it easier for children to have a stable peer connection network[55], and more likely to frequently study with friends or share motivational ideas, such as common goals and values[56]. Relevant empirical studies have found a link between the school climate and friendship quality[55,57,58]. On the contrary, the school climate full of low expectations, stereotypes, constraints, ridicule, discrimination, isolation, punishment, and other characteristics will lead to exclusion and disgust for the class and negative identity[59], and then more likely to show

behaviors that undermine the friendship quality, such as noncompliance with class rules[60]. To summarize, because school climate has a positive impact on friendship quality, and friendship quality predicts academic resilience. Therefore, the research hypothesis H2 is proposed: friendship quality will mediate the relationship between the school climate and primary school students' academic resilience.

The mediating role of learning engagement between school climate and academic resilience

According to social stratification theory[61], the hierarchical differentiation of social identity and economic status often places underprivileged children at a disadvantage in terms of family cultural capital—such as mainstream language patterns, knowledge reserves, and behavioral habits[62]. This disparity in starting points makes them more susceptible to "symbolic violence" within the education system[63,64], where educational practices unconsciously preset the culture of the privileged class as the standard, thereby exacerbating their academic struggles. However, schools serve as pivotal arenas for breaking this vicious cycle. High-quality schools can create conditions for resilience among disadvantaged students by providing equitable growth environments, active social support networks, and systematic cultural capital supplementation[65]. Yet static environmental resources do not automatically translate into academic outcomes. Only through deep engagement with supportive school climate and sustained, focused academic practice can disadvantaged children internalize external support into their own learning motivation and capabilities[66]. This enables them to overcome structural limitations from home, reshape learning goals, attitudes, and behavioral habits, and ultimately develop academic resilience—the capacity to persevere and achieve academic success despite adversity. Therefore, learning engagement may serve as the core mediator in the relationship between school climate and primary students' academic resilience[67].

Learning engagement refers to the positive, fulfilling, and sustained state of mental focus students exhibit during the learning process[68,69]. Empirical research indicates that learning engagement positively predicts academic resilience among students in socially disadvantaged positions[70]. Martin et al.[70] found that affective engagement within learning engagement showed little correlation with academic resilience, whereas behavioral and cognitive engagement exerted significant influence—with behavioral engagement demonstrating greater impact. Specifically, high levels of behavioral engagement—such as regular school attendance or active participation in classroom

discussions—extend students' exposure to systematic instruction and learning activities[71]. This increased access to teacher support and other academic resources within the school environment helps develop their critical thinking skills and specific abilities to navigate academic challenges[70]. In terms of cognitive engagement, future academic expectations, as an important component, will drive students to exhibit adaptive learning behaviors, such as active learning, overcoming difficulties,, etc., thereby strengthening their learning resilience[72].

Currently, research directly examining the positive impact of learning engagement on academic resilience remains limited, though its crucial role in psychological resilience has been widely demonstrated. A study of preschool education undergraduates revealed that students' psychological resilience increases with higher levels of learning engagement, with psychological resilience mediating the relationship between learning engagement and professional identity[73]. For military academy students, high-level engagement behaviors such as punctual attendance in theoretical courses not only promote systematic mastery of military and cultural knowledge but also help them accumulate rich experiences through interactions with instructors and peers. This prepares them to cope with dual pressures from academics and training, thereby enhancing psychological resilience[74]. Research on upper-grade primary students similarly reveals a positive relationship between learning engagement and psychological resilience[75]. Since academic resilience is a key manifestation of psychological resilience, these studies indirectly demonstrate the close relationship between learning engagement and academic resilience among primary school students.

In terms of the relationship between school atmosphere and primary school students' learning engagement, research has shown that in a warm and sustainable school environment, students' perceptions of autonomy-supportive behaviors, such as attention and autonomy from teachers, can provide them with social and academic assistance, are closely related to their engagement in learning, as well as higher learning outcomes[76]. Research addressing physical education further points to the positive atmosphere created by teachers and peers, such as positive peer evaluations, as one of the key factors in motivating students to participate in physical activities[77]. Positive teacher-student relationships also helps teenagers to persist in their studies, such as less absenteeism, and dropping out of school[78]. In conclusion, because school climate positively influences learning engagement and learning engagement positively predicts academic resilience. Therefore, the research hypothesis H3 is proposed: learning engagement will mediate the relationship between the school climate and primary school students' academic resilience.

The chain mediating role of friendship quality and learning engagement between school climate and academic resilience

The theory of social capital posits that the relational networks of individuals or groups constitute a form of valuable capital, which facilitates access to resources, information, and support, thereby promoting goal attainment[79]. In the context of education, the friendship networks of primary school students serve as a significant vehicle for such social capital[80,81]. Through peer interactions grounded in trust and norms of reciprocity, students are able to obtain academic resources, emotional support, and behavioral guidance[82]. This, in turn, lowers the perceived cost of academic effort and enhances both the sustainability and depth of learning engagement[83]. Thus, the quality of friendships may play a important role in students' academic involvement.

High-quality friendships provide students with security, encouragement, resource sharing, positive feedback and conflict resolution, and confidences[84].These positive experiences form a crucial emotional foundation that not only directly fosters academic engagement but also moderates the negative impact of anxiety on learning motivation and cognitive ability[85]. Consequently, this reciprocal process enhances both academic commitment and performance[86].In addition, primary school students are able to enhance their cooperation, communication, and problem-solving skills in their interactions with friends[87], skills that are equally important in their social adjustment and academic engagement. Therefore, the research hypothesis H4 is proposed: friendship quality and learning engagement may serve as chain mediators in the relationship between school climate and primary school students' academic resilience.

Method

Participants and Procedure

The survey targeting fourth- to sixth-grade primary school students was conducted in November 2024. To ensure the sample schools were situated in typical rural settings, the study focused on Linxia Hui Autonomous Prefecture, Gansu Province, China, a region characterized by its rural socioeconomic status.

We submitted the research proposal to the local Education Bureau administrators to secure their support. Based on considerations of research feasibility and sample representativeness, the local education

bureau has recommended several candidate schools that reflect the current state of education in impoverished rural areas. Following a thorough review, we chose schools A, B, and C as research samples, employing a cluster convenience sampling technique.This means that after the school samples, all primary school children in grades 4-6 will be sampled as well.

School A is typical of rural schools in distant mountainous places; it is located in Jishishan County's mountains. According to media sources, the difficult terrain and bad transportation have been the most significant barriers to Jishishan's development[88]. The county only got its first expressway to the city center in November 2023[89]. In the area where School A is located, there are no public buses or school buses. Primary school students either walk long distances or are transported by their parents on electric scooters.

School B is a typical rural school with insufficient resources, located in Kangle County. The county's economic development has been lagging behind for a long time, and its per capita GDP ranks low in the province. The limited local financial resources have resulted in relatively poor educational conditions. The teaching facilities in schools are relatively rudimentary, and there is also a shortage of teaching staff.

School C is located in Guanghe County and is a typical rural school in an ethnic minority settlement area. The ethnic minorities in the county are highly concentrated, accounting for over 98% of the total population. The manifestation of this weakness at the school level is the scarcity of high-quality teaching resources, traditional social and cultural concepts, and almost no parental involvement in school education.

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and received approval from the Research Ethics Committee of the College of Education Science, Northwest Normal University (approval no: 2024-1030). Informed consent was obtained from all participating schools, and provided a thorough explanation of the research's objective, importance, and process. At the same time, written informed consent was obtained from all subjects and their parents.

This study was conducted in strict accordance with academic ethical standards. The research team comprised postgraduate students in education who had received professional training. During data collection, three staff members were assigned to each classroom for supervision. Prior to distributing the questionnaires, the staff read the survey guidelines aloud to the students, explaining that the data would be used solely for academic research and school improvement. The questionnaires were anonymous, and we ensured the complete confidentiality of all data, with no personal information being shared. Participation was entirely voluntary. Participants have the right to withdraw at any time. After reading the guidelines, students must

complete the questionnaire independently within 40 minutes and do a completeness check after answering all of the questions to verify there are no omissions.As a token of appreciation, after submitting the questionnaire, participants were given three learning tools (ruler, cartoon pen, and file bag).

For this survey, we distributed 391 questionnaires (paper-based) and collected 340.After screening out invalid responses, we retained 316 valid questionnaires, resulting in an effective response rate of 92.94%. This high rate thus supports the representativeness of the sample. The age distribution exhibits a certain degree of diversity, among which there is 1 student aged 8 (0.32%), 4 students aged 9 (1.27%), 54 students aged 10 (17.09%), 105 students aged 11 (33.23%), 113 students aged 12 (35.76%), 36 students aged 13 (11.39%), and 3 students aged 13 or above (0.95%). In terms of the grade distribution, there are 46 students in the fourth grade (14.56%); 136 students in the fifth grade (43.04%); and there are 134 students in the sixth grade (42.41%). Regarding the regional distribution, 121 students (35.6%) were from Guanghe County, 112 students (32.9%) were from Jishishan County, and 107 students (31.5%) were from Kangle County. Regarding the gender distribution, there are 150 male students (47.47%) and 166 female students (52.53%). In terms of the educational attainment of parents, 244 (77.22%) have fathers with an educational level of junior high school or below, and 246 (77.85%) have mothers with an educational level of junior high school or below.

Measures

School climate scale

This research referred to the study on school climate by Jia et al. and employed the school climate scale they developed[90]. This scale has been utilized by Chinese scholars such as Zhao Liang[91], and its reliability and validity have been verified to be excellent. The scale consists of 25 questions and is composed of 3 factors: teacher support (7 items, such as "The teacher believes I can do well"); support among students (13 items, such as "students help each other"); classroom autonomy opportunities (5 items, such as "students help decide how to utilize class time"). The questions were graded on a Likert scale ranging from 1 (never) to 4 (always). The higher the scale' s total score, the more positive the school climate perceived by the students. In this study, the Cronbach's α coefficient of the scale was 0.90, indicating good internal consistency.

Friendship quality scale

The friendship quality scale used in this study was adapted by Katie Davis from the Peer Trust subscale of the Inventory of Parent and Peer

Attachment (IPPA)[92], originally developed by Armsden and Greenberg[93]. This scale has been employed by Chinese scholars such as Fan Xinghua and Li Weiwei, and its reliability and validity have been confirmed[94,95]. The scale encompasses a total of 14 items and is constituted by four factors: trust (6 items, such as "My friends understand me"), communication (4 items, such as "My friends will listen to what I have to say"), alienation (including 1 item, such as "I wish I had different friends", reverse-scored), and reciprocity (3 items, such as "When my friends need to confide in someone, they can rely on me")[96]. The items were scored on a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) . The higher the total score of the scale, the better the friendship quality of the students. In this research, the Cronbach's α coefficient of the scale was 0.95, suggesting excellent internal consistency.

Learning engagement scale

This study employed the Utrecht Work Engagement Scale for Students (UWES-S), developed by Schaufeli[97]. This scale has been widely used by Chinese researchers, such as Xuhui, and has demonstrated strong reliability, validity, and cultural adaptability within the Chinese context[98]. The scale contains 14 items and is divided into three categories: vitality (5 items, such as "When I study, I feel brimming with energy"); dedication (5 items, such as "I find my study replete with meaning and purpose"); and concentration (4 items, such as "When I study, I forget everything around me"). The items were scored on a Likert scale ranging from 1 (never) to 7 (always) . The higher the total score of the scale, the greater the level of students' learning engagement. In this research, the Cronbach's α coefficient of the scale was 0.901, suggesting favorable internal consistency.

Academic resilience scale

This study drew upon the research findings of Clark and Malecki regarding academic resilience and employed the academic resilience scale they developed[99]. This scale has been utilized by Chinese scholars including Rongmao Lin[100], and its reliability and validity have been attested to be satisfactory. The scale encompasses 10 questions and is constituted by 3 factors: determination (5 items, such as "Once I set a goal at school, I will endeavor to overcome any challenges that emerge"); resilience (3 items, such as "Regardless of how difficult the homework is, I will complete it"); concentration (2 items, such as "Even if I could do something more amusing, I will exert my utmost efforts to finish my schoolwork first"). The items were scored on a Likert scale ranging from 1 (utterly unlike me) to 5 (very much like me). The higher the total score of the scale, the greater the level of students' academic resilience. In this research, the Cronbach's α coefficient of the scale was 0.73, suggesting

relatively good internal consistency.

Statistical analyses

The specific procedures were as follows. First, Excel was used to process the questionnaire data, which included checking for and removing missing or anomalous data. Secondly, SPSS 21.0 was used for bias test and Pearson correlation analysis. The former was used to avoid common method bias problems, while the latter was used to examine the relationship between school climate, academic resilience, friendship quality, and learning engagement.Then, a mediation analysis was performed using the Model 6 of the PROCESS macro for SPSS, and the significance of the mediation model was tested using the Bootstrap method. Finally, the conceptual model diagram was created using ProcessOn.

Results

Common method variance test

Harman's single-factor test was employed to assess the potential of common method bias[101]. The data analysis results showed that the explained variance of the first factor was 20.005%, which was less than the critical standard of 40%, indicating that the data in this study had no severe common method bias, meeting the requirements for subsequent analyses.

Descriptive and correlation analysis

Table 1 presents the correlation coefficients and significance levels for the variables under study. As demonstrated, there was a significant correlation between most variables (Table 1), with the exception of gender and age. School climate is significantly positively correlated with friendship quality ($r = 0.469$, $p < 0.01$), learning engagement and academic resilience ($r = 0.438$ and $r = 0.454$, $p < 0.01$). Friendship quality is significantly positively correlated with learning engagement ($r = 0.325$, $p < 0.01$) and academic resilience ($r = 0.417$, $p < 0.01$). Learning engagement is significantly positively correlated with academic resilience ($r = 0.509$, $p < 0.01$).

Item	1	2	3	4	5	6	M	SD
1 Gender	—						1.528	0.506
2 Age	-0.064	—					11.408	0.993
3 School climate	0.070	-0.055	—				2.858	0.41
4 Friendship quality	0.012	-0.115*	0.469**	—			5.075	1.091
5 Learning engagement	0.067	-0.074	0.438**	0.325**	—		4.243	1.098
6 Academic resilience	0.124*	-0.125*	0.454**	0.417**	0.509**	—	3.645	0.524

Table 1. Correlation coefficients of study variables (n=316) $*P<0.05, **P<0.01, **P<0.001$ (The same applies hereinafter)

Examination of the chain mediation effect

Following Wen and Ye's[102] method for testing moderated mediation models, we used the Model 6 of the PROCESS macro for SPSS, extracted 5000 resamples for a bootstrapping analysis and calculating 95% confidence intervals (CIs) to test our proposed model.

The results of the regression analysis are presented in Table 2. First, the total effect of school climate on academic resilience, without including any mediators, was significant (β = 0.443, p < 0.001), supporting Hypothesis 1. When friendship quality and learning engagement were included as mediators in the model, the impact of school climate on academic resilience was reduced but remained significant (β = 0.197, p < 0.001). This reduction suggests the presence of mediation effects.

Further regression analysis confirmed the presence of a mediating effect. The results indicated that school climate significantly predicted friendship quality (β = 0.464, p < 0.001), and friendship quality significantly predicted academic resilience (β = 0.201, p < 0.001), supporting Hypothesis 2. At the same time, school climate also directly predicted learning engagement (β = 0.365, p < 0.001), while learning engagement significantly predicted academic resilience (β = 0.351, p < 0.001), which supports Hypothesis 3. Lastly, friendship quality significantly predicted learning engagement (β = 0.149, p < 0.01), further supporting Hypothesis 4.

The significant paths for all proposed relationships supported the chain mediation model, indicating that school climate influences academic resilience through the serial mediation of friendship quality and learning engagement. The model is presented in Figure 1.

Predictive variable	Result variable			Result variable			Result variable		
	Friendship quality			Learning engagement			Academic resilience		
	β	**t**	**95% CI**	***β***	**t**	**95% CI**	***β***	**t**	**95% CI**
Gender	0.032	0.630	[-0.132, 0.257]	-0.029	-0.582	[-0.254, 0.138]	0.089	1.959	[-0.0008,0.352]
Age	-0.047	-0.933	[-0.146, 0.052]	-0.085	-1.695	[-0.186, 0.138]	-0.053	-1.169	[-0.144, 0.037]
School climate	0.464***	9.271	[0.366, 0.562]	0.365***	6.422	[0.253, 0.477]	0.197***	3.621	[0.090, 0.304]
Friendship quality				0.149**	2.627	[0.038, 0.261]	0.201***	3.888	[0.099, 0.302]
Learning engagement							0.351***	6.878	[0.250, 0.451]
R^2	0.223			0.218			0.370		
F	29.915***			21.663***			36.366***		

Table 2. Regression analysis of variable relationship in the Mediation Model

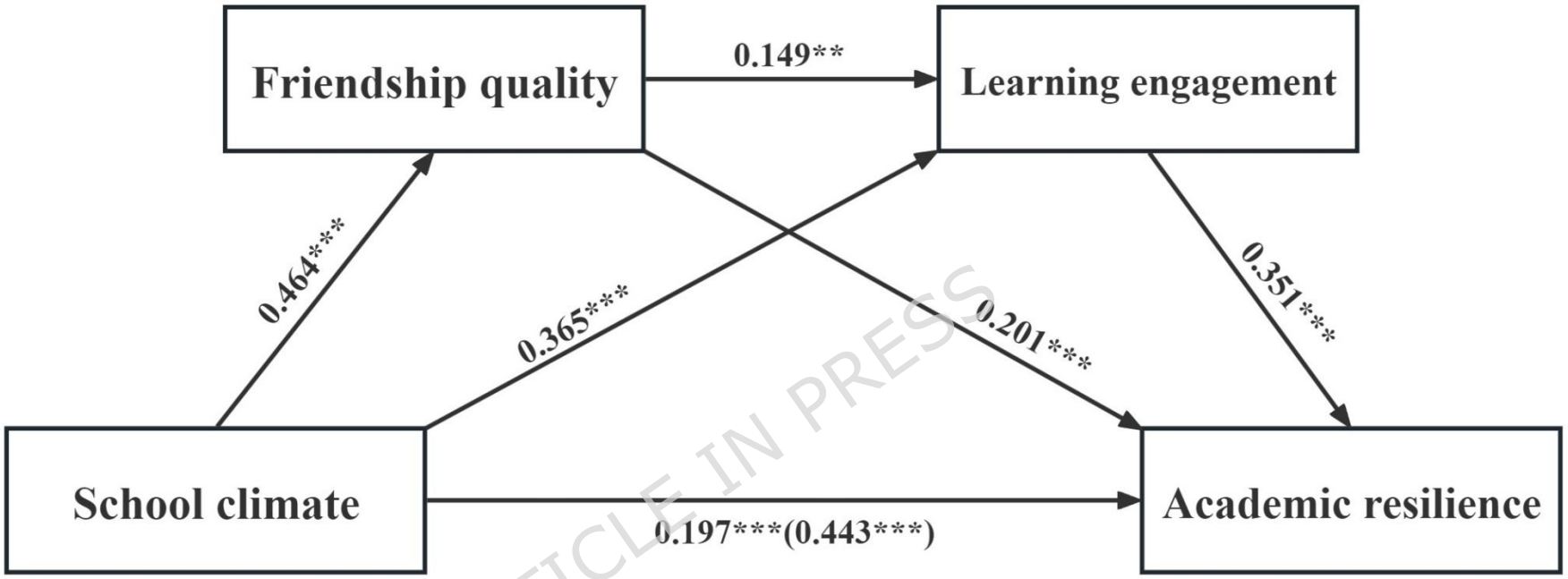

Figure 1. The chain mediation model.

Specifically, the magnitude of the mediating effect was 0.245, accounting for 55.30% of the total effect (0.443) of the school climate on the academic resilience of primary school students. This mediating effect is jointly constituted by three different paths (the 95% confidence intervals calculated by the Bootstrap method do not contain 0). Firstly, an indirect effect 1 is produced via "School climate→ Friendship quality→Academic resilience " with a value of 0.093 (20.99%). Secondly, an indirect effect 2 is generated through "School climate→Learning engagement→Academic resilience", with a value of 0.128 (28.89%). Finally, an indirect effect 3 is formed through "School climate→Friendship quality→Learning engagement→Academic resilience ", with a value of 0.024 (5.42%). See Table 3 for details.

Effect	Path	Effect size	Se	95%CI		Effect dose
				Upper limit	Lower limit	
Total effect	School climate→Academic resilience	0.443	0.050	0.345	0.541	100.00%
Direct effect	School climate→Academic resilience	0.197	0.054	0.090	0.304	44.47%
Indirect effect	School climate→Friendship quality→Academic resilience	0.093	0.030	0.043	0.160	20.99%
Indirect effect	School climate→Learning engagement→Academic resilience	0.128	0.025	0.081	0.181	28.89%
Indirect effect	School climate → Friendship quality → Learning engagement → Academic resilience	0.024	0.010	0.007	0.047	5.42%

Table 3. Bootstrap 95% CI of the mediating effect path.

Discussion

Effect of school climate on academic resilience

First, we found that school climate positively influences children's academic resilience, consistent with previous research findings[103].

One possible reason for this positive impact is that the school climate compensates for insufficient family support in the development of academic resilience among rural primary students. In rural areas of western China, parenting philosophies tend to be relatively traditional. Against a backdrop of declining academic prestige and increasing employment challenges, many rural parents view schooling as a high-risk investment demanding immediate returns, placing significant emphasis on their children's academic performance[104]. At the same time, most rural children must also cope with being left behind (with one or both parents working away from home). The absence of companionship makes them more prone to feelings of inferiority, anxiety, and depression[105]. The dual burden of immense academic pressure and psychological trauma can lead to a reluctance to tackle academic challenges[106]. When faced with academic challenges, they are more likely to withdraw into themselves, give up on their efforts, and even fall into the negative coping state of "invisible dropout"[107].

However, academic support from teachers within a positive school climate enables children to face academic challenges with both confidence and effective strategies[108]. For example, many rural primary schools in Pingliang City, Gansu Province, and Shiyan City, Hubei Province, provide children with dedicated "homework time" after school. During this period, teachers not only supervise students in completing assignments within the allotted time but also address questions and clarify doubts. This high-quality accompaniment not only helps rural primary students promptly resolve knowledge gaps but also provides emotional support. This has significantly impacted their academic performance and enhanced their sense of efficacy in tackling academic challenges[109].

On the other hand, some high-performing rural schools have also comprehensively enhanced primary students' self-awareness, social consciousness, and interpersonal skills by offering mental health courses such as "social-emotional learning"[110]. By offering a wide variety of arts interest groups, some schools also provides rural primary students with a platform for recreation and self-expression[111]. These activities enable children to gain a more comprehensive understanding of themselves, build greater self-confidence, feel more comfortable seeking help from others, and approach learning with increased optimism. This, in turn, lays the foundation for enhancing their resilience in academic settings[110].

Moreover, effective schools typically place great emphasis on leveraging peer role models, which can compensate for the resilience guidance rural children cannot obtain from their families[112]. For example, in some rural schools, teachers deliberately seat underperforming students near top students. This increases the frequency of interaction between neighbors, fostering mutual dependence and trust among classmates[113]. Through peer modeling, students with low academic achievement will witness how their admired role models translate the abstract concept of "effort" into concrete actions. This provides them with specific methods to emulate[114], significantly reducing their academic apprehension and ultimately enhancing their perseverance and resilience in academic pursuits[115].

In conclusion, the school climate found in this study can have a significant positive impact on children's academic resilience. It is worth noting that the impact of school climate on the academic resilience of rural children is much more important than that of urban children. Because urban children can get more diversified, more suitable and more targeted help through parents, psychological counseling centers, training institutions outside school, communities, learning machines and other resources. However, school support is a "life-saving straw" for rural children, and it is almost the only way for these children to obtain systematic professional support.

The mediating effect of friendship quality between school climate and academic resilience

This study demonstrates that friendship quality acts as a mediator between school climate and students' academic resilience, hence supporting hypothesis H2. This is consistent with prior research findings that a positive school environment influences student-peer relationships[116], and peer support can predict academic resilience[117,118].

The possible reason is that a better school climate may compensate for a lack of emotional care from family members, improve rural primary school students' sense of happiness, and foster a more optimistic attitude, which is conducive to a more rational and objective approach to problems. When peer dispute arises, these primary school students tend to accept it as a natural occurrence of interpersonal communication and treat their classmates more leniently, which helps to sustain good friendship quality.

Secondly, guidance from teachers will teach primary school students how to understand the feelings of others in the process of interacting with others, and gradually learn to care for and sympathize with others, as well as how to resolve peer conflicts. This helps students become more

comfortable and confident when facing various social situations, and enables them to build higher quality friendships with their peers.

Why does the quality of friendship have a special impact on the academic resilience of rural primary school students in China? According to research, the average family income of these primary school students is relatively low[119], and their parents also have lower educational backgrounds. For example, the 2006 Gansu Province Children and Family Survey (GSCF) revealed that rural parents have lower levels of schooling[120]. Fathers and mothers have an average education of 7 years (near to junior high) and 4.2 years (fourth grade of primary school), respectively.

Families find it challenging to provide focused learning recommendations or to afford extracurricular academic tutoring for primary school students. Students in remote primary schools are therefore limited to using resources outside of their families when they encounter academic challenges. However, because there is a teacher shortage in remote primary schools, it is very impossible to get teachers to provide individualized help on scholastic issues. So, peers will take on the role of "little teachers". Consider this: a primary school student whose parents are not present all year is depressed due to test results; what kind of mood would he be in if a close buddy was prepared to selflessly explain tough problems to him?

In terms of academic resilience,the particular concern is that the friendship between rural primary school students may be deeper, so the influence of peers on rural primary school students may be particularly greater compared to urban primary school students. Rural China is an "acquaintance society" with blood and geography at its heart[121], so many rural primary school students share blood ties with their classmates or friends. Moreover, the architectural style of open courtyards and the social habit of "visiting" in the rural areas of Northwest China, also further draw the distance between primary school students and their peers in space and encourage children to establish very close emotional relationships with their peers. This will enable friends to play a huge role in the learning and life of rural children.

To sum up, the conclusion of this study shows that the key to the effect of positive school climate on rural primary school students' academic resilience is to shape the support network based on peer relationships, which further expands the theory of social support. This suggests that by focusing on promoting peer communication of trust, acceptance and mutual assistance, schools in rural or weak areas can not only transform the macro school climate into the emotional belonging that every student can feel personally, but also provide indispensable endogenous power for the cultivation of their learning quality.

The mediating role of learning engagement between school climate and academic resilience

Third, our findings indicate that school climate has a favorable impact on primary school students' academic resilience, and that learning engagement mediates the association between school climate and academic resilience.

The possible reason is that a positive school climate supports the needs of primary school students to develop their talents by providing ample opportunities for activities, which enhances their sense of belonging to the school and interest in learning. Although the school surveyed in this study is a rural school in difficult conditions, it has set up 17 extracurricular interest classes for students, including dance classes, art classes, piano classes, and model airplane classes. The principal said, "The purpose of offering so many interest classes for children is to 'train their guts'. " "Our children may not achieve excellent academic achievement in the future, but they will be courageous and confident. "

In this supportive setting, the acknowledgment and gratitude students receive from others for displaying their gifts boosts their self-esteem and sense of efficacy[122]. This strengthens their psychological resources for dealing with obstacles and challenges. As a result, when faced with a challenge, students no longer give up readily, but instead seek positive solutions and perform better in school and in life[123]

At the same time, research has shown that the positive effects of school climate also extend to the home. For example, some rural schools promote deeper involvement of primary caregivers of rural left-behind children in their children's school life through home-school interaction activities, such as home visits[124]. This helps parents to clarify their parenting responsibilities and increase their educational and emotional commitment to the child[125].This support leads to the establishment of a stronger parent-child bond. For families with lower socioeconomic position, the entire family's internal relationships may improve, and the family environment of resilience may be considerably increased. This environment, in turn, encourages academic resilience among primary school students, resulting in a virtuous circle of academic resilience. In summary, the school atmosphere influences the academic resilience of rural primary school students through learning participation, which further supports the viewpoint in social stratification theory that the core of successful breakthrough for disadvantaged children lies in their interaction with high-quality school environments and their high-level learning participation.

The chain mediating role of friendship quality and learning engagement between school climate and academic resilience

This study suggests that there is a chain relationship between friendship quality and learning engagement, which is consistent with previous research findings[126].

The possible reason is that, in rural areas of western China, influenced by traditional ideas such as "all parents are good" and "filial piety comes from under the stick", parents often adopt a dictatorial approach to education, listen less to their children's thoughts and feelings, and even often adopt a repressive approach to education. This educational model may lead to feelings of oppression and pain when communicating with parents, affecting the development level of rural primary school students, causing lags in cognitive, emotional, and social development[127], and ultimately weakening their ability to fully engage in learning[128].

In this situation, the important relationship in school, the "peer relationship", plays an important emotional compensation role[129]. Peer communication provides a channel for rural primary school students to confide, making them feel understood and sympathized with[130]. Positive interactions such as encouragement, comfort, and praise among friends further help primary school students alleviate negative experiences such as depression, loneliness, and lack of confidence[131], enabling them to focus on efficient learning activities.

More importantly, if there are students in the peer group who love learning and have excellent academic performance, their learning attitude and behavior will have a motivating effect on other children[132], enhancing role identification among primary school students. By imitating the behavior of peers and positive competition, students will be more proactive and demonstrate higher levels of learning engagement[133]. In summary, it can be seen that friendship quality can enhance students' resilience to academic adversity by providing diverse resource support, mobilizing students' initiative, and stimulating sustained and in-depth interaction between students and learning activities. This further supports the view in social capital theory that a companion network can provide assistance for disadvantaged students.

Significance

This research has revealed that the school climate exerts a notable positive influence on the academic resilience of rural primary school students. Moreover, friendship quality and learning engagement play a

chained mediating role in the relationship between them. This discovery not only improves our understanding of the elements that influence academic resilience, but it also has substantial theoretical and practical implications for interventions targeting the academic resilience of rural primary school students.

Theoretical significance of this research

First, this study extends the applicable context of the academic resilience theory. Focusing on rural areas in western China, it offers empirical evidence for the applicability of the academic resilience theory in poverty-stricken settings where resources are scarce and conditions are limited, thus filling a gap in relevant research. This study not only discovered the theoretical model of "school climate-friendship quality-learning engagement-academic resilience" was discovered in this study, but it also discussed the unique challenges that rural primary school students face in their learning and growth process, taking into account the current state of rural education and the characteristics of their physical and mental development. And suggested a cultural context-based explanation, which provides a novel theoretical framework for addressing the academic difficulties of rural primary school students while also expanding the explanatory boundaries of academic resilience-related ideas.

Second, this study complements the previous studies on the formation of academic resilience in primary school students and provides empirical support for the theory of biological ecology. This study not only found that the school climate was a positive predictive factor for the academic resilience of primary school students, but also innovatively revealed multiple paths through which the school climate had a positive impact on the academic resilience of rural primary school students. By deeply analyzing the friendship quality at the social-emotional level and the synergistic effect of learning engagement at the cognitive behavioral level on the formation of academic resilience, this study breaks through the limitation of traditional research that only focuses on a single environmental variable or a single mediating variable, and extends the factors affecting the formation of children's academic resilience to a dynamic interactive system. This enriches Bronfenbrenner's ecosystem theory.

Practical significance of this research

Primarily, optimizing the rural school climate represents a crucial measure for enhancing the academic resilience of rural primary school students. Specifically speaking: first, rural schools should scientifically plan class size. Due to the population outflow from rural areas and limited financial resources, some local governments have adopted the strategy of combining classes or combining schools in rural areas. Schools should avoid excessive class size due to blind implementation of

combined class system or combined school system[134], and ensure that every student can get sufficient attention and love in small class teaching. Secondly, schools should implement the teacher-student interaction guidelines centered on support, listening and encouragement from top to bottom, actively build a positive, inclusive and harmonious teacher-student relationship, give students emotional respect and acceptance, and make up for the absence of family support in academic studies. For example, schools could implement incentive guidance principles to help students build sustainable learning confidence through positive feedback mechanisms. Additionally, they should establish differentiated care systems, with particular attention to special groups such as left-behind children and economically disadvantaged students, using methods like emotional counseling, guidance, and responsive support for emotional needs. Thirdly, rural schools should utilize their own advantages to offer a range of extracurricular activities, including local opera, paper-cutting, bamboo weaving, and other distinctive rural intangible cultural heritage courses, in addition to regular enjoyable sporting events.This will help students feel the warmth of the collective and the care of the school in the activities, thereby enhancing their sense of belonging to the school and allowing them to truly feel that "the campus is home". Fourth, the role of the class committee should be actively established and fully played in the class, and the leading role, organizational ability and exemplary power of class cadres should be fully utilized. Not only did they maintain the daily operation order of the class, but they also meticulously planned a variety of rich and diverse cultural and sports activities, such as reading sharing sessions, fun sports meets, and theme class meetings, effectively consolidating the cohesion of the class. The class committee strives to build the class into a warm collective that not only has a strong learning atmosphere but also is full of humanistic care, allowing each student to thrive in a positive, relaxed and pleasant academic atmosphere, and also find a strong sense of belonging in a united, friendly and mutually supportive collective.

Furthermore, improving the friendship quality can effectively promote the learning engagement of rural primary school students. Teachers should first guide students to recognize the multifaceted values of friendship and understand the diverse support provided by different types of peer relationships. For example, students in school can develop a learning partnership to help each other by sharing learning resources and providing instrumental support. Neighbors living nearby can develop into family-like partnerships. They can establish long-term and stable emotional connections and mutual support through ways such as going to school together and helping each other harvest during the busy farming season. Second, schools should focus on cultivating students' ability to interact with peers and help them establish and maintain good

interpersonal relationships. For instance, regularly organize theme activities such as "Friendship Day"and "Good Friend Day", and through scenario simulation and role-playing, enable students to enhance their communication and conflict resolution skills among peers in practice. Third, teachers should guide students to formulate and abide by friendship rules, such as respecting others, learning to listen, avoiding gossip and negative evaluation, so as to establish and maintain a positive and healthy friendship relationship. Fourth, schools can incorporate peer learning assistance into the comprehensive quality assessment and establish a long-term incentive mechanism. The multi-evaluation model combining teachers' evaluation with students' mutual evaluation was adopted to evaluate students' performance in learning assistance comprehensively and objectively. The "mutual assistance credit system" was implemented, the frequency, quality and effect of assistance were recorded, and the outstanding students were publicly commended and awarded the "star learning Assistance Medal".

Finally, enhancing learning engagement is the key path to building the academic resilience of rural primary school students. First, teachers should teach metacognitive strategies such as planning, monitoring and reflection to improve learning efficiency in view of the characteristics of rural primary school students' single learning method, unclear goals and lack of planning. For example, teachers should guide students to arrange their study schedules flexibly in accordance with agricultural seasons. During the off-peak agricultural periods, students can formulate study plans and concentrate on their studies. In contrast, during peak farming seasons, students can utilize fragmented time for review and reinforcement of knowledge. Meanwhile, teachers should also teach students to make error attribution charts, guiding them to analyze the reasons for their mistakes, such as knowledge gaps, comprehension errors or carelessness, and make targeted improvements to achieve correct attribution and enhance primary school students' ability to solve academic difficulties. Second, schools can build academic progress and growth portfolio to comprehensively record students' academic development. In addition to examination results, the portfolio can also cover classroom participation performance, such as the frequency and quality of answering questions, and the level of activity in group discussions,as well as homework completion, including accuracy, punctuality, and innovation. These data can be shown using visualization techniques such as progress step charts and curve graphs. Among these, the progress ladder chart is used to indicate goal achievement at various levels, whilst the curve graph shows the changing trend of performance ratings. Thirdly, give full play to the exemplary role of role models to stimulate the learning motivation of primary school students. Schools are advised to arrange for students to watch inspiring documentaries. For

example, The Documentary of Rural College Students' Struggles can eloquently and realistically illustrate the concept of "knowledge can transform one's destiny" through real-life video and tales. This approach is conducive to boosting students' confidence in breaking through academic predicaments. In addition, we can also invite outstanding alumni from previous years back to the school to give lectures, allowing them to share their experiences of how they struggled in difficult situations and eventually achieved success. This will enable students to feel the power of role models around them, further igniting their desire and pursuit of knowledge, and strengthening their belief in realizing their own value and improvement.

Limitations

Although we attempted to investigate the influence mechanism of the school climate on the academic resilience of rural primary school students in depth and thoroughly, some limitations were unavoidable in this study.

First of all, Bronfenbrenner supplemented the chronosystem in his proposed ecological systems theory, emphasizing that both the environment and the development of individuals change dynamically with time[13]. This suggests that the impact of school climate on academic resilience may change over time[135].

Nonetheless, the cross-sectional research approach used in this study could only indicate the academic resilience of rural primary school students at a single time point, and it was unable to reveal their dynamic growth trajectory or important turning moments. This limitation constrains our in-depth exploration of certain crucial questions. For example, whether the degree of influence of the school climate on academic resilience diminishes or intensifies as primary school students advance in age? At which stage is the influence more pronounced? Future studies ought to employ a longitudinal follow-up design to observe the variations and developments of academic resilience at distinct time points. We intend to collect multi-time point data on a regular basis (for example, once every semester or academic year) to map the growth trajectory of academic resilience among rural primary school student and so identify crucial intervention windows.

Second, this study employed a cluster convenience sampling method, which may introduce selection bias. This sampling approach, along with the relatively small sample size and the specific focus on impoverished rural districts in Northwest China, limits the generalizability of the findings. Therefore, the results should be generalized to the broader population of rural primary schools, whether in other Chinese regions or

international contexts, with considerable caution. Future study should broaden the sample size to include other economic development zones in China, such as the developed and underdeveloped parts of Southwest, East, and North China. This would help validate the universality of the relationship between school climate and academic resilience in primary students, providing a more comprehensive reflection of how school climate influences academic resilience across different regions. Simultaneously, this would provide additional support for the developmental trajectory of academic resilience among children in northwest rural areas in relation to school climate, increasing the regional representativeness, credibility, and stability of the results. If feasible, the study could extend to educational settings across diverse cultural contexts in East Asia, the Americas, and Europe. Through cross-cultural comparative research, it could explore both the universality and particularities of this relationship, providing more broadly applicable theoretical guidance for global educational practices.

All the data in this study originated from the self-rating scales of primary school students. Despite the absence of common method bias upon examination, the responses might still be affected by social desirability bias and cognitive limitations. Consequently, primary school students might still respond in a manner that aligns with social expectations, namely, exaggerating their positive characteristics (such as friendship quality and learning engagement)[136]. Moreover, primary school students' comprehension of the rather abstract concept of "resilience" might not necessarily comprehensive. Hence, future studies should employ the triangulation approach to enhance the validity of the research. This strategy should encompass data collection from multiple perspectives, including students' self-reports, teachers' evaluations, and in-depth interviews with parents. At the same time, the research should incorporate structured classroom observation data and student file information, such as attendance records and homework submission situations, to achieve multiple verifications of the data. Furthermore, artificial intelligence technology can be employed to analyze the behavior logs of online learning platforms, which will contribute to monitoring the dynamic changes of academic resilience of primary school students in the learning process more accurately.

Potential moderating variables were also not fully considered in this study. For instance, individual student characteristics and family backgrounds may exert moderating effects on the relationship between school climate and resilience. This limitation may constrain the systematic elucidation of the complex mechanisms through which school climate influences primary students' academic resilience. Furthermore, this study primarily discusses the overall concept of school climate. It should be noted, however, that school climate is actually a complex

system composed of multiple core dimensions (such as the safe environment, interpersonal relationships, teaching and learning, the physical environment, etc.)[137]. Although this study validated the significant impact of school climate on academic resilience, it has not yet delved into the interactive mechanisms among these dimensions. Specifically, different dimensions may jointly influence students' academic resilience through synergistic or compensatory mechanisms, and this multidimensional dynamic process warrants further investigation.Therefore, future research should adopt a more comprehensive perspective. This could involve incorporating individual factors such as students' cognitive abilities, personality traits, and emotional regulation, as well as moderating variables like family economic status and parental education levels into the analytical framework. Simultaneously, it is necessary to delve into the interactions among the core dimensions of school climate and their collective impact on academic resilience. This would help provide more insightful recommendations for school improvement strategies.

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Author contributions

Liping Guo spearheaded this research, overseeing conceptualization, methodology, project administration, funding acquisition, and manuscript review. Jingchen Hu assisted with data curation, formal analysis, and

drafting. The research concept was a collaborative effort involving Liping Guo, Jingchen Hu, Dongyu Xie, Ziyi Liu, Xiuwen Xi, Yuxuan Yang, and Lili Luo. Field investigation was carried out by Liping Guo, Jingchen Hu, Dongyu Xie, Ziyi Liu, and Xiuwen Xi. The original manuscript was drafted by all seven authors, with final editing handled by Liping Guo.

Declarations

Ethics approval and consent to participate

This study received ethical approval from the Research Ethics Committee of the College of Education Science, Northwest Normal University (Approval No. 2024-1030). Prior to participation, written informed consent was obtained from all subjects and their parents. Participants were thoroughly informed about the research's purpose, methodology, and their rights, including the right to withdraw from the study at any time without penalty.

Competing interests

The authors declare no competing interests.

Additional information

Data availability

Due to the sensitive nature of the human data collected in this study, the raw data are not publicly available to protect participant confidentiality. With the approval of the Research Ethics Committee of the College of Education Sciences, Northwest Normal University, the data can be obtained by contacting the corresponding author, Jingchen Hu (17709467796@163.com).