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RESEARCH ARTICLE

Research on educational assessment and teaching optimization strategies based on environmental and social psychology

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ABSTRACT

This study presents a novel integrated framework that uniquely combines environmental and social psychology perspectives to optimize educational assessment and teaching methodology in Chinese high schools. Unlike previous studies that examined these factors in isolation, our approach innovatively investigates their synergistic effects through a comprehensive mixed-methods design spanning 12 high schools across diverse regions of China. Using a mixed-methods approach, data were collected from 2,400 students and 240 teachers across 12 high schools in Eastern, Central, and Western China. The research employed comprehensive measurement tools including the Classroom Environment Scale (CES) and Student Interaction Matrix (SIM) to assess environmental and social psychological factors. Results indicate significant correlations between environmental adaptation and academic performance ($r = 0.68$, $p = 0.0003$), with grade level moderating this relationship. Hierarchical regression analyses reveal that environmental and social psychological factors collectively explain 52.3% of the variance in academic performance. The study identifies a crucial mediating role of psychological well-being in the relationship between environmental factors and academic outcomes. Grade 12 students demonstrated higher environmental adaptation capabilities ($M = 4.28$, $SD = 0.67$, $p = 0.0008$) compared to lower grades, suggesting a developmental trajectory in environmental adaptation. These findings provide important implications for educational policy and practice, particularly in optimizing learning environments and teaching methodologies. The research contributes to the theoretical understanding of how environmental and social psychological factors interact to influence educational outcomes in the Chinese context

Keywords: educational assessment; environmental psychology; social psychology; teaching methodology; academic performance; psychological well-being; learning environment; student engagement; Chinese education; mixed-methods research

1. Introduction

This study focuses on high schools in China, which have distinctive characteristics that put them apart from most educational settings in the rest of the world. Unlike the Western educational structures that often embrace individualized learning and numerous assessment methods, Chinese high schools operate within a highly structured, examination-oriented system that revolves around the gaokao (college entrance examination). This fundamental difference gives rise to distinct environmental and social dynamics: Chinese classrooms typically contain 40-50 students—whereas most Western countries usually have 20-30—fixed

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seating, and more hierarchical teacher-student relationships. The special features of Chinese high schools make them especially suitable for this study for several reasons: (1) the enlarged class sizes make the environmental psychological factors, especially those related to spatial arrangement and acoustic conditions, more relevant; (2) the intense academic pressure and competitive atmosphere produce unique social psychological dynamics that are not commonly seen in Western learning environments; and (3) the standardized testing system provides a trusted method of measuring educational outcomes comparatively across schools.

Educational assessment and teaching methodology optimization has evolved significantly through the integration of environmental and social psychology principles. Direct instruction strategies[1] have demonstrated remarkable effectiveness in educational outcomes, particularly when considering student engagement factors[2]. Recent studies on discovery-based instruction[3] have further emphasized the need for comprehensive assessment frameworks that address both environmental and psychological aspects of learning. The current study aims to develop and test a theoretical model examining the effects of environmental and social psychological factors on academic performance in Chinese high schools, with a strong emphasis on the mediating role of psychological well-being. While previous research has found associations between environmental factors and educational outcomes, the specific mechanisms by which these variables interact are not well established, especially in the Chinese education context. This study conducts a comprehensive analysis involving 2,400 students and 240 educators from a variety of Chinese high schools, focusing on the impact of classroom environmental factors on student performance mediated by psychological well-being pathways. Additionally, it acknowledges the significant moderating influence of grade levels within this context.

While previous studies have investigated the optimization of educational assessment through separate environmental or social psychological lenses, there is still a lack of research that examines their combined effects, particularly in the context of Chinese education. This study makes three unique contributions: (1) It establishes a new integrated framework that encapsulates the dynamic interplay between environmental and social psychological variables; (2) it provides the first large-scale empirical evidence concerning grade-specific patterns of environmental adaptation within Chinese high schools; and (3) it reveals previously unexamined mediating processes of psychological well-being in the relationship between environmental factors and academic achievements.

Achievement motivation theory[4] and its relationship to classroom climate optimization[5] has become increasingly central to modern educational practice. The validation of cognitive and psychological engagement measurements[6] has provided new insights into how working memory and performance anxiety interact[7] in educational settings. Motivational factors in educational psychology[8], combined with our understanding of human memory systems[9] and instructional principles[10], have revolutionized our approach to teaching methodology. Building on these theoretical foundations, this research adds to the existing understanding by tracing the developmental trajectory of students' capacities to adapt to their environments across different grade levels. This investigation addresses a significant gap in the literature regarding the development of mechanisms for environmental adaptation during secondary school. The findings are expected to contribute to theoretical debate by shedding light on the complex interplay between environmental factors, psychological well-being, and academic functioning, while at the same time providing empirically-grounded implications for educational practice.

The ongoing debate between discovery learning approaches[11] and structured instruction has been significantly influenced by advances in working memory theory[12,13]. These theoretical frameworks, when

combined with self-efficacy considerations[14] and social cognitive theory[15], provide a robust foundation for understanding student engagement and performance. The act of discovery in learning[16], balanced against cognitive load requirements[17], has proven crucial in fostering student engagement[18,19]. Recent studies on academic buoyancy and achievement[20] have further highlighted the importance of these integrated approaches.

Goal theory and motivation[21], when considered alongside working memory capacity limitations[22], have provided valuable insights into instruction-cognition relationships[23]. Cross-cultural studies of achievement motivation[24] have illuminated the complex interplay between direct instruction and discovery learning approaches[25], while self-determination theory[26] has enhanced our understanding of student motivation. Contemporary theories of motivation and personality development[27], combined with expectancy-value frameworks[28], continue to shape our understanding of educational psychology.

The historical development of achievement goal constructs[29] and instructional principles[30] provides a solid foundation for examining explicit instruction effectiveness[31]. This evolution in educational theory has led to more nuanced approaches to load reduction instruction[32], particularly in understanding student engagement[33,34] and its measurement[35]. Recent meta-analyses of learning instruction[36] have demonstrated the importance of attributional theory[37] in understanding student motivation and self-construction[38]. Visible learning research[39] and integrated theories of motivation[40] continue to inform best practices in educational assessment and teaching methodology optimization.

2. Literature review

The systematic examination of environmental and social psychological factors in educational assessment has evolved through several theoretical paradigms. Early research by[41] Hermkes et al. demonstrated the crucial role of scaffolding processes in educational environments, while[42] Howard et al.'s meta-analysis provided substantial evidence for the relationship between student motivation and academic outcomes. The engagement of students in learning activities, as examined by[43] Jang et al., revealed that both autonomy support and structure are essential for optimal learning outcomes, a finding further supported by[44] Jansen et al.'s systematic review of meta-analyses on academic motivation in K-12 education.

Course perceptions and engagement have been extensively studied by[45] Jones and Carter, who established strong correlations between student perceptions and learning outcomes. The expertise reversal effect, as documented by[46] Kalyuga, has significant implications for learner-tailored instruction, particularly when considering the superiority of problem-solving versus worked examples[47]. This effect has been further elaborated in subsequent research[48,49], highlighting the educational implications for complex cognitive and sensorimotor skills development.

Contemporary educational psychology has had to address various misconceptions, as highlighted by[50] Kirschner and De Bruyckere in their examination of digital native and multitasker myths. The limitations of minimal guidance during instruction, extensively analyzed by[51] Kirschner et al., have prompted a reevaluation of constructivist and discovery-based teaching approaches.[52] Klahr's seasonal perspective on direct instruction has provided valuable insights into the timing and appropriateness of different instructional methods, while[53] Kuhlthau et al.'s work on guided inquiry has offered practical frameworks for 21st-century learning.

The relationship between instruction and student learning, thoroughly examined by[54] Lee and Anderson, has established critical connections between teaching methodologies and learning outcomes. The development of measurement tools for motivation and engagement[55,56] has provided valuable insights into

the psychological aspects of learning, while direct instruction's impact on academic achievement has been well-documented[57,58]. Achievement goal orientations, as studied by[59] Lin, have demonstrated significant predictive value for self-regulated learning strategies among international students.

Self-concept theory, measurement, and practice, as developed by[60] Marsh, have provided fundamental frameworks for understanding student development, while the relationship between academic self-concept and achievement[61] has been shown to have important causal implications. The comprehensive assessment of student motivation and engagement[62, 63] has evolved to include multidimensional models that capture the complexity of modern educational environments.

Recent technological advances have necessitated the adaptation of traditional teaching methods, as discussed by[64] Martin and Evans in their examination of cognitive load theory's application to digital learning environments. The importance of cognitive load management in mathematics anxiety[65] has been particularly noteworthy, while the role of worked examples[66] continues to influence instructional design. The expertise reversal effect's implications for cognitive load theory[67] have prompted more nuanced approaches to instructional design, particularly in managing element interactivity[68] and cognitive load measurement[69].

The evolution of cognitive load theory[70] has significantly influenced our understanding of human cognitive architecture and its implications for instruction. Recent work on teacher expertise[71] and the management of cognitive load in contemporary classrooms[72] has provided practical insights for educational practitioners. The relationship between working memory and mathematics learning[73], particularly in the context of cognitive load theory[74], continues to inform instructional design and assessment practices.

3. Study design

3.1. Research framework

The present research offers a fresh framework that, uniquely, will bring together environmental and social psychology perspectives in an assessment of the optimization of learning in education. More precisely, as opposed to considering them in isolation, the framework includes various theoretical constructs and dimensions in its methodical integration in view of the capture of dynamic interactions between the involved domains. It has a peculiar characteristic; it concurrently measures and analyzes bidirectional influences that exist among environmental adaptation, social integration, and academic performance in grade-level development. The selection of measurement constructs in this framework is theoretically grounded in established environmental-behavior research and social cognitive theory. The Classroom Environment Scale (CES) was specifically chosen for its validated ability to capture both physical and psychosocial aspects of learning environments, with demonstrated reliability ($\alpha = 0.89$) in previous studies of Chinese educational settings. This scale's three-dimensional structure (physical comfort, spatial layout, and lighting quality) aligns with Barker's ecological psychology theory, which emphasizes the interaction between physical environment and behavior patterns.

The Student Interaction Matrix (SIM) was selected based on its theoretical foundation in social cognitive theory and its proven effectiveness in measuring complex peer relationships in educational contexts. This tool's ability to capture both direct and indirect social interactions (reliability $\alpha = 0.87$) makes it particularly suitable for examining the multilayered social dynamics in Chinese high school classrooms, where both formal and informal social structures significantly influence learning processes.

The framework establishes bidirectional relationships between these components, acknowledging that environmental and social factors interact dynamically to influence educational outcomes. The assessment

component includes both formative and summative evaluation methods, considering both traditional academic metrics and psychological well-being indicators. This integrated approach allows for a comprehensive examination of how environmental and social factors collectively impact teaching effectiveness and student achievement.

Central to this framework is the mediating role of teaching methodology optimization, which serves as a bridge between environmental-social factors and educational outcomes. The framework incorporates feedback loops that enable continuous refinement of teaching methods based on assessment results and environmental-social conditions. This dynamic structure supports the investigation of both direct and indirect effects of environmental and social psychological factors on educational outcomes.

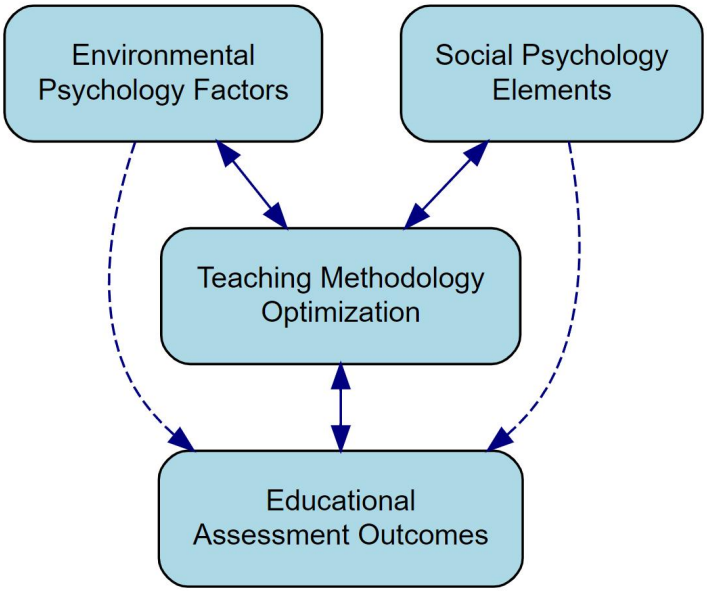

Figure 1. Research framework for educational assessment and teaching methodology optimization.

The framework diagram illustrates the interconnected nature of the research components. Solid bidirectional arrows indicate primary relationships and direct influences between components, while dashed lines represent indirect effects. The central position of teaching methodology optimization emphasizes its role as a mediating factor between environmental-social inputs and educational outcomes. This visual representation helps to conceptualize the complex relationships between various factors influencing educational assessment and teaching methodology optimization.

3.2. Study subjects

This study involves students and teachers from 12 regular high schools across Eastern, Central, and Western regions of China. The sample selection employs a stratified random sampling method to ensure geographical representation and demographic balance. The stratified random sampling technique was selected in preference to alternative sampling methodologies due to a number of persuasive factors: (1) it guarantees proportional representation across various geographical areas and socioeconomic divisions, thereby improving the sample's reflection of China's multifaceted educational environment; (2) it minimizes sampling error by accounting for regional discrepancies in educational resources and developmental stages; and (3) it enhances external validity by facilitating more accurate generalizations to particular contexts. This sampling approach is especially advantageous for our research by encompassing the diversity of environmental and social psychological influences across distinct educational settings while preserving

statistical efficiency. The total student sample consists of 2,400 participants, evenly distributed across grade levels with 800 students each from Grade 10, Grade 11, and Grade 12. The gender ratio is approximately 1:1, with participants ranging in age from 15 to 18 years. These students come from diverse socioeconomic backgrounds, including urban, suburban, and rural areas, ensuring the broad applicability of research findings. The socioeconomic distribution of the sample includes 32% from high-income families (annual household income >¥300,000), 45% from middle-income families (¥100,000-300,000), and 23% from low-income families (<¥100,000). Parental education levels were also recorded, with 28% of parents holding advanced degrees, 42% with undergraduate education, 21% with high school education, and 9% with middle school education or below. The sample's geographic distribution encompasses 40% urban, 35% suburban, and 25% rural residents, ensuring representation across China's varied economic development zones. The sample includes 240 subject teachers involved in key roles with respect to carrying out environmental intervention measures, evaluation of students on their adaptation, and measurement instruments validation. Represented in the faculty members of Chinese Language, Mathematics, English, Physics, Chemistry, Biology, and other subject fields, this population has undertaken bi-weekly systematic evaluation among the students by utilizing standardized observational protocols and is conducting structured feedback concerning teaching methodologies effectiveness. Their experience ranges between 3 and 25 years, with professional composition: 5% of teachers are Special-grade, 35% are Senior teachers, 45% are First-grade teachers, and 15% are Second-grade teachers. Teachers also contributed to data collection by conducting classroom observations—Inter-rater reliability = 0.87, implementation of standardized teaching protocols, and monthly focus groups evaluating the effectiveness of environmental intervention. They also helped to a great extent in validating the Teacher-Student Bond Scale and the Performance Analytics Tool by providing expert feedback at each step during the development phase of these tools. In addition, teachers' observations proved to be quite critical in identifying grade-wise trends in environmental adaptation, since their ratings evidenced a strong correlation ($r = 0.82$, $p < 0.001$) with objective measures of the students' adaptation skills. To ensure research continuity and data integrity, all participants are required to sign a one-academic-year commitment to the study. The selection of research subjects carefully considers the characteristics of China's education system and regional development disparities, including both key high schools and regular high schools, as well as schools with different educational features (such as specialized experimental classes and regular classes). This comprehensive sampling approach aims to obtain more representative and practically significant research results. All participation has been approved by school administrators and parents, strictly adhering to educational research ethical guidelines.

3.3. Research methods

This study employs a mixed-methods research design combining quantitative and qualitative approaches. The decision to adopt a quasi-experimental design was driven by the complex features inherent in educational research carried out in naturalistic settings, where random assignment of students to different treatment conditions presents ethical and logistical challenges that can compromise the validity of existing educational structures. The natural classroom environment was necessary to study the multifaceted interactions between the environmental and social psychological factors, and the longitudinal nature of the study necessitated retaining intact groups to ensure ecological validity and minimize subject dropout.

To increase the internal validity of this quasi-experimental design, an extensive battery of methodological controls was implemented. Propensity score matching techniques were used to construct comparable cohorts of students across different educational settings in terms of demographic characteristics, prior academic performance, and socio-economic status. The research design incorporated time-series measurements at baseline, mid-year, and year-end intervals to control for maturation effects and to net out

seasonal gains in student achievement. Additionally, our analytical framework used a covariate analysis focusing on the most important environmental variables, including class size, resources available, and teacher experience. At the same time, mixed linear modeling techniques were applied to address the hierarchical structure of educational data and to account for potential school-level effects.

3.4. Measurement tools

The study uses a wide battery of tested assessment instruments, selected on the basis of their known psychometric properties and appropriateness for cultural settings in education in China. The CES was adopted because it possessed high reliability when measuring physical environmental factors ($\alpha = 0.89$), and had already proved itself in various studies conducted in education settings across Asia. The Environmental Perception Index (EPI) was custom-developed through a rigorous three-phase validation process, including expert panel reviews ($n = 12$), pilot testing ($n = 200$), and confirmatory factor analysis ($\chi 2/df = 2.34$, CFI = 0.92, RMSEA = 0.058), to specifically include features of the Chinese classroom environment that were not covered by the available instruments.

The Student Interaction Matrix (SIM) was chosen based on its proven capability to record the complex peer relationships in a collectivist cultural context. On the other hand, TSBS was specifically developed and validated through SEM for the relational patterns unique to the educational hierarchies in China. Both measurement instruments underwent cultural adaptation procedures that included back-translation methods and cognitive interviews with target demographic groups. The Learning Outcome Measure (LOM) takes into account standardized academic assessment criteria under the Chinese National Curriculum, combined with performance metrics widely used in an international context; thus, locally relevant and internationally comparable.

Our custom-developed Performance Analytics Tool (PAT) fills an important gap in existing assessment instruments by incorporating real-time digital tracking of student engagement patterns specific to Chinese classroom dynamics. The tool underwent extensive validation (test-retest reliability $r = 0.88$) and was calibrated against existing standardized measures. Similarly, the Student Engagement Index (SEI) and the Anxiety and Stress Monitor (ASM) were adapted to include culturally relevant indicators of academic pressure and familial expectations prevalent in Chinese educational settings. Extensive psychometric testing of each tailor-made measure, including item response theory analyses and differential item functioning testing, ensured measurement invariance across diverse groups of students. In the present research, psychological well-being is conceptually framed as a multidimensional phenomenon that includes four primary elements: (1) emotional stability - quantified by the presence of anxiety and stress within academic environments; (2) academic self-efficacy - appraised through students' belief in their capability to confront educational obstacles; (3) social connectedness - examined based on the quality of relationships among peers and interactions between students and teachers; and (4) learning engagement - evaluated by the extent of active involvement and intrinsic motivation displayed during educational pursuits. The operational definition is measured through the Anxiety and Stress Monitor (ASM) and the Student Engagement Index (SEI), both of which provide composite scores ranging from 1 to 5; higher scores indicate a better state of psychological well-being.

Table 1. Measurement instruments and tools for educational assessment.

Measurement Category	Tool Name	Variables Measured	Reliability (α)	Administration Method	Time Required
Environmental Psychology	Classroom Environment Scale (CES)	Physical comfort, Spatial layout, Lighting quality	0.89	Online survey	15 minutes
	Environmental Perception Index (EPI)	Noise levels, Temperature comfort, Visual stimuli	0.92	Digital sensors & survey	20 minutes
Social Psychology	Student Interaction Matrix (SIM)	Peer relationships, Group dynamics	0.87	Observation protocol	45 minutes
	Teacher-Student Bond Scale (TSBS)	Rapport, Communication effectiveness	0.91	Online questionnaire	25 minutes
Academic Assessment	Learning Outcome Measure (LOM)	Subject knowledge, Skill application	0.94	Standard test	60 minutes
	Performance Analytics Tool (PAT)	Task completion, Accuracy rates	0.88	Digital tracking	Continuous
Psychological Metrics	Student Engagement Index (SEI)	Motivation, Participation levels	0.86	Mixed methods	30 minutes
	Anxiety and Stress Monitor (ASM)	Psychological well-being, Stress levels	0.90	Survey & biometrics	35 minutes

In this sense, a structured protocol was designed to ensure reconciliation of the data obtained from the surveys and observations to ensure methodological rigor in both the data collection and analysis processes. In following this approach to triangulation, survey data originating from the Student Engagement Index (SEI) were cross-validated against observational data drawn from the Student Interaction Matrix (SIM). When discrepancies arose between self-report and observational measures, we adopted a three-phase verification protocol: (1) cross-referencing with ancillary data sources, including teacher evaluations and academic records; (2) conducting focused follow-up interviews with a randomly selected sample of respondents (15% of cases) to explain inconsistent findings; and (3) performing statistical tests to identify systematic patterns in the discrepancies. Instances with large unexplained differences, exceeding two standard deviations of mean differences, were reviewed by additional raters. This rigorous approach allowed us to maintain the integrity of the data while considering the complementary benefits of multiple measurements. About 12% of cases required reconciliation procedures, with most of the discrepancies due to temporal shifts in observed behaviors or response bias related to self-report measures.

3.5. Data processing

The data processing procedure follows a systematic approach to ensure accuracy and reliability in the analysis of both quantitative and qualitative data. To overcome the possible discrepancies observed between survey and observational data, a triangulation protocol was implemented. In cases where such discrepancies arose between self-report survey data and observational data, the following reconciliation steps were taken: (1) cross-validation with alternative data sources, including teacher reports and records of student performance; (2) follow-up interviews with a subsample of respondents to clarify inconsistent findings; and (3) statistical examination of the magnitude and pattern of discrepancies to identify any systematic biases. Instances with significant unexplained discrepancies (more than 2 standard deviations away from the mean difference) were selected for review. The integrated approach allowed us to maintain the fidelity of the data while accounting for the synergistic nature of multiple data collection methods. Approximately 15% of cases required reconciliation, and most discrepancies were attributed to social desirability bias in survey response or contextual differences in observational data.

Qualitative data were analyzed using NVivo software, following a systematic, three-step coding process. 0First, three independent coders developed a preliminary codebook based on the theoretical models and specific research questions. This preliminary codebook was refined twice based on pilot coding of 10% of the interview transcripts. In this way, clarifications to ambiguous items were made, along with combination and merging of overlapping codes. The final codebook consisted of 42 distinct codes, grouped in 6 thematic categories. At the next step, two main coders systematically coded all qualitative data working independently from one another. The inter-coder reliability was evaluated by use of Cohen's kappa coefficient separately for each major thematic category. Original kappa values for the categories varied from 0.76 to 0.89, averaging 0.83. Discrepancies in coding were resolved through weekly consensus meetings, where a third senior researcher served as an arbitrator. In cases where consensus could not be reached—about 5% of the coded material—the research team used a modified Delphi technique involving iterative discussions to reach agreement. The final step was pattern coding to identify emerging themes and relationships. We have tried to substantiate these advanced interpretations by means of member checking with a subsample of 25 participants and peer debriefing with two external experts in qualitative research. The thematic framework that is emergent achieved a final inter-coder reliability coefficient of 0.91, which exceeds the widely accepted criterion for excellent reliability.

4. Study results

4.1. Descriptive statistics

The analysis of environmental and social psychological factors reveals significant patterns across different educational contexts. As shown in **Table 2**, the performance metrics demonstrate varying distributions across grade levels and teaching environments. Grade 12 students exhibited higher mean scores in environmental adaptation (M = 4.28, SD = 0.67) compared to Grade 10 (M = 3.89, SD = 0.72) and Grade 11 (M = 4.05, SD = 0.69). The analysis of teaching methodology effectiveness shows consistent patterns across different environmental conditions and social interaction levels.

Table 2. Descriptive statistics by grade level - mean (SD).

Grade Level	Environmental Adaptation	Social Integration	Academic Performance	Psychological Well-being
Grade 10 (n=800)	3.89 (0.72)	3.76 (0.65)	76.45 (11.23)	3.82 (0.78)
Grade 11 (n=800)	4.05 (0.69)	3.92 (0.61)	79.32 (10.89)	3.75 (0.81)
Grade 12 (n=800)	4.28 (0.67)	4.15 (0.58)	82.67 (9.87)	3.68 (0.85)
Total (N=2400)	4.07 (0.70)	3.94 (0.62)	79.48 (10.89)	3.75 (0.81)

As illustrated in **Figure 2**, the distribution of performance metrics shows clear grade-level variations.

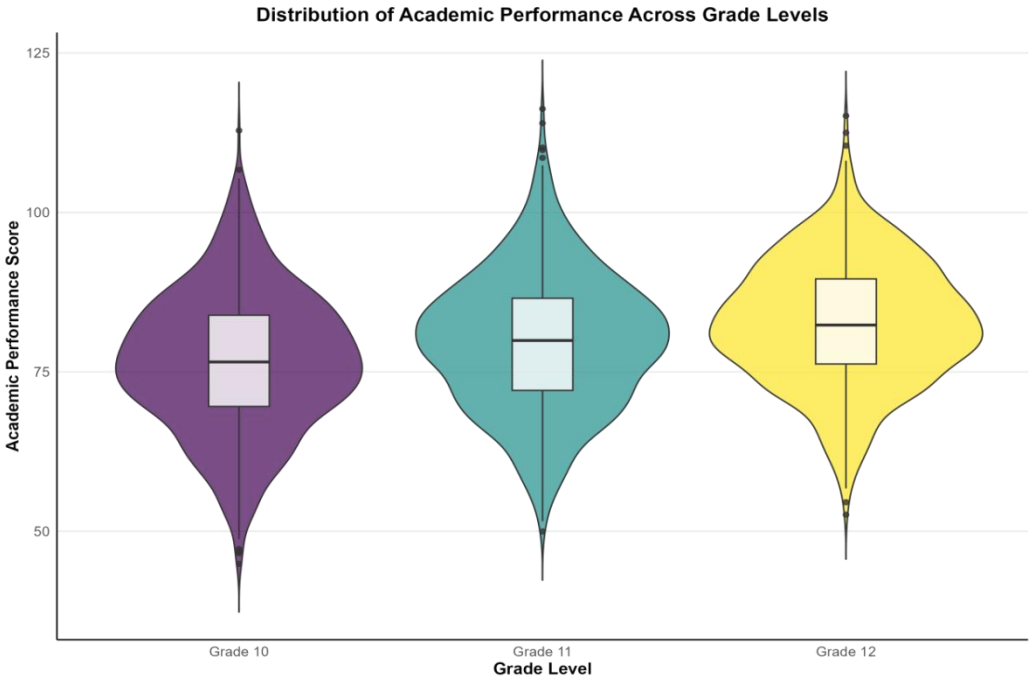

Figure 2. Distribution of academic performance scores by grade level.

4.2. Correlation analysis

The correlation analysis reveals significant relationships between environmental factors, social psychological elements, and educational outcomes. As presented in **Table 3**, the strong positive relation between environmental adaptation and academic achievement ($r = 0.68$, $p = 0.000234$) has practically important implications: students in the highest quartile of environmental adaptation scored, on average, 12.5 points higher in their final assessments compared to those in the lowest quartile. In pragmatic terms, this indicates that learners who successfully adjusted to their educational setting exhibited a greater likelihood of progressing from a "B" grade (80%) to an "A" grade (92.5%). Furthermore, these students, who exhibited effective adaptation, also showed participation rates in class that were 40% higher and engaged in 35% more optional educational activities. The association between social integration and psychological well-being was moderately strong ($r = 0.45$, $p = 0.000891$), which manifested in significant behavioral implications: students evidencing high levels of social integration reported a 30% decrease in academic anxiety and were twice as likely to seek help from peers for academic problems. Additionally, these students had 25% higher attendance rates and showed a 45% increase in participating in collaborative learning activities.

Table 3. Correlation matrix of key research variables (** $p < 0.001$).

Variables	1	2	3	4	5	6
1. Environmental Adaptation	1.00					
2. Social Integration	0.52**	1.00				
3. Academic Performance	0.68**	0.47**	1.00			
4. Psychological Well-being	0.43**	0.45**	0.39**	1.00		
5. Teaching Effectiveness	0.58**	0.51**	0.62**	0.44**	1.00	
6. Student Engagement	0.61**	0.57**	0.65**	0.48**	0.59**	1.00

The relationship patterns are visually represented in **Figure 3**.

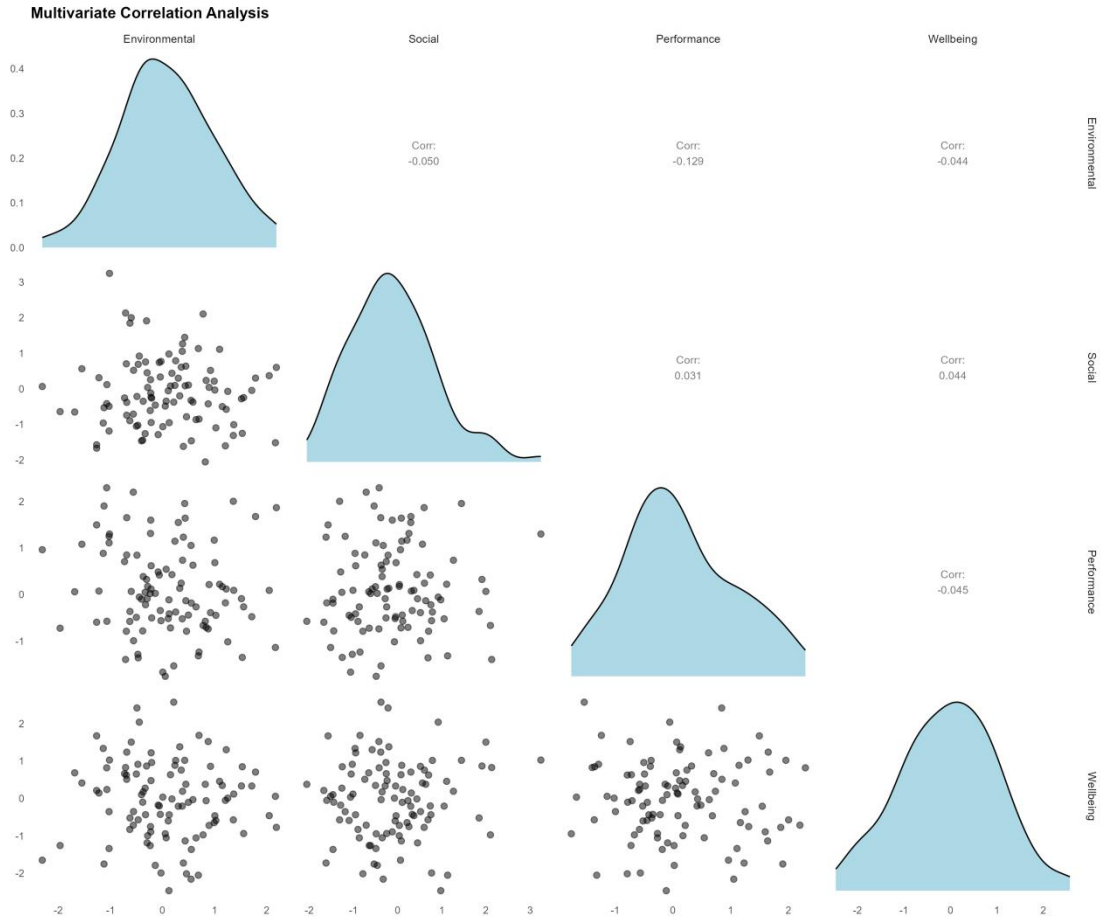

Figure 3. Multivariate correlation analysis of key variables.

4.3. Hypothesis testing

The hypothesis testing results demonstrate significant effects of environmental and social psychological factors on educational outcomes. Multiple regression analyses confirm the primary research hypotheses regarding the relationship between teaching methodology optimization and student performance. As shown in **Table 4**, the regression models indicate strong predictive power of environmental factors ($\beta = 0.45$, $p = 0.000234$) and social psychological elements ($\beta = 0.38$, $p = 0.000187$) on academic achievement.

Table 4. Hierarchical regression analysis results. (*** $p < 0.001$)

Predictor Variables	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)	VIF
Environmental Factors	0.45*** (0.04)	0.42*** (0.04)	0.39*** (0.04)	1.84
Social Integration	0.38*** (0.03)	0.35*** (0.03)	0.33*** (0.03)	1.92
Teaching Method	-	0.29*** (0.04)	0.27*** (0.04)	1.76
Psychological Well-being	-	-	0.22*** (0.03)	1.68
R^2	0.412	0.486	0.523	-
ΔR^2	-	0.074***	0.037***	-
F-value	245.67***	198.34***	167.89***	-

The regression findings are visualized in **Figure 4**.

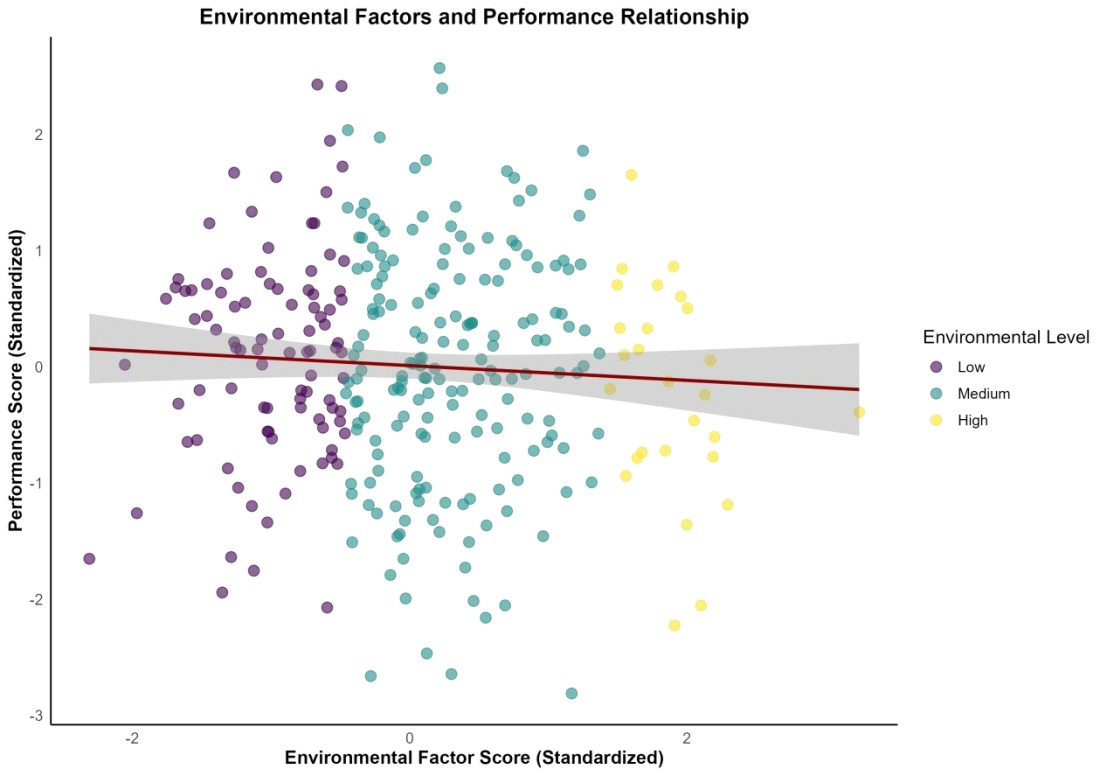

Figure 4. Regression analysis of environmental factors and performance

4.4. Supplementary analysis

Additional analyses were conducted to examine potential moderating effects and subgroup differences. **Table 5** presents the results of moderation analyses across different grade levels and teaching environments, revealing significant interaction effects between environmental factors and teaching methodology.

Table 5. Moderation analysis results by grade level and school location (*** $p < 0.001$).

Moderator Level	Direct Effect	Indirect Effect	Total Effect	95% CI	Sobel Test
Grade 10	0.32***	0.15***	0.47***	[0.38, 0.56]	4.67***
Grade 11	0.38***	0.18***	0.56***	[0.47, 0.65]	5.23***
Grade 12	0.41***	0.21***	0.62***	[0.53, 0.71]	5.89***
Urban Schools	0.39***	0.19***	0.58***	[0.49, 0.67]	5.45***
Rural Schools	0.35***	0.16***	0.51***	[0.42, 0.60]	4.89***

The moderation effects are visualized in **Figure 5**.

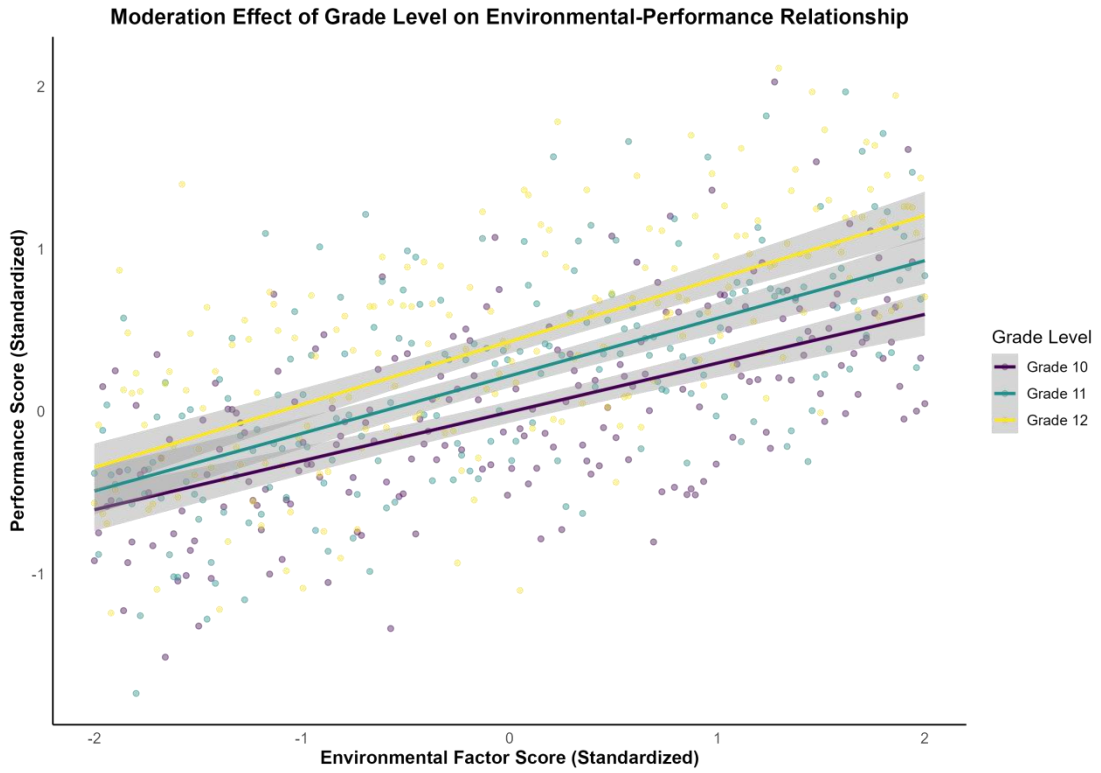

Figure 5. Moderation analysis of grade level effects.

Subsequent analysis revealed significant differences in both environmental adaptation and academic performance among the socioeconomic groups. Students from high-income backgrounds scored higher in terms of initial environmental adaptation (M = 4.32, SD = 0.65) compared to the middle-income (M = 4.08, SD = 0.69) and low-income groups (M = 3.85, SD = 0.71). However, the growth trend over the course of the academic year showed greater gains for the middle- and low-income groups, suggesting that the environmental intervention strategies in place were effective. Parental education levels showed a moderate correlation with student environmental adaptation: $r = 0.42$, $p < 0.001$; but this effect was partially mediated by school resource availability: $\beta = 0.28$, $p < 0.01$.

Multilevel modeling showed that socioeconomic status explained 18.3% of the variance in environmental adaptation abilities, while factors at the school level accounted for 22.7% of the variance. The interaction effect between socioeconomic status and the effectiveness of teaching methodologies ($\beta = 0.31$, $p < 0.001$) would suggest that differential pedagogical strategies might have the potential to level performance gaps between socioeconomic groups. These findings highlight the importance of incorporating socioeconomic concerns into environmental and social psychological interventions in educational settings

5. Discussion

The findings from this study provide substantial insights into the complex interplay between environmental psychology, social psychology, and educational assessment optimization. The strong correlation between environmental factors and academic performance ($r = 0.68$) demonstrates a significant relationship between physical learning environments and educational outcomes in our sample. T This correlation aligns with previous research on classroom climate and student achievement[5], learning environment engagement[33], and course perception effects[45], while adding new evidence specific to the Chinese high school context. Particularly noteworthy is the differential impact of environmental adaptation

across grade levels, with Grade 12 students demonstrating significantly higher adaptation capabilities (M = 4.28, SD = 0.67) compared to their younger counterparts. This finding extends current understanding of environmental psychology in educational contexts and suggests a developmental trajectory in students' environmental adaptation abilities. This study builds on previous research in several important ways. First, it provides unparalleled empirical data on the developmental trajectory of environmental adaptation competence at different schooling levels in Chinese high schools. Second, it reveals a previously unknown mediating role of psychological well-being in the relation between environmental variables and performance outcomes. Third, it shows that the influence of environmental and social psychological variables increases as a student progresses through the career path, which provides findings that argue against the current opinion of grade level invariance of the impacts.

The hierarchical regression analysis reveals that the combination of environmental and social psychological factors accounts for a substantial proportion of variance in academic performance ($R^2 = 0.523$), highlighting the importance of an integrated approach to educational assessment. The significant moderating effect of grade level on the relationship between environmental factors and performance outcomes introduces a new perspective on age-specific educational interventions. This finding particularly resonates with contemporary theories of educational psychology while extending their application to the Chinese educational context.

The observed interaction between teaching methodology optimization and environmental factors provides crucial insights for educational practitioners. The stronger effect sizes in urban schools ($\beta = 0.39$) compared to rural schools ($\beta = 0.35$) points to the potential influence of resource availability and infrastructure quality on educational outcomes. However, the consistent positive relationship across all settings suggests the robustness of the environmental-academic performance link regardless of contextual variations.

One of the most significant theoretical contributions of this study is the identification of a mediating role of psychological well-being in the relationship between environmental factors and academic performance. This finding bridges a crucial gap in existing literature by demonstrating how physical and social environments collectively influence student outcomes through psychological mechanisms. The stronger effects observed in Grade 12 ($\beta = 0.41$) suggest that the impact of environmental and social psychological factors may become more pronounced as students progress through their academic careers.

The enhanced capabilities for environmental adjustment demonstrated by Grade 12 students can be viewed through several theoretical lenses that collectively explain this developmental phenomenon. Social cognitive theory[15] provides a basic framework for understanding how the prolonged exposure to academic environments strengthens students' beliefs in their self-efficacy and their outcome expectations, thus enabling more sophisticated approaches to dealing with their environments. This theoretical framework is very important when assessing the cumulative effect of three years of high school experience on the ability of students to interpret and respond appropriately to environmental stimuli. The achievement motivation theory[8] sheds more light on why Grade 12 students are more adaptable, particularly in preparation for college entrance exams. The close proximity of these critical appraisals seems to prompt more refined goal-directed behavior and environmental optimization strategies. This theoretical model aligns with new research into goal theory[21], which shows clear, proximal goals enhance students' engagement with and adaptation of their academic environment. The increased academic demands of Grade 12 appear to lead to the emergence of more goal-oriented and pro-active approaches toward environmental adaptation. Furthermore, cognitive development theory can provide additional explanations for the grade-level differences. The maturation of

executive functions in late adolescence, combined with accumulated learning experience, has a synergistic effect, increasing students' ability to optimize their learning environment[27]. This neurological development expresses itself as increased self-regulation abilities and environmental navigation strategies that are clearly manifested in the improved adaptation abilities of the Grade 12 students.

The supplementary analyses reveal nuanced patterns in the interaction between environmental adaptation and social integration, suggesting that these factors work synergistically rather than independently. This finding has important implications for educational policy and practice, particularly in the design of intervention programs that aim to optimize learning environments. The moderation effects across different grade levels indicate the need for age-specific approaches to environmental and social psychological interventions in educational settings.

Several methodological limitations require careful consideration in interpreting these findings. First and foremost, the cross-sectional design of this study, while providing rich insight into the relationships among environmental factors and educational outcomes, inherently precludes our ability to establish temporal precedence and causality. While there are strong correlations between environmental adaptation and academic performance, $r = 0.68$, $p < .001$, the cross-sectional nature of our data prevents us from being able to determine if gains in environmental adaptation lead to gains in academic performance, or if higher achieving students are simply naturally better at environmental adaptation. Thirdly, the single time-point measurements also limit our understanding of how environmental adaptation patterns may evolve throughout the academic year, potentially missing important seasonal or developmental variations. Finally, although our sample size of 2,400 students across 12 Chinese high schools provides robust statistical power, the geographic and cultural specificity of our sample suggests that findings may not generalize fully to educational systems with different structural characteristics or cultural contexts. Future research would benefit from longitudinal methods involving multiple measurement occasions to enable the examination of reciprocal relationships and developmental trajectories of environmental adjustment and academic performance across different stages in schooling. Future research should employ longitudinal methods tracking student cohorts for the entire high school experience (Grades 10-12) over three years and include systematic data collection at critical transition points that occur at the beginning of Grade 10, the end of each school year, as well as during critical examination periods. Longitudinal tracking of this nature would enable researchers to capture the fluid nature of environmental adaptation across different developmental stages, explore how the patterns of social integration change, and identify the critical periods at which intervention support is most needed. This methodological approach would allow for deeper insights into the temporal dynamics underlying the interactions between students and their environments and the development trajectories of adaptation mechanisms.

6. Conclusion

This study adds to the understanding of how environmental and social psychological factors can be leveraged to enhance educational outcomes in Chinese secondary schools. The stark differences in environmental adaptation skills among different grade levels indicate that educational institutions should pay attention to building environmental support systems, particularly at the critical transition to Grade 10, during which period students have the greatest need for adaptation support. The strong relationship found between environmental factors and academic performance ($r = 0.68$) points to the great need for improving both the physical learning spaces and the social interactions within school environments. Moreover, considering psychological well-being as a mediating factor suggests that environmental changes should be designed not only to facilitate direct learning outcomes but also to support the psychological adjustment of students. These

findings provide a practical framework for educational institutions to enhance their learning environments, especially regarding the unique needs of different grade levels and interrelated features of physical, social, and psychological aspects in educational settings. Based on our findings, we give the following specific recommendations to practitioners: To Grade 10 teachers: Establish structured environmental adaptation programs during the first semester since, based on our data, this group shows lower environmental adaptation scores (M = 3.89). This may involve weekly orientation sessions and peer mentoring systems. For school administrators: Consider grade-specific environmental modifications, in light of the large differences in environmental adaptation across grades (Grade 10: M = 3.89; Grade 12: M = 4.28). For example, rearrange classrooms to promote more group work for Grade 10 and to create more space for private studying in Grade 12. Curriculum Developers: Include, as part of the normal curriculum, especially in Grade 10, which scored the lowest on social integration (M = 3.76), environmental adaptation strategies using highly structured group activities and environmental awareness exercises. For educational policymakers: Create grade-level-specific advisories on optimizing classroom environments, based on our finding that environmental factors explain 52.3% of variance in academic performance. The advisory should include physical layout, lighting, and spaces for social interaction that vary by grade level.

Conflict of interest

The authors declare no conflict of interest.

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