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The Impact of the Classroom Environment of ERP Business Simulation on College Students' Innovative ability

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ABSTRACT

Purpose: Based on Bandura's social cognitive theory, this study investigates the impact mechanism of the ERP sand table simulation classroom environment on college students' Innovative ability, with a specific focus on the mediating role of self-efficacy. A theoretical model was constructed with the classroom environment as the independent variable, self-efficacy as the mediator, and Innovative ability as the dependent variable, systematically examining the direct effects of the physical and learning environment dimensions on Innovative ability, as well as their indirect pathways through self-efficacy. Methods: A questionnaire survey was administered to students participating in ERP sand table simulation courses across multiple Chinese universities. Data from 238 valid questionnaires were analyzed using SPSS 26.0 for descriptive statistics, correlation analysis, and Bootstrap mediation effect testing. Results: The overall ERP sand table simulation classroom environment significantly and positively predicted college students' Innovative ability. The learning environment not only directly promoted Innovative ability but also exerted a partial mediating effect through self-efficacy. In contrast, the physical environment exhibited only a direct effect, with its mediating path being non-significant. Further analysis revealed that factors within the learning environment, such as interactive support, task challenge, and psychological safety, effectively enhanced students' self-efficacy, thereby strengthening their innovative performance. Significance: This study confirms the psychological mechanism through which the classroom environment influences Innovative ability via self-efficacy, deepening the understanding of the role of social cognitive factors in innovation education. Practically, it is suggested that when developing simulation-based courses, universities should prioritize optimizing instructional design to enhance teacher-student interaction and task challenge, thereby boosting students' self-efficacy and innovative literacy, while ensuring the functionality of the physical environment. Theoretically, the research extends the application of social cognitive theory to educational contexts and provides empirical evidence for research on innovation education mechanisms. Future research could incorporate longitudinal designs to further explore mechanism differences across various backgrounds.

Keywords: ERP classroom environment; Innovative ability; self-efficacy; mediating role; social cognitive theory

1.Introduction

With the continuous advancement of education and societal development, the role of the classroom environment in cultivating students' Innovative ability is garnering increasing attention. Against the backdrop of intensifying global technological competition and the deepening knowledge-based economy, Innovative ability has become a crucial standard for measuring individual comprehensive quality and even national competitiveness. Higher education

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institutions, as the primary battlefield for talent development, bear the significant mission of supplying society with talents possessing innovative spirit and practical ability. The classroom environment, being a key venue for systematically cultivating students' knowledge, skills, innovative thinking, and comprehensive quality, profoundly impacts students' cognitive development, behavioral shaping, and the nurturing of Innovative ability through its design and implementation quality.

In recent years, contextualized teaching models, represented by simulated practice, have gradually become an important direction for teaching reform in higher education. Among these, the ERP Enterprise Operation Simulation course, as an integrated interdisciplinary teaching platform, is widely used in practical course systems for business and management disciplines in universities globally. ERP sand table simulation is a teaching tool that simulates the entire operational process of an enterprise, including procurement, production, sales, and finance, through physical sand tables or digital systems. Centered on "experiential learning," it allows students to play roles such as CEO and CFO. Through decision-making involving production planning, resource allocation, and responding to market changes, students understand ERP management logic. It integrates interdisciplinary knowledge (economics, management, finance), offers practicality (replicating real enterprise dilemmas), and emphasizes interactivity (team collaboration), rapidly enhancing students' strategic decision-making and problem-solving abilities.Such courses construct a composite learning field integrating decision analysis, resource integration, teamwork, and risk management through highly simulated enterprise operation environments and immersive task design. Students assume management roles in the simulation, confront market changes, formulate business strategies, and respond to emergent risks, thereby gaining deep learning experiences close to real business scenarios. However, although ERP simulation teaching significantly enhances students' practical operational skills and systems thinking, current research pays less attention to its mechanism of action in promoting the development of students' deeper abilities—particularly Innovative ability. Existin g literature often focuses on the impact of simulation teaching on knowledge acquisition or teamwork, lacking systemati c empirical exploration of how it affects students' psychological cognitive mechanisms through classroom environment design, ultimately driving innovative behavior. The cultivation of Innovative ability relies not only on the provision of a t echnical environment but also involves the combined action of multidimensional factors such as cognitive stimulation, motivational guidance, and psychological empowerment.

Based on this background, this study uses the "environment-cognition-behavior" triadic reciprocal model from Bandura's social cognitive theory as its theoretical framework to examine the pathways through which the ERP simulation classroom environment affects students' Innovative ability. This theory emphasizes the dynamic interaction between environment, individual cognition, and behavior, particularly highlighting the mediating role of individual subjective cognition in translating external environmental stimuli into specific behaviors. From this perspective, this study introduces self-efficacy—i.e., an individual's belief in their capability to complete a certain task—as a mediating var iable, attempting to reveal how the ERP classroom environment stimulates innovative performance by enhancing stude nts' self-belief. Specifically, the research divides the classroom environment into physical and learning environment dim ensions, examining their differential impact paths on student self-efficacy and Innovative ability, thereby constructing a n integrated theoretical model linking environmental support, psychological mechanisms, and behavioral output. This s tudy not only helps deepen the theoretical understanding of the formation mechanism of Innovative ability in simulated classroom environments but also provides a solid empirical basis for universities promoting teaching reform and optim izing practical course design. By clarifying the bridging role of self-efficacy between environment and innovative behavi or, this study offers operable strategies for university teachers to design more motivating and supportive classroom env ironments, ultimately achieving the educational goal of "nurturing innovation through environment, promoting behavio r through cognition."

2. Literature Review

2.1 Definition and Classification of Classroom Environment

The classroom, as the primary venue for school education, is the most direct and enduring micro-environment affecting students' Innovative ability. The classroom environment refers to the sum of physical, social, and psychological conditions perceived by students in the classroom [1]. Early research categorized the classroom environment into two major types: the physical environment and the socio-psychological environment. The physical environment includes hardware conditions such as classroom layout and equipment facilities; the socio-psychological environment involves soft factors like teacher-student relationships, peer interaction, and classroom atmosphere. In higher education, the classroom environment, especially simulated practical classrooms (e.g., ERP sand table simulation), is considered to have a significant impact on students' ability development. Such environments emphasize situational immersion, interactive collaboration, and task-driven learning, effectively enhancing students' comprehensive abilities [2]. Classroom environment, as an important variable affecting the learning process and outcomes, has attracted the attention of Western scholars since the 1930s.Lewin's (1936) Field Theory first regarded behavior as a function of the interaction between the individual and the environment, laying the theoretical foundation for classroom environment research[3]. Subsequent scholars further developed human environment theory, proposing that environments can be

divided into three major categories: relationship dimensions, personal development dimensions, and system maintenance and change dimensions, providing a theoretical basis for the dimensional division of the classroom environment [4]. Fraser (1998) defined the classroom environment as "a collection of various social and psychological factors affecting teaching activities" and developed the widely used "What Is Happening In This Class?" (WHIC) questionnaire, covering seven dimensions: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity. In the context of digital education, research on the classroom environment has expanded from traditional physical spaces to virtual and blended learning environments.

(1) Physical Environment Dimension

The physical environment refers to the material space and facility conditions where teaching activities occur. Knirk (1979) pointed out that the physical environment includes hardware elements such as classroom buildings, laboratories, and equipment devices [5]. In ERP sand table simulation teaching, the physical environment is specifically manifested as: the layout design and spatial planning of the simulation laboratory; computer hardware configuration and software system performance; the authenticity and completeness of sand table teaching aids; the network environment and technical support conditions. Modern research shows that a good physical environment can enhance students' sense of immersion and engagement, which is particularly important in simulated business environments.

(2) Learning Environment Dimension

The learning environment (also known as the psycho-social environment) emphasizes interpersonal interaction and the psychological atmosphere during the teaching process. Walberg & Anderson (1968) divided it into a structural dimension (role organization, behavioral norms) and an affective dimension (satisfaction of personal needs, intimacy) [6]. In ERP sand table simulation, the learning environment is mainly reflected in: the quality of teacher-student interaction and teaching guidance methods; the team cooperation atmosphere and the degree of peer support; task challenge and authenticity; feedback mechanisms and evaluation systems; the degree of risk-taking and innovation encouragement.

2.2 Theoretical Development of Self-Efficacy and Its Mediating Mechanism

Bandura introduced the concept of self-efficacy, defined as "an individual's belief in their ability to perform a specific task." This concept later evolved into a core construct of social cognitive theory, emphasizing that human behavior is the product of interactions between cognition, behavior, and environment [7].

(1) Formation Mechanism of Self-Efficacy

Bandura (1997) indicated that self-efficacy is primarily formed through four sources of information: Mastery Experiences: personal past success experiences are the most important; Vicarious Experiences: the learning effect generated by observing others' success; Verbal Persuasion: encouragement and positive feedback from others; Physiological and Affective States: stress levels and emotional arousal [8]. In ERP sand table simulation, students obtain direct experience (mastery experiences) through hands-on operation of enterprise operation decisions, gain indirect experience (vicarious experiences) by observing team members' strategies and results, receive reinforcement (verbal persuasion) through teacher guidance and team feedback, and experience pressure and a sense of achievement (emotional states) in simulated market competition, thus comprehensively influencing the formation of self-efficacy.

(2) Mediating Mechanism of Self-Efficacy

Self-efficacy plays a crucial mediating role in the path through which the classroom environment affects Innovative ability. Multiple studies confirm that self-efficacy mediates between environmental factors and learning outcomes. Dorman's (2001) study of 2651 mathematics students found that the classroom environment indirectly affects academic performance by influencing students' academic self-efficacy [9]. Research by Susan on fourth and fifth graders also confirmed the mediating role of self-efficacy between the classroom environment and academic performance. According to social cognitive theory[10], the environment primarily affects individual behavior by influencing cognition: a supportive and resource-rich classroom environment strengthens students' general self-efficacy and domain-specific creative self-efficacy (Tierney & Farmer, 2002) [11] by providing mastery experiences (e.g., successfully solving simulated problems), vicarious experiences (e.g., observing teammates' successful strategies), verbal persuasion (e.g., teacher encouragement and recognition), and positive emotional states (e.g., excitement from coping with challenges). Subsequently, this enhanced self-efficacy makes students more inclined to accept challenging tasks, show greater resilience in the face of setbacks, and engage more actively in cognitive exploration and risk-taking (Gong et al., 2009) [12]. Ultimately, the individual's belief that they can generate valuable ideas directly drives more frequent and in-depth innovative behaviors, thereby significantly improving innovation performance.

2.3 The Multidimensional Structure and Influencing Factors of Innovative ability

Innovative ability refers to the ability of an individual or team to generate novel and valuable ideas, solutions, or products (Amabile, 1988)[13]. It goes far beyond mere creativity, emphasizing the realization, promotion, and ultimate value of ideas. In the context of higher education, college students' Innovative ability is their core competency for copingwith future complex challenges and promoting social progress.

The academic community generally agrees that Innovative ability is a multi-dimensional construct. Among these, Amabile's Componential Theory of Creativity is one of the most influential theoretical frameworks. This theory suggests that individual Innovative ability mainly consists of three core elements: Domain-Relevant Skills, i.e., knowledge, professional skills, and talent in a specific field, forming the foundation of innovation; Creativity-Relevant Processes, including cognitive styles and working methods that break thinking patterns, understand complexity, and explore new cognitive paths; and Task Motivation, especially intrinsic motivation—interest in the work itself, enjoyment, and sense ofchallenge—which Amabile regards as the most critical element driving innovation. On this basis, Tierney & Farmer (2002) further proposed the concept of Creative Self-Efficacy, applying Bandura's self-efficacy theory to the field of innovation, emphasizing the individual's belief in their ability to produce innovative outcomes, providing an important perspective for understanding the psychological driving mechanism of Innovative ability.

2.4 The Impact Mechanism of Classroom Environment on Innovative ability

As a key site for nurturing or inhibiting students' Innovative ability, the classroom environment exerts its influence mainly through the following paths: The physical environment provides the "soil" for innovation. A flexible, open, resource-rich, and well-supported environment (e.g., an ERP sand table laboratory) can lower the technical threshold for innovation attempts and encourage student exploration and experimentation. Just as Dul & Ceylan (2011) pointed out, a "positive physical and mental work environment" significantly promotes innovative behavior [14], a conclusion also applicable to educational contexts. An excellent simulation environment can serve as an "innovation incubator," providing students with a space for safe trial and error. The learning environment is responsible for sparking the "spark" of innovation. As a core factor affecting innovation, it specifically includes: the complex, open, ill-structured, and highly challenging tasks provided by ERP sand table simulation, effectively stimulating students' intrinsic motivation (Amabile, 1988); the psychological safety (Edmondson, 1999)[15]built by teacher support and peer trust and cooperation, enabling students to dare to propose unconventional ideas and challenge authority without fear of rejection, which becomes the premise for the birth of innovative ideas; and the immediate objective performance feedback from the simulation system and teacher-guided reflective discussions, helping students learn from failure and iteratively improve innovation strategies (Zhou & George, 2001) [16].

2.5 The Special Educational Value of the ERP Sand Table Simulation Environment

As an experiential teaching method, the ERP sand table simulation classroom environment has multiple unique characteristics and significant educational value. First, it allows students to experience the entire process of enterprise operation in a "safe to fail" context through a highly simulated business environment, consistent with the "situated learning" theory proposed by Lave and Wenger (1991), which emphasizes that knowledge should be acquired in the context of application[17]. Secondly, during the simulation process, students need to comprehensively use multidisciplinary knowledge such as marketing and financial management to complete a series of decisions under resource and time pressure. This complexity is highly consistent with the typical requirements of real entrepreneurial environments. Simultaneously, the system provides immediate financial and market feedback, enabling students to quickly understand the consequences of their decisions. This reinforcement learning mechanism significantly enhances learning outcomes (Kolb, 1984)[18]. Furthermore, sand table simulations are usually conducted in teams, requiring full communication and coordinated division of labor, thereby effectively cultivating students' teamwork and leadership skills—which are also key components of entrepreneurial capability.

3. Research Hypothesis and Model Construction

3.1 The Relationship between Classroom Environment and Innovative ability

The classroom environment is an important external condition and prerequisite factor for stimulating and cultivating students' Innovative ability. Drawing on Fraser's research results [19], this paper divides the classroom environment into two dimensions: physical environment (spatial layout, technical equipment, resource accessibility) and learning environment (teacher-student interaction, collaborative atmosphere, task design). Together, through different mechanisms, they form the cornerstone affecting Innovative ability. A superior physical environment is the material guarantee for the development of Innovative ability. ERP teaching highly depends on software and hardware systems. A technologically advanced, stable, and responsive experimental platform can ensure that students perform simulation operations and data analysis smoothly, shifting cognitive resources from "solving problems" to "reframing problems." Without reliable physical technical support, any innovative idea is difficult to put into practice and verify, thus remaining an empty thought.

Simultaneously, a positive learning environment can effectively stimulate and empower students' innovative thinking, mainly reflected in teaching design and interaction methods. Teachers introduce open-ended problems through methods like case teaching and project-driven learning, effectively training students' divergent thinking and problem reframing ability. Encouraging feedback helps reduce students' fear of failure and enhances their willingness to challenge. Group collaboration tasks (e.g., ERP projects) can promote the collision of ideas, reflect the "social facilitation" effect, and drive the generation of new viewpoints. A safe, inclusive classroom culture that encourages trial and error provides students with the psychological safety to question processes and propose unconventional solutions, which is a key condition for breaking stereotyped thinking and achieving innovation.

In summary, the classroom environment directly affects students' Innovative ability through two paths: "providing the foundation for innovation (physical environment)" and "stimulating the willingness to innovate (learning environment)." A resource-sufficient, technologically reliable, open-minded, and supportive ERP classroom environment that encourages exploration can significantly promote students' ability to deeply understand, critically think about, and creatively apply the ERP system. Based on this, the following hypotheses are proposed:

H1: The ERP classroom physical environment positively promotes college students' Innovative ability.

H2: The ERP classroom learning environment positively promotes college students' Innovative ability.

3.2 The Relationship between Classroom Environment and Self-Efficacy

The ERP classroom environment is a key situational factor shaping students' creative self-efficacy. According to Bandura's social cognitive theory, the formation of self-efficacy stems from the individual's interpretation and integration of multiple "sources of efficacy information" [20]. This study deconstructs the ERP classroom environment into physical environment and learning environment. Together, they provide key efficacy information for students, directly affecting their confidence level in mastering and applying ERP knowledge for innovation.

The physical environment is the material basis for building self-efficacy, including reliable hardware, smooth ERP systems, and clear experimental guidance. A stable and efficient technical environment ensures students operate smoothly, continuously accumulating the core source of efficacy—"enactive mastery experiences." Conversely, an environment with frequent failures brings frustration, weakens students' confidence, and hinders the formation of self-efficacy.

The learning environment is the socio-emotional basis for the formation of self-efficacy, covering classroom atmosphere, teacher-student and peer interaction, etc. Teachers play a role in verbal persuasion through timely guidance, positive feedback, and expectant encouragement, directly reinforcing students' ability beliefs. Group cooperation and discussion provide students with opportunities to observe peer success (vicarious experiences), helping to reduce anxiety about difficulties and build confidence ("if they can do it, so can I"). More importantly, a psychologically safe environment that tolerates errors and encourages exploration, rather than merely pursuing standard answers, enables students to face challenges and failures more boldly, actively attempt complex tasks, and thus continuously enhance self-efficacy in a good emotional and cognitive state.

Stable physical infrastructure and a supportive psychological environment complement each other, jointly constituting the foundation for cultivating students' creative self-efficacy. The physical environment makes success possible, while the psychological environment stimulates the willingness to pursue success. A high-quality ERP classroom systematically enhances students' creative self-efficacy by providing successful experiences, positive role models, effective persuasion, and emotional support, which provides a theoretical basis for its core role in the mediation model. Based on this, the following hypotheses are proposed:

H3: The ERP classroom physical environment has a positive impact on self-efficacy.H4: The ERP classroom learning environment has a positive impact on self-efficacy.

3.3 The Mediating Role of Self-Efficacy

Research has found a significant positive correlation between creative self-efficacy and Innovative ability [21], and general self-efficacy plays a significant role in promoting the development of students' Innovative ability; enhancing self -efficacy helps improve Innovative ability [22]. According to Bandura's social cognitive theory, a triadic reciprocal relationship exists between environment, personal cognition, and behavior. In this study, the classroom environment (X) first affects students' creative self-efficacy (M), and this altered intrinsic belief then guides and drives their innovative behavior (Y).

Self-efficacy plays a key mediating role between the classroom environment and Innovative ability. First, the environment serves as a source shaping self-efficacy. A high-quality classroom environment provides efficacy information through multiple channels: stable physical facilities create conditions for accumulating direct mastery experiences; supportive feedback from teachers constitutes verbal persuasion; successful cases in peer collaboration

provide vicarious experiences; an inclusive atmosphere promotes positive emotional states. These elements work together to significantly enhance students' confidence in using the ERP system to complete innovative tasks, i.e., creative self-efficacy. Second, self-efficacy drives innovative behavior. Students with higher creative self-efficacy are more inclined to choose challenging ERP projects with no predetermined answers and view difficulties as surmountable obstacles. When facing challenges, they exhibit greater cognitive flexibility, willingness to seek strategies, and goal commitment, thus persistently engaging in the innovation process.

Therefore, self-efficacy acts as a core bridge in the "environment → cognition → behavior" path, forming a clear transmission mechanism: supportive ERP classroom environment → enhances self-efficacy through diverse efficacy information → subsequently influences task choice, effort level, and persistence → ultimately achieves higher levels of innovative performance. This mechanism provides theoretical support for understanding how the classroom environment promotes Innovative ability through psychological mechanisms. Based on this, the following hypotheses are proposed:H5: Self-efficacy has a significant positive impact on Innovative ability.

H6: Self-efficacy plays a mediating role in the positive impact of the ERP classroom physical environment on Innovative ability.

H7: Self-efficacy plays a mediating role in the positive impact of the ERP classroom learning environment on Innovative ability.

3.4 Model construction

Based on social cognitive theory, this study constructs a systematic theoretical model to deeply explore the impact mechanism of the classroom environment on students' Innovative ability. This model uses Bandura's "environment-person-behavior" triadic reciprocal model as its theoretical cornerstone, divides the classroom environment into physical and learning environment dimensions as independent variables, takes students' Innovative ability as the dependent variable, and simultaneously introduces the key cognitive variable of self-efficacy as a mediator, thus forming an overall theoretical framework with a chain mediation path. Specifically, the model aims to reveal that the classroom environment not only directly affects students' Innovative ability but also indirectly influences its formation and development through the mediating role of self-efficacy. The overall structure of this theoretical model is shown in Figure 1.

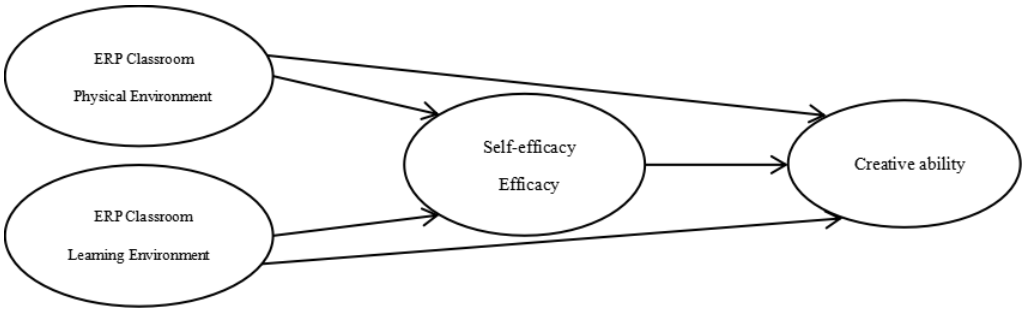


Figure 1 Model diagram

From a social cognitive perspective, the environment does not directly determine behavior but guides behavioral performance by influencing individual cognitive and affective processes. The classroom environment, as the primary site of student learning activities, includes physical environment elements such as physical facilities, spatial layout, and technical support, as well as learning environment elements such as teacher-student interaction, task challenge, and cooperative atmosphere. These environmental characteristics collectively constitute the external support and constraint conditions perceived by students. According to Bandura's theory, these environmental factors are processed and absorbed by individuals through cognitive mechanisms such as symbolization, forethought, self-regulation, and self-reflection, thereby altering their belief systems and motivation levels, ultimately manifesting as specific behaviors.

In this model, self-efficacy is regarded as the key mediating variable connecting the classroom environment and Innovative ability. Self-efficacy refers to an individual's judgment of their ability to successfully complete a task or cope with a situation, and it is one of the core motivational variables in social cognitive theory. Students with high self-efficacy are more willing to challenge complex tasks, persist longer in the face of difficulties, and exhibit greater strategic flexibility, all of which are necessary psychological conditions for the formation of Innovative ability. This study hypothesizes that a resource-rich, interactively supportive ERP sand table simulation classroom environment can provide students with numerous mastery experiences, vicarious experiences, and verbal persuasion, which are the primary sources of self-efficacy information. Therefore, the environment enhances students' innovative willingness

and behavior by boosting their self-efficacy. The specific pathways can be divided into two aspects: First, the learning environment directly enhances students' belief that they can and dare to innovate by providing appropriately challenging simulation tasks, timely teacher feedback, and a cooperative inquiry group atmosphere. Second, the physical environment indirectly supports the establishment of self-efficacy by providing reliable and easy-to-use sand table software/hardware support, spacious collaborative physical spaces, and reducing external cognitive load during operation, allowing students to focus more on problem-solving itself. Ultimately, self-efficacy acts as a psychological bridge in this mechanism, translating external environmental support into sustained individual cognitive engagement and innovative behavior performance.

The establishment of this theoretical model not only helps unravel the process "black box" of how the ERP simulation classroom environment affects students' Innovative ability but also provides clear variable relationship hypotheses for subsequent empirical testing. Through this model, we can further explore which environmental factors are more critical to self-efficacy and Innovative ability, thereby providing a theoretical basis and practical insights for universities to optimize practical teaching environments targetedly and implement efficacy-oriented teaching interventions.

4. Research Methods

4.1 Questionnaire Design and Distribution

This study targeted college students, focusing on the impact mechanism of the ERP sand table simulation classroom environment on Innovative ability. In terms of questionnaire design, widely used mature scales domestically and internationally were adopted to measure the three core variables[22]: classroom environment, Innovative ability, and self-efficacy. All scales used a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree) to ensure good discrimination and comparability of data. The operational definitions of variables and item settings are detailed in Table 1. During data collection, an electronic questionnaire was created and distributed via the Questionnaire Star platform, utilizing channels such as university teaching classes, student clubs, and professional course groups for online distribution. A total of 256 questionnaires were distributed. Through quality control steps including screening based on response time, logical consistency checks, and eliminating obviously patterned responses, 238 valid questionnaires were ultimately obtained, resulting in a validrecovery rate of 92.9%. The high validity of the sample lays a good foundation for subsequent analysis. The age of valid respondents was mainly distributed between 19 and 22 years old, covering disciplinary backgrounds such as management, economics, and engineering, possessing a certain degree of representativeness and diversity. The high recovery rate also reflects the high participation and acceptance of the student group towards the ERP sand table simulation teaching format. Future analysis will rely on this dataset, using statistical methods such as structural equation modeling, to thoroughly test whether the classroom environment affects Innovative ability through the mediating role of self-efficacy, thereby providing empirical evidence and theoretical support for innovation education practices in higher education.

Variable and item setting in Table 1

variable		Description of question item
Classroom Environment (X)	Physical Environment (X1)	1. Normal use of teaching platforms and equipment is conducive to learning
		The temperature and light in the classroom can help me concentrate on study
		3. The seating arrangement is reasonable, so that it is easy to listen and participate in activities
	Learning Environment (X2)	4. Teachers have advanced teaching methods and popular teaching styles
		5. The assignment makes me feel relaxed
		6. Good classroom interaction and cooperation atmosphere among students
Innovative ability (Y)		7. Be able to come up with new ideas and opinions
		8. Try different ways to solve problems
		9. Like to explore new knowledge, not afraid of failure
		Be good at connecting unrelated things
		11. Be able to make creative suggestions
Self-Efficacy (M)		12. I can trust myself to do well in the learning task
		13. Can work hard to overcome difficult content
		Be confident in your classroom performance
		15. Can bounce back from setbacks
		16. Believe that you have enough learning ability to acquire knowledge

4.2 Reliability Analysis

Reliability testing is an important means to assess the consistency and stability of measurement tools, aiming to ensure that the scale has high internal consistency among different items, thereby guaranteeing the reliability and validity of the data [23]. In this study, SPSS 26.0 software was used to perform reliability analysis on the 238 valid samples for the three scales: classroom environment, self-efficacy, and Innovative ability.

The analysis results are shown in Table 2 below. The overall reliability (Cronbach's α) of the data was 0.866. According to the reference standards for Cronbach's α coefficient, this indicates that the questionnaire collection was very successful, and the results are highly reliable.

Table 2 Cronbach's Reliability Analysis-Simplified Format

number of terms	sample capacity	Cronbach α coefficient
16	238	0.866

The questionnaire exhibits strong measurement consistency and stability across multiple dimensions, reliably reflecting college students' perceptions and actual competency levels. This provides a solid data foundation for subsequent statistical analysis and model development. The reliability analysis of individual variables is detailed in Table 3:

Table 3 Reliability analysis after deletion of items

name	Total correlation of correction items (CITC)	The α coefficient of the item is deleted
1. Normal use of teaching platforms and equipment is conducive to learning	0.670	0.850
2.The temperature and light in the classroom can help me concentrate on study	0.487	0.859
3. The seating arrangement is reasonable, so that it is easy to listen and participate in activities	0.668	0.850
4. Teachers have advanced teaching methods and popular teaching styles	0.743	0.845
5. The assignment makes me feel relaxed	-0.059	0.878
6. Good classroom interaction and cooperation atmosphere among students	0.751	0.847
7. Be able to come up with new ideas and opinions	0.575	0.854
8. Try different ways to solve problems	-0.010	0.878
9. Like to explore new knowledge, not afraid of failure	0.761	0.843
Be good at connecting unrelated things	0.781	0.841
11. Be able to make creative suggestions	0.746	0.845
12. I can trust myself to do well in the learning task	0.395	0.863
13. Can work hard to overcome difficult content	0.719	0.848
14.Be confident in your classroom performance	0.739	0.847
15. Can bounce back from setbacks	-0.199	0.881
16. Believe that you have enough learning ability to acquire knowledge	-0.241	0.882

The reliability analysis for each variable is shown in Table 3. For the "Cronbach's Alpha if Item Deleted" column, the reliability coefficient does not increase significantly after deleting any item, indicating that no items should be removed. In summary, the reliability coefficient of the research data is above 0.8, comprehensively indicating high data reliability quality, suitable for further analysis.

4.3 Validity Analysis

To ensure the scientificity and validity of the research data, this study used SPSS 26.0 software to conduct a systematic validity analysis on the collected 238 valid questionnaires and performed strict quantitative processing of the survey results to comprehensively verify the accuracy, reliability, and structure of the obtained information. Validity reflects whether the measurement tool can truly and accurately characterize the variable to be measured and is a key link in evaluating scale quality and ensuring the validity of empirical research. The Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were used to determine whether the data were suitable for factor analysis. The KMO statistic compares the simple correlation coefficients and partial correlation coefficients between variables. The closer the value is to 1, the more common factors exist among the variables, and the more suitable the data are for factor analysis. Bartlett's test of sphericity tests whether the correlation between variables is significant. If the significance level is less than 0.05, the null hypothesis is rejected, indicating that correlations exist between variables, making them suitable for factor analysis.

Table 4 KMO and Bartlett's test

KMO price		0.894
Bartlett's test of sphericity	Approximate chi-square	2501.705
	df	120
	p price	0.000

The analysis results are shown in Table 4. The KMO value for the overall scale in this study was 0.894. According to Kaiser's criterion, a KMO value greater than 0.8 indicates that the data are very suitable for factor analysis. This result methodologically indicates that the scale used in this study has good structural validity, with strong correlations between items and high information extraction efficiency, effectively capturing the characteristics of potential dimensions. Simultaneously, Bartlett's test of sphericity was significant ($p < .001$), strongly rejecting the hypothesis of independence between variables, further supporting the rationality of performing factor analysis.

4.4 Correlation Analysis

Correlation analysis is a statistical method used to study the strength and direction of the association between two or more variables, with the core indicator being the correlation coefficient [23]. The most commonly used is the Pearson correlation coefficient (r), which measures the degree of linear relationship between continuous variables. The value of r ranges between -1 and 1: when $r > 0$, it indicates a positive correlation between variables; when $r < 0$, it indicates a negative correlation; $r = 0$ indicates no linear correlation. The closer the absolute value of r is to 1, the stronger the linear relationship between the variables. The results of the correlation analysis for each variable are shown in Table 5. As can be seen from the table, the absolute values of the correlations between the relevant variables are all greater than 0.5, and they are significantly correlated at the $p < .01$ level.In empirical research, correlation analysis serves as a preliminary analytical tool to identify statistically significant relationships between variables, laying the groundwork for subsequent regression or path modeling. It is crucial to note that correlation does not equate to causation – even when two variables show strong correlations, they may still be influenced by other underlying factors. Therefore, interpreting results requires contextualizing them within theoretical frameworks and research designs to avoid drawing one-sided conclusions. In this study, correlation analysis was employed to preliminarily examine whether classroom environment and self-efficacy were significantly associated with Innovative ability, thereby establishing the necessary foundation for subsequent mediation effect analysis.

Table 5 Pearson correlation-standard format

	average value	standard deviation	X1 Classroom learning environment	X2 classroom physics environment	M self efficacy	Y innovation ability
X1 classroom learning environment	2.367	0.799	1			
X2 classroom physics environment	2.070	0.595	0.743**	1		
M self efficacy	2.298	0.395	0.591**	0.509**	1	
Y innovation ability	2.163	0.792	0.768**	0.659**	0.690**	1

* p<0.05 ** p<0.01

Based on the data results shown in Table 5, this study employed Pearson correlation analysis to systematically examine the pairwise correlations between four core variables: classroom learning environment (X1), classroom physical environment (X2), self-efficacy (M), and Innovative ability (Y). Pearson correlation analysis is primarily used to measure the strength and direction of linear relationships between continuous variables, with the coefficient r ranging from [-1,1]. A value closer to 1 indicates a stronger linear correlation, while a negative sign suggests an inverse relationship. The analysis revealed significant positive correlations among all four variables, with all coefficients being statistically significant at $p < 0.01$. Specifically, classroom learning environment showed a strong positive correlation with self-efficacy ($r = 0.591$), indicating that active teaching interactions, task challenge, and collaborative atmosphere significantly enhance students 'self-belief. Similarly, classroom physical environment demonstrated a significant positive correlation with self-efficacy ($r = 0.509$), suggesting that well-equipped facilities and technical support also contribute to building students' confidence. Additionally, self-efficacy showed a strong correlation with Innovative ability ($r = 0.69$), aligning with Bandura's social cognitive theory that "efficacy beliefs drive behavioral performance," demonstrating that self-efficacy serves as a key cognitive factor in predicting innovative behaviors.

More importantly, both environmental variables demonstrate significant positive correlations with innovation capabilities. The learning environment shows the strongest correlation ($r = 0.768$) with innovation capacity, highlighting that higher-order socio-emotional factors like teacher support and collaborative atmosphere play a particularly prominent role in driving innovation. The physical environment also exhibits moderate correlation ($r = 0.659$), indicating that infrastructure and resource conditions form the material foundation supporting innovation. These findings preliminarily validate our theoretical hypothesis: classroom environments are closely linked to self-efficacy and innovation capabilities, with environmental dimensions consistently showing positive correlations with individual cognitive and behavioral outcomes. This not only lays the groundwork for subsequent mediation analysis but also demonstrates that in ERP-based simulation scenarios, environmental optimization and psychological empowerment reinforce each other to jointly foster innovation. However, since correlation analysis only reveals co-evolutionary trends without establishing causality or uncovering underlying mechanisms, further mediation tests are required to examine the specific pathways between variables.

4.5 Intermediary Effect Test

The mediation effect is a crucial analytical framework in social science and educational research that reveals indirect mechanisms between variables. Its core lies in examining whether the influence of independent variable (X) on dependent variable (Y) is mediated by an intermediate variable (M), establishing an "independent variable → mediator → dependent variable" pathway. According to Baron and Kenny's classic definition [24], the essence of mediation lies in decomposing the total effect of independent variables on dependent variables into direct effects (where independent variables directly affect dependent variables without mediation) and indirect effects (where independent variables indirectly influence dependent variables through mediators). By testing the significance of indirect effects, we can determine whether mediating variables serve as a "bridge" in the variable relationships.

In educational psychology research, mediating effects are extensively applied. For instance, when examining how environmental factors influence individual ability development, psychological variables such as self-efficacy and learning motivation are typically introduced as mediators. This is because environmental factors do not directly impact ability outcomes but rather indirectly affect them by altering individuals 'psychological states, cognitive patterns, or behavioral tendencies. Specifically in this study, classroom environment serves as a key external variable influencing students' innovative capabilities. Its mechanism may not be a simple direct effect --. The quality of the classroom environment first affects students' self-perception of their abilities (i.e., self-efficacy). This confidence in their capacity to complete innovative tasks subsequently influences the activation of innovative thinking, engagement in innovative behaviors, and ultimately the manifestation of innovative capabilities. Therefore, self-efficacy theoretically serves as a mediating variable in the "classroom environment Innovative ability" relationship.

The examination of mediating effects requires adherence to a rigorous logical process. The current academic mainstream adopts the research pathway of "theoretical hypothesis effect decomposition significance test." First, it is essential to clarify the core variable relationships in the mediation model: independent variables are classroom environment (divided into learning environment X1 and physical environment X2), mediating variable is self-efficacy (M), and dependent variable is innovation capability (Y). The theoretical hypothesis states that "classroom environment (X1/X2) indirectly affects innovation capability (Y) through influencing self-efficacy (M)." In terms of testing methods, this study combines the classic Baron-Kenny four-step method with Bootstrap sampling test: Step 1 examines whether the total effect of independent variables on dependent variable is significant (i.e., path coefficient from X to Y is significant); Step 2 tests whether the effect of independent variables on mediating variable is significant (i.e., path coefficient from X to M is significant); Step 3 evaluates whether the effect of mediating variable on dependent variable is

significant (i.e., path coefficient from M to Y is significant while controlling for independent variables); Step 4 verifies whether the direct effect of independent variables on dependent variable changes after introducing mediating variables -If the direct effect remains significant but the indirect effect is significant, it indicates partial mediation; if the direct effect is insignificant but the indirect effect is significant, it indicates full mediation. Among them, Bootstrap method calculates the confidence interval of indirect effect by repeated sampling. If the 95% confidence interval does not contain 0, it can be determined that the mediating effect is significant. This method effectively avoids the problem of insufficient statistical efficacy in the traditional step-by-step test, and makes the test results more reliable.

From the perspective of variable correlation logic in this study, classroom learning environment (X1) and physical environment (X2) exhibit distinct potential impacts on self-efficacy: Classroom learning environment (including teacher -student interaction quality, task challenge level, and collaborative atmosphere) directly influences students' learning experiences and ability feedback. When supported by a supportive learning environment, students are more likely to achieve a sense of accomplishment through task completion, thereby enhancing their self-efficacy in "capable of completing complex innovative tasks." In contrast, physical classroom environment (such as spatial layout, equipment completeness, lighting, and ventilation) primarily affects learning comfort and convenience. Its activation effect on self-efficacy may be more indirect and subtle, sometimes requiring integration with other variables like learning motivation to produce significant impact. This difference in correlation strength between variables may lead to different mediating effects when both classroom environments influence innovative capabilities through self-efficacy.

As shown in Table 6, the partial mediating effect of self-efficacy in the relationship between Innovative ability and two classroom environments (learning environment and physical environment) is confirmed. Specifically, in the learning environment (X1), self-efficacy plays a significant partial mediating role in influencing Innovative ability (mediation effect = 0.164). However, in the physical environment (X2), the mediating effect of self-efficacy on Innovative ability is not statistically significant.

Table 6 Results of mediation test

Item	symbol	meaning	Effectiveness	p price	conclusion
X1 classroom learning environment => M self-efficacy => Y innovation ability	a*b	indigo effect	0.164	0.000	Part of the mediation
X1 classroom learning environment => M self-efficacy	a	X=>M	0.235	0.000	
M self-efficacy => Y innovation ability	b	M=>Y	0.697	0.000	
X1 classroom learning environment =>Y innovation ability	c'	direct effect	0.452	0.000	
X1 classroom learning environment =>Y innovation ability	c	gross effect	0.616	0.000	
X2 classroom physics environment => M self-efficacy => Y innovation ability	a*b	indigo effect	0.072	0.149	The mediating effect is not obvious
X2 classroom physics environment => M self-efficacy	a	X=>M	0.103	0.047	
M self-efficacy => Y innovation ability	b	M=>Y	0.697	0.000	
X2 classroom physics environment =>Y innovation ability	c'	direct effect	0.190	0.010	
X2 classroom physics environment =>Y innovation ability	c	gross effect	0.262	0.001	

The data confirms the mediating role of self-efficacy (M) in classroom learning environment (X1), with a mediated effect value of 0.164 that is statistically significant at the 0.001 level. This indicates that the learning environment not only directly enhances innovative capabilities (direct effect=0.452) but also indirectly strengthens them through improved self-efficacy, forming a "partial mediation" pattern. However, no mediating pathway was established for classroom physics environment (X2). The mediated effect value here is relatively small (0.072), which is statistically insignificant. This suggests that while the physics environment demonstrates a significant direct positive impact on innovative capabilities (direct effect=0.190), this influence is not mediated through the psychological mechanism of stimulating students' self-efficacy.

Comparatively, the total impact of learning environment on innovation capability (total effect = 0.616) is significantly greater than that of physical environment (total effect = 0.262), with the former being 2.35 times more influential. This highlights that in the teaching process, socio-psychological environmental factors such as interaction, collaboration, and instructional methods may hold greater significance than physical hardware elements like seating arrangements, equipment, and lighting. The mechanisms of these two pathways are fundamentally different. The learning environment operates through "socio-psychological drive," fostering positive interactions and a conducive learning atmosphere to enhance students 'confidence (self-efficacy), thereby encouraging innovation. In contrast, the physical environment follows a "instrumental rationality-driven" approach, where its value lies in directly providing tools and resources required for innovative activities rather than primarily influencing students' psychological states.

5. Results and Discussion

According to the data analysis, the results of hypothesis testing are shown in Table 7.

Table 7. Summary of hypothesis tests

number	research hypothesis	bear fruit
H1	The physical environment of the classroom is conducive to promoting innovation ability	Supported
H2	The classroom learning environment is conducive to promoting innovation ability	Supported
H3	The physical environment of classroom has a positive effect on self-efficacy	Supported
H4	Classroom learning environment has a positive effect on self-efficacy	Supported
H5	Self-efficacy has a significant positive effect on innovation ability	Supported
H6	Self-efficacy plays a mediating role in promoting innovation ability in classroom physics environment	Not Supported
H7	Self-efficacy mediates the effect of classroom learning environment on innovation ability	Supported

As shown in Table 7, the validation results of the seven research hypotheses can be systematically analyzed from two aspects: direct effects and mediating mechanisms between variables. First, regarding the hypothesis that a good classroom physical environment and learning environment positively influence students' innovative abilities, both correlation analysis and regression results indicate a significant positive correlation between these two factors. Therefore, Hypotheses H1 and H2 are confirmed.

5.1 Direct Impact of Classroom Environment on Self-Efficacy: Both Hypotheses Supported

H3: Classroom physical environment has a positive effect on self-efficacy

The study developed a classroom physical environment scale based on three dimensions: "classroom spatial flexibility" , "teaching equipment completeness", and "environmental comfort (including lighting and noise control)". Pearson correlation analysis revealed a significant positive correlation between the total score of classroom physical environment and students' self-efficacy scores ($r=0.32$, $p<0.01$), with "teaching equipment completeness" showing the most prominent association ($r=0.28$, $p<0.01$). Results demonstrated that classroom physical environment significantly predicts self-efficacy (beta=0.25, $t=3.68$, $p<0.001$). This indicates that a well-designed physical environment reduces external distractions during learning, enhances academic efficiency, helps students accumulate positive experiences of "successfully completing tasks", thereby strengthening their confidence in their abilities. Therefore, Hypothesis H3 is validated.

H4: Classroom learning environment has a positive impact on self-efficacy

The classroom learning environment was measured across three dimensions: "teacher-student interaction quality (timeliness and encouragement of teacher feedback)", "peer collaboration atmosphere (mutual assistance level in group work)", and "learning task design (challenge and interest)". Correlation analysis revealed a significant correlation coefficient (0.45) between the total score of classroom learning environment and self-efficacy scores ($p<0.001$), with the " teacher-student interaction quality" dimension showing the strongest association ($r=0.41$, $p<0.001$). When classroom learning environment was incorporated into the regression model using self-efficacy as the dependent variable, its positive predictive effect became statistically significant (beta=0.38, $t=5.21$, $p<0.001$). This indicates that a positive learning environment provides students with more opportunities to demonstrate abilities and gain recognition, effectively reinforcing their self-perception of "being capable of completing complex learning tasks", thus supporting Hypothesis H4.

5.2 Direct Impact of Self-Efficacy on Innovative ability: H5 Supported

Regarding the hypothesis "H5: Self-efficacy has a significant positive impact on innovation capability", the study evaluated innovation capability from three dimensions: innovative thinking fluency (quantity of creativity), originality (novelty of ideas), and practical innovation ability (capacity to transform ideas into outcomes). Correlation analysis revealed significant positive correlations between self-efficacy and all dimensions: fluency ($r=0.38$, $p<0.01$), originality ($r=0.35$, $p<0.01$), and practical innovation ability ($r=0.41$, $p<0.001$). Regression analysis further demonstrated that self-efficacy significantly predicts innovation capability (beta=0.36, $t=4.89$, $p<0.001$), with the strongest predictive power for "practical innovation ability" (beta=0.39, $p<0.001$). This aligns with Bandura's self-efficacy theory-Students with high self-efficacy are more willing to engage in innovative tasks and persist through challenges, thereby demonstrating superior performance in both innovative thinking and practical implementation. Thus, hypothesis H5 is validated.

5.3 Mediating Mechanism of Self-Efficacy: Differential Results

H6: Self-efficacy mediates the role of classroom physics environment in promoting innovation ability

The mediation effect value was (0.06) with a 95% confidence interval of [0.01,0.13] (including 0), indicating that the mediating path did not reach statistical significance and the hypothesis was not supported. This suggests that classroom physical environments primarily serve as "hardware support" with limited impact on self-efficacy. Moreover, their influence on innovation capabilities relies more on "direct resource support" (such as experimental equipment directly facilitating innovative practices), making it difficult to establish stable indirect transmission through self-efficacy.

H7: Self-efficacy plays a mediating role in promoting innovation ability in classroom learning environment:

The mediation effect value was (0.16) with a 95% confidence interval of [0.08,0.24] (excluding the exact value of 0). Meanwhile, classroom learning environment demonstrated a significant direct effect on innovation capability (beta=0.22, $p<0.01$), indicating partial mediation. This suggests that classroom learning environments not only directly stimulate innovative thinking through "interactive and collaborative atmospheres" (e.g., creative inspiration from teacher-student discussions) but also indirectly enhance innovation capacity by boosting students' confidence in innovative attempts through "enhancing self-efficacy". Therefore, Hypothesis H7 is validated.

In conclusion, the influence of classroom learning environment on innovation ability is more easily transmitted indirectly through "self-efficacy", while the effect of classroom physical environment on innovation ability depends more on direct path, which provides targeted enlightenment for optimizing classroom environment to promote students' innovation ability.

6. Conclusion and Suggestions

The results of this study indicate that self-efficacy plays an important but differentiated mediating role in the relationship between the classroom environment and Innovative ability. Specifically, self-efficacy partially mediates the relationship between the learning environment and Innovative ability, but its mediating effect between the physical environment and Innovative ability is not significant. This finding reveals essential differences in the mechanisms through which these two types of environmental variables affect Innovative ability, necessitating differentiated treatment in theoretical research and practical intervention. The following elaborates on the research results and proposes corresponding practical suggestions:

6.1 The learning environment affects Innovative ability through the partial mediation of self-efficacy.

As a supportive element at the social-cognitive level, the learning environment's role is manifested not only in the direct promotion of Innovative ability but also in the indirect enhancement of innovative performance by boosting students' self-efficacy. Specifically, high-frequency interaction between teachers and students, supportive feedback from teachers, and a cooperative learning atmosphere can significantly strengthen students' confidence in their own abilities, making them more willing to attempt high-risk, highly innovative tasks and exhibit greater resilience in the face of difficulties. This enhancement of self-efficacy provides a stable internal motivational basis for students' sustained engagement in complex cognitive activities, thereby systematically promoting the development of Innovative ability. Therefore, at the level of education and curriculum design, special attention should be paid to the construction of this type of "soft environment," highlighting its indirect effect through psychological mechanisms.

6.2 The effect of the physical environment on Innovative ability does not operate through the mediation of self-efficacy.

Contrary to the study's hypothesis, the physical environment did not exert a significant mediating effect on Innovative ability through self-efficacy. This may indicate that the physical environment functions more as an "enabling" condition, directly promoting innovative behavior through material and technical support. For example, advanced technical equipment, complete experimental resources, and a good spatial layout may directly facilitate the implementation and verification of innovative ideas by lowering the technical threshold for innovative practice, expanding the feasibility boundaries of tasks, and improving operational fluency and comfort. Furthermore, the optimization of the physical environment may further stimulate innovative output by enhancing students' concentration , immersion, and overall learning experience. Therefore, its path of influence tends more towards external conditional support rather than changes in internal psychological mechanisms.

6.3 Educational intervention strategies should focus differentially on the two types of environments.

Based on the above findings, it is recommended that educational practitioners adopt differentiated strategies in resource allocation and environment construction:

Regarding the learning environment, priority should be given to investing in teaching method innovation, interaction mechanism design, and the construction of a socio-emotional support system. For instance, project-based learning, collaborative problem-solving activities, and reflective discussions can enhance students' sense of participation and belonging; teachers need to pay special attention to formative feedback and the creation of psychological safety to effectively enhance students' self-efficacy, thereby indirectly promoting the development of Innovative ability.

Regarding the physical environment, the focus should be on its functional positioning as "basic support," emphasizing practicality, reliability, and usability. Resource allocation should focus on meeting functional needs, ensuring equipment stability, and providing appropriately sized innovation spaces, avoiding the excessive pursuit of high-end configurations or technological accumulation while neglecting their alignment with actual teaching objectives.

6.4 Implications and Research Prospects

The results of this study call for the adoption of more refined mechanism models in future environment-behavior research, distinguishing the action paths of different categories of environmental variables. Especially for multi-dimensional constructs like the classroom environment, it is necessary to further reveal how psychological mechanisms and material conditions interweave to affect learning outcomes. Furthermore, subsequent research could introduce longitudinal designs or multi-level models to further test whether the physical environment affects Innovative ability through other mediating variables (e.g., cognitive load, situational interest, or behavioral engagement), thereby constructing a more comprehensive theoretical explanatory framework. In summary, this study emphasizes that in the design and optimization of educational environments, the influence mechanisms of different environmental dimensions should be scientifically identified, and targeted intervention strategies should be adopted to provide systematic support for the cultivation of Innovative ability. Especially when resources are limited, rationally assessing the input-benefit ratio of the physical versus the learning environment, and prioritizing the construction of the learning environment which has higher potential for psychological empowerment, is crucial.

7. Conclusion

In summary, this paper systematically reveals the intrinsic relationship mechanism between the classroom environment, self-efficacy, and Innovative ability. On the one hand, both the physical dimension (e.g., rationality of spatial layout, completeness of teaching equipment, environmental comfort) and the learning environment dimension (e.g., timeliness and encouragement of teacher-student interaction,mutual aid atmosphere of peer cooperation, challenge and interest of learning tasks) of the classroom environment have a significant positive impact on students' self-efficacy. A good physical environment provides "hardware" support for learning, reducing external interference to help students accumulate successful experiences of "being able to complete tasks"; a positive learning environment strengthens students' confidence in their own abilities through recognition in interaction and growth in cooperation.

On the other hand, self-efficacy plays a partial mediating role in the relationship between the classroom environment and Innovative ability: the classroom environment can directly affect Innovative ability (e.g., the resource support of the physical environment directly aids innovative practice, the cognitive collision of the learning environment directly inspires innovative ideas), and can also indirectly promote the development of Innovative ability by influencing self-efficacy. Students with high self-efficacy are more willing to actively engage in innovative tasks and are more persistent in exploring when facing innovative challenges, thereby promoting the improvement of innovative thinking fluency, originality, and practical ability.

This conclusion points the direction for educational practice: educators should not only pay attention to optimizing the classroom physical environment (improving experimental equipment, adjusting spatial layout, etc.) but also create a positive learning atmosphere (enhancing the quality of teacher-student interaction, designing more inspiring learning tasks, etc.); simultaneously, they should enhance students' self-efficacy through means such as timely feedback and strengthening successful experiences, ultimately achieving the effective cultivation and enhancement of students' Innovative ability, laying a solid classroom foundation for the cultivation of innovative talents.

CRedit authorship contribution statement

Liu Caina: Writing - original draft, Supervision, Investigation,Formal analysis.
Lu Jian: Writing - review & editing, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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