

THE INFLUENCE OF LEARNING STRATEGIES ON INNOVATION LITERACY AMONG COLLEGE STUDENTS IN GUANGXI, CHINA

A INFLUÊNCIA DAS ESTRATÉGIAS DE APRENDIZAGEM NA ALFABETIZAÇÃO EM INOVAÇÃO ENTRE ESTUDANTES UNIVERSITÁRIOS EM GUANGXI, CHINA

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Abstract

In today's knowledge-driven economy, universities emphasize the cultivation of students' innovative behaviors; however, the innovation literacy of many college students remains insufficient to meet societal and labor market demands. Grounded in the Constructivist Theory of Education, this study examined how different learning strategies contribute to college students' innovation literacy and whether self-management mediates this relationship. The study aimed to test the hypotheses that learning strategies positively predict innovation literacy and that self-management serves as a significant mediating mechanism. A cross-sectional survey design was employed, and data were collected through an online questionnaire from 426 undergraduate students across nine universities in China. Structural equation modeling and bootstrapping procedures were used to analyze the relationships among variables and to test mediation effects. The results indicated that the adoption of effective learning strategies significantly enhanced students' self-management abilities, which in turn positively predicted innovation literacy. Moreover, self-management played a significant mediating role in the relationship between learning strategies and innovation literacy, suggesting both direct and indirect effects. These findings highlight the importance of promoting adaptive learning strategies and strengthening self-management skills in higher education. The study provides empirical evidence for designing instructional interventions and institutional policies aimed at improving students' innovation literacy and better aligning higher education outcomes with societal needs.

Resumo

Na economia atual, impulsionada pelo conhecimento, as universidades enfatizam o desenvolvimento de comportamentos inovadores nos alunos; no entanto, a alfabetização em inovação de muitos estudantes universitários continua insuficiente para atender às demandas da sociedade e do mercado de trabalho. Baseado na Teoria Construtivista da Educação, este estudo examinou como diferentes estratégias de aprendizagem contribuem para a alfabetização em inovação dos estudantes universitários e se a autogestão medeia essa relação. O estudo teve como objetivo testar as hipóteses de que as estratégias de aprendizagem predizem positivamente a alfabetização em inovação e que a autogestão atua como um mecanismo mediador significativo. Foi empregado um desenho de pesquisa transversal, e os dados foram coletados por meio de um questionário online com 426 estudantes de graduação de nove universidades na China. Modelagem de equações estruturais e procedimentos de bootstrapping foram utilizados para analisar as relações entre as variáveis e testar os efeitos de mediação. Os resultados indicaram que a adoção de estratégias de aprendizagem eficazes melhorou significativamente as habilidades de autogestão dos estudantes, o que, por sua vez, predizia positivamente a alfabetização em inovação. Além disso, a autogestão desempenhou um papel mediador significativo na relação entre estratégias de aprendizagem e alfabetização em inovação, sugerindo efeitos tanto diretos quanto indiretos. Essas descobertas destacam a importância de promover estratégias de aprendizagem adaptativas e fortalecer as habilidades de autogestão no ensino superior. O



Keywords: Innovation Literacy. Learning Strategies. Self-Management. Higher Education. Structural Equation Modeling.

estudo fornece evidências empíricas para a concepção de intervenções pedagógicas e políticas institucionais destinadas a melhorar a alfabetização em inovação dos alunos e a alinhar melhor os resultados do ensino superior às necessidades da sociedade.

Palavras-chave: Alfabetização em Inovação. Estratégias de Aprendizagem. Autogestão. Ensino Superior. Modelagem de Equações Estruturais.

1 INTRODUCTION

As pioneers in knowledge acquisition and innovation, college students play a critical role in societal advancement. College students with high innovation literacy are able to break through traditional modes of thinking, since they are not confined to conventional theories in their professional studies and can broaden their academic horizons from unique perspectives [1]. If, during their learning process, they can integrate knowledge from different disciplines to generate innovative ideas and novel perspectives, they will contribute significantly to social and national progress [2]. Therefore, innovation literacy has become one of the core competencies emphasized in higher education talent cultivation, and its importance is self-evident [3].

The innovation literacy of college students is of great significance to high-quality economic and social development. Scholars have proposed various approaches to enhancing innovation literacy from different perspectives [4]. Guo and Zheng [5] emphasized integrating scientific practice into talent cultivation programs and forming a positive interaction with open evaluation systems, which can help students improve their innovative capabilities and stimulate their motivation for innovation through practice, thereby further enhancing innovation literacy. Zong [6] advocated for deep integration with industry, combining theory and practice to foster innovation literacy. Enterprise participation provides students with innovation-oriented guidance aligned with market demands and practical resources, thereby strongly supporting the cultivation of innovation literacy. Bian [7] argued that student innovation practice activities are key to overcoming difficulties in improving innovation literacy. Through practical experience,

students accumulate knowledge and enhance their innovation literacy, providing valuable insights for universities in cultivating innovative talents. However, while Chinese students maintain a leading position in foundational disciplines, they face criticism regarding creative thinking, critical thinking, and practical problem-solving abilities—competencies closely related to innovation literacy [8,9]. Therefore, in-depth research on innovation literacy is crucial for cultivating high-quality talents in China who can meet the demands of the times [10].

Previous scholars have argued that learning strategies can effectively influence students' innovation literacy [11]. For example, Zheng [12] suggested that the application of metacognitive strategies can effectively enhance students' autonomous learning abilities. Li and Jia [13] proposed that cultivating the use of cognitive strategies significantly improves learning outcomes for all students. Zhang and Guan [14] contended that the acquisition and refinement of these strategies are central to fostering students' innovation literacy. Therefore, exploring the differential effects of these two types of strategies on innovation literacy and enhancing students' ability to apply learning strategies are of profound significance for innovation education in higher education and for broader societal innovation development [15].

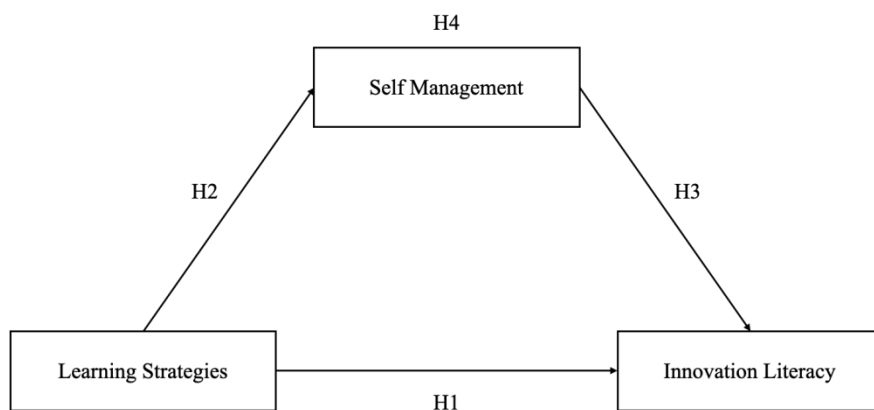
Cui [16] pointed out that in the process of using learning strategies to enhance innovation literacy, students' self-management is positively influenced. Hess [17] argued that improving college students' self-management abilities helps regulate mindset and maintain positive emotions, thereby ensuring the sustainability of innovative attempts. Furthermore, self-motivation within self-management can stimulate students' intrinsic motivation, providing sustained motivational support for the enhancement of innovation literacy [18,19]. This suggests that the implementation of learning strategies can continuously optimize and improve students' self-management, and by strengthening the goal orientation and specificity of self-management, further enhance innovation literacy [20].

This study takes college students in Chinese universities as the research subjects to examine the relationships among learning strategies, innovation literacy, and self-management. It aims to clarify the effect of learning strategies on innovation literacy and to reveal the mediating role of self-management between learning strategies and innovation literacy. By doing so, the study seeks to provide a scientific basis and practical

strategies for improving college students' innovation literacy and enriching educational practice, offering significant theoretical and practical value. Based on the foregoing discussion, the conceptual framework of this study is presented in Figure 1.

Figure 1

Research Framework Diagram



1.1 The impact of learning strategies on innovation literacy

Learning strategies are the methods and approaches students use to accomplish specific learning tasks and are closely related to the cultivation of innovation literacy. They mainly include cognitive strategies and metacognitive strategies [21]. Cognitive strategies consolidate college students' foundational knowledge through repeated engagement with learning content, building a solid knowledge base for innovative activities and enabling students to flexibly apply knowledge in innovation [22]. Cognitive strategies organize and categorize learning content into a structured knowledge system, allowing college students to systematically master knowledge, improve learning efficiency, provide ideas for innovative programming projects, and facilitate the cultivation of innovation literacy.

Metacognitive strategies refer to strategies through which students monitor and regulate their own cognitive processes and are of great significance to the cultivation of innovation literacy [23]. Metacognitive strategies require college students to formulate detailed plans before engaging in learning and innovative activities, clarify goals, steps, and methods, and dynamically adjust and optimize them during implementation to

improve learning and innovation efficiency [24]. Metacognitive strategies emphasize that during the process of learning and innovation, students should monitor their cognition in real time, regularly examine their learning progress and level of mastery, reflect on and evaluate their approaches and methods in innovative activities, promptly identify problems and make adjustments, thereby ensuring learning quality and facilitating the development of innovation literacy [25].

In summary, learning strategies refer to students evaluating and summarizing learning outcomes after completing learning and innovative activities, proposing improvement measures, and applying them in subsequent learning and innovation in order to continuously enhance their innovation capabilities [26]. Based on the above reasoning, this study proposes the following hypothesis:

H1: Learning strategies among Chinese college students have a significant positive effect on innovation literacy.

1.2 The impact of learning strategies on self-management

Haniah et al. [27] pointed out that learning strategies significantly enhance the effectiveness of self-management. Through repeated study of foundational knowledge, learning strategies build a solid knowledge base for self-management, enabling learners to confidently and efficiently arrange content and schedules according to their level of knowledge mastery when planning learning or work tasks, thereby reducing management confusion caused by insufficient knowledge. By influencing students' self-management, learning strategies enable students to consider solutions from multiple perspectives when facing complex problems or tasks.

Learning strategies not only improve learning efficiency but also cultivate learners' logical thinking and sense of organization. In addition to helping learners plan and categorize their lives in an orderly manner, they make life and study more structured and facilitate efficient self-management. Therefore, learning strategies enhance self-management abilities, allowing college students to allocate resources rationally, strengthen the purposefulness and initiative of their actions, and establish a clear framework for self-management [28]. Moreover, during cognitive activities, students can promptly evaluate and provide feedback on outcomes, assess the alignment between

actions and goals, identify problems in a timely manner, and avoid deviations from intended objectives.

Based on the above reasoning, this study proposes the following hypothesis:

H2: Learning strategies among Chinese college students have a significant positive effect on self-management.

1.3 The impact of self-management on innovation literacy

Gao et al. [29] pointed out that through self-management, college students are able to accurately identify their own interests, strengths, and weaknesses, thereby sensitively recognizing innovation literacy embedded in different fields. Self-management not only effectively stimulates college students' awareness of innovation but also helps them focus on their areas of expertise, avoid blind attempts, and lay a solid foundation for the improvement of innovation literacy [30].

In the cultivation of innovation literacy, college students inevitably encounter conflicts between academic pressure and innovation tasks, delays caused by time constraints, and difficulties arising from insufficient resources. Self-management can help optimize time management, improve learning efficiency, and expand access to resources, thus providing strong support for the development of innovation literacy [31]. In addition, when innovation yields results, college students can, through self-management, further strengthen their recognition of their own abilities, encouraging them to engage in more complex and challenging areas of innovation, deeply explore their innovative potential, and achieve advancement in innovation literacy.

Self-management serves as a behavioral guideline for innovative activities. It guides college students to adhere strictly to academic ethics and regulations, avoid blind innovation or improper operations, and ensure that innovative activities proceed along legal and compliant paths [32]. Self-management helps college students reasonably plan their time and energy and overcome procrastination [33]. Furthermore, by formulating and strictly implementing learning and innovation plans, college students can devote themselves fully to innovative practice, effectively enhance innovation literacy, and enable innovative thinking to be more rapidly transformed into tangible outcomes [34].

Based on the above reasoning, this study proposes the following hypothesis:

H3: Self-management among Chinese college students has a significant positive effect on innovation literacy.

1.4 The mediating role of self-management

First, Khan et al. [41] found a significant and strong positive correlation between the use of learning strategies and self-management. Effective learning strategies help learners transform abstract self-management goals into concrete and actionable steps. At the same time, through feedback following the application of learning strategies, learners can better monitor their learning progress, adjust their self-management, form a positive cycle, and further strengthen the positive relationship between the two. Qiao [35] indicated that learning strategies serve as the core support of self-management, and a significant positive relationship exists between them. The mastery and application of learning strategies can systematically enhance learning-related self-management.

Second, Yuksel and Günsel [45] confirmed a significant and strong positive correlation between self-management ability and innovation literacy; the stronger the self-management ability, the more prominent the performance in innovation literacy. Learning strategies exert a key positive influence on the formation and development of students' innovation literacy. The mechanism of learning strategies does not directly transmit innovative skills; rather, it supports innovation literacy by optimizing cognitive processes and activating learners' agency.

Based on the above reasoning, this study proposes the following hypothesis:

H4: Self-management among Chinese college students plays a mediating role between learning strategies and innovation literacy.

2 METHOD

This study adopted a questionnaire survey method. To enhance the generalizability of the research findings, college students from nine different types of universities in China were selected as research participants. The types of institutions included "985" or "211" key universities, as well as public and private universities. Since all variables in this study were self-reported by respondents, there was a potential risk of

common method variance. To address this issue, the following procedures were implemented: (1) item meaning concealment: the names of the constructs measured by each scale were hidden to prevent respondents from guessing the research purpose or adopting defensive attitudes; (2) exclusive electronic questionnaire links were directly sent to respondents' mobile phones or computers, allowing them to complete the survey with greater privacy and without concern that their answers would be observed, thereby reducing the influence of social desirability [36].

3 PARTICIPANTS

The sample consisted of 426 college students from six universities in China. The average age was 20.73 years, with an age range of 18 to 22 years. Among them, 228 students were female and 198 were male, accounting for 53.52% and 46.48%, respectively. Most participants were from liberal arts disciplines ($n = 294$, 60.01%), while the remaining participants were from science disciplines ($n = 132$, 30.99%).

4 RESEARCH INSTRUMENTS

4.1 Learning strategies

Learning strategies are defined as a series of planned actions and cognitive steps adopted by college students to complete learning tasks and achieve learning goals, enabling students to acquire, store, and apply knowledge more effectively [37]. This study employed the *College Students' Learning Strategies Questionnaire* developed by Xu et al. [31]. The scale consists of two dimensions: cognitive strategies and metacognitive strategies, with a total of 30 items. A five-point Likert scale was used (1 = strongly disagree, 5 = strongly agree). The Cronbach's α coefficient was .955.

4.2 Innovation literacy

Innovation literacy is defined as the ability of college students to understand environmental and social events, grasp technological developments, and gain insight into

innovation-related issues [38]. This study adopted the *Innovation Literacy Survey Questionnaire* developed by Tong and Song [39]. The scale includes three dimensions: innovation awareness, innovation traits, and innovation practice, with a total of 16 items. A five-point Likert scale was used (1 = completely inconsistent, 5 = completely consistent). The Cronbach's α coefficient was .957.

4.3 Self-management

Self-management is defined as a comprehensive ability through which college students actively manage and regulate their thoughts, emotions, behaviors, and surrounding environment during learning, daily life, and personal development by applying cognitive and behavioral strategies. It emphasizes students' ability to manage their own behavior through internal cognitive resources [40]. This study used the *Self-Management Scale for Higher Vocational College Students* developed by Zhang [14]. The scale includes five dimensions: self-cognition, self-planning, self-coordination, self-motivation, and self-control, with a total of 20 items. A five-point Likert scale was used (1 = completely inconsistent, 5 = completely consistent). The Cronbach's α coefficient was .944.

4.4 Control variables

To exclude other variables that might affect the research results, gender and major were included as control variables. (1) Gender: Previous studies have indicated that gender influences individual innovation literacy and perceptions of events [4,39]; therefore, gender was controlled in this study. (2) Major: Song and Wan [41] suggested that science students tend to demonstrate stronger innovation literacy and are more inclined to use scientific methods and technical approaches to solve problems during innovation processes, whereas liberal arts students place greater emphasis on humanistic literacy and critical thinking and are more likely to explore new perspectives and ideas from cultural, social, and historical angles [42]. Therefore, age was included as a control variable in this study.

5 RESULT

5.1 Common method variance (CMV) analysis

The formal data of this study were collected from nine universities during the same time period. To eliminate the possibility that the relationships among variables were inflated by common method variance, Harman's single-factor test was conducted on the 56 items measuring the three variables. The results indicated that seven factors with eigenvalues greater than 1 accounted for a cumulative total variance of 63.469%. The first factor explained 24.163% of the total variance, which did not exceed 50%, indicating that the problem of common method variance was not serious [36].

5.2 Descriptive statistics and correlation coefficients

Correlation analysis was conducted to examine the relationships among the variables. The results are presented in Table 1. Learning strategies were significantly and positively correlated with innovation literacy and self-management ($r = .599, .659, p < .001$). Innovation literacy was also significantly and positively correlated with self-management ($r = .613, p < .001$).

Table 1

Correlation Coefficients and Descriptive Statistics Hypothesis Testing

Variables	Mean	SD	Learning Strategies	Innovation Literacy	Self-Management
Learning Strategies	3.89	0.502	(.883)		
Innovation Literacy	3.52	0.607	.599***	(.812)	
Self-Management	3.83	0.517	.659***	.613***	(.889)

Note 1: *** $p < .001$; $N = 426$.

Note 2: Mean refers to the average; SD refers to the standard deviation.

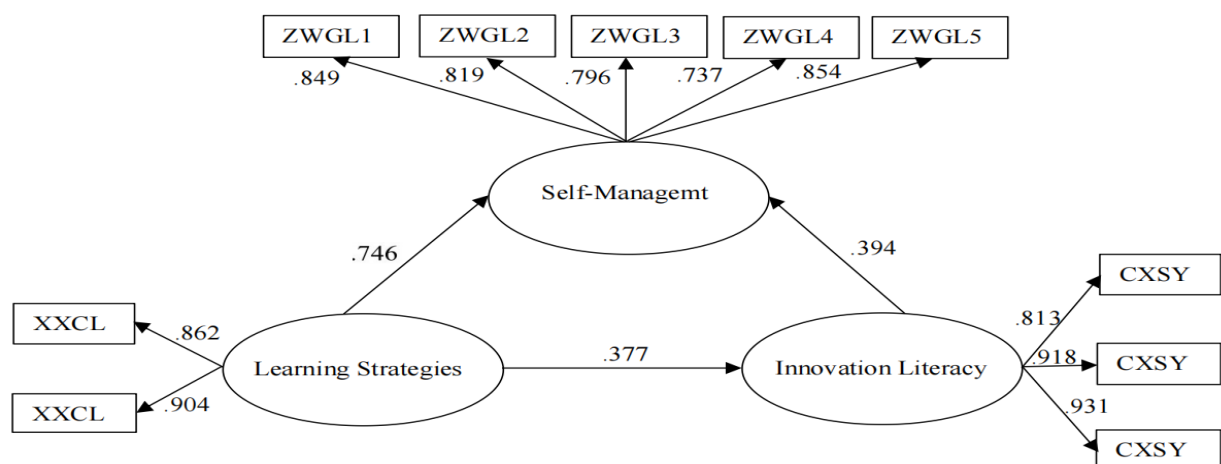
Note 3: Reliability values are presented on the diagonal.

5.3 Hypothesis testing

The structural equation model constructed for learning strategies, self-management, and innovation literacy showed that the standardized factor loadings of all observed variables on their corresponding latent variables ranged from .737 to .931 ($p < .001$), indicating good convergent validity of the scales. Regarding the structural paths, learning strategies had significant positive predictive effects on self-management ($\beta = .746$, $p < .001$) and innovation literacy ($\beta = .377$, $p < .001$). Self-management also had a significant positive predictive effect on innovation literacy ($\beta = .394$, $p < .001$). These results indicate that learning strategies not only directly promote the improvement of innovation literacy but also indirectly influence innovation literacy through the mediating role of self-management, as shown in Figure 2.

Figure 2

Structural Model of Learning Strategies, Self-Management, and Innovation Literacy



Note 1: XXCL1–XXCL2 represent the dimensions of the learning strategies scale; CXSY1–CXSY3 represent the dimensions of the innovation literacy scale; XWGL1–XWGL5 represent the dimensions of the self-management scale.

Note 2: *** $p < .001$.

Table 2 presents the model fit indices estimated using the maximum likelihood method. The results showed that $\chi^2/df = 3.439$, RMSEA = .076, SRMR = .036, GFI = .959, AGFI = .920, NFI = .972, RFI = .955, NNFI = .968, and CFI = .980. All fit indices met or exceeded the recommended criteria ($\chi^2/df < 5$, RMSEA < 0.08 , SRMR < 0.05 , and

other indices > 0.9), indicating that the structural model demonstrated good fit to the data and satisfactory structural validity.

Table 2

Summary of Model Fit Indices for the Learning Strategies, Innovation Literacy, and Self-Management Scales

Fit Index	χ^2/df	RMSEA	SRMR	GFI	AGFI	NFI	RFI	NNFI	CFI
Ideal Criteria	<5	<0.08	<0.05	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9
Model Values	3.439	.076	.036	.959	.920	.972	.955	.968	.980

Table 3 presents the results of the nonparametric percentile Bootstrap method (5,000 resamples) used to test the mediating effect of self-management between learning strategies and innovation literacy. The results showed that the total effect of learning strategies on innovation literacy was .789 (SE = .059, $p < .001$, 95% CI = [.674, .940]); the direct effect was .443 (SE = .098, $p < .001$, 95% CI = [.246, .637]); and the indirect effect through self-management was .346 (SE = .077, $p < .001$, 95% CI = [.194, .505]). The 95% confidence interval did not include 0, indicating that self-management played a significant mediating role between learning strategies and innovation literacy. Learning strategies not only directly promoted innovation literacy but also indirectly influenced innovation literacy through the mediating pathway of self-management.

Table 3

Bootstrap Mediating Effect of Self-Management and Confidence Intervals (Structural Equation Model)

Path	Effect	SE	p-value	95% Confidence Interval [Lower, Upper]
Total Effect	.789	.059	.001	.674,.940
Direct Effect	.443	.098	.001	.246,.637
Indirect Effect	.346	.077	.001	.194,.505

Note 1: The Bootstrap method was conducted with 5,000 random resamples.

Note 2: 95% LLCI = lower limit of the 95% confidence interval; 95% ULCI = upper limit of the 95% confidence interval.

Note 3: Indirect path = Learning Strategies → Self-Management → Innovation Literacy.

6 DISCUSSION AND RECOMMENDATIONS

6.1 Discussion of results and theoretical implications

The results showed that Chinese college students scored above 3 on learning strategies, innovation literacy, and self-management (5-point scale), indicating that the respondents generally possessed awareness and ability in the active use of cognitive and metacognitive strategies, consistent with previous research [43]. The comprehensive application of learning strategies not only improves the efficiency and depth of knowledge acquisition but also breaks fixed patterns of thinking and stimulates exploratory thinking, providing core support for the cultivation of innovation literacy. When college students skillfully apply cognitive and metacognitive strategies to actively construct and regulate their learning processes, their flexibility in problem-solving, critical thinking, and creativity is significantly enhanced. Students also demonstrate a certain level of innovative awareness, innovative traits, and practical ability [44], as well as satisfactory self-regulation abilities, enabling them to clearly understand their personal characteristics, scientifically plan learning processes, and proactively coordinate internal and external resources to achieve goals.

Among the control variables, male college students demonstrated significantly higher levels of innovation literacy than female students, consistent with previous findings. Male students are more willing to attempt interdisciplinary innovation and challenge traditional approaches, whereas female students tend to emphasize rigor and reliability, leading to a more gradual and cautious approach to innovation [44, 45].

Regarding the relationships among variables, the findings indicated that: (1) learning strategies had a significant positive effect on innovation literacy, consistent with previous studies. Learning strategies facilitate deep processing and integration of knowledge, providing a cognitive foundation for generating creative ideas and enhancing autonomy and sustained exploration in innovation literacy. (2) Learning strategies had a significant positive effect on self-management. Effective learning strategies promote deeper understanding and optimized learning pathways, thereby enhancing self-management capacity. (3) Self-management had a significant positive effect on innovation literacy. As a core ability for regulating cognition, behavior, and environment,

self-management provides structured internal support for innovation literacy. (4) Self-management played a mediating role between learning strategies and innovation literacy. Learning strategies enhanced innovation literacy not only directly but also indirectly through the mediating mechanism of self-management.

6.2 Research limitations and suggestions for future research

This study focused on Chinese college students, and the selected universities did not fully represent all institutional characteristics, which may limit the generalizability of the findings. Future research is recommended to adopt stratified sampling across different regions and institutional types to enhance representativeness. Comparative studies involving students from ethnic minority regions or cross-border educational backgrounds may further clarify contextual influences.

Second, this study employed a cross-sectional survey design using a single time-point online questionnaire, which limits causal inference and fails to capture longitudinal developmental trajectories. Innovation literacy was measured through self-reported scales without objective behavioral indicators. Future studies are encouraged to adopt longitudinal designs with multi-wave data collection and incorporate multi-source data, including teacher evaluations, peer assessments, and objective indicators such as innovation achievements and research participation, to reduce common method bias.

Finally, future research may further explore additional dimensions of self-management and examine learning motivation as a potential moderating variable. Expanding the measurement of innovation literacy to include practical and entrepreneurial innovation dimensions and incorporating qualitative methods, such as in-depth interviews and case analysis, may provide a more comprehensive understanding. Further model expansion could introduce moderating variables such as learning motivation and self-efficacy, and examine differential mediating effects across the five dimensions of self-management.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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