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Metacognitive ability as a mediator between learning environment and artificial intelligence literacy among Chinese nursing students: A cross-sectional study

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Abstract

Background

The integration of artificial intelligence (AI) into nursing education in the digital era underscores the growing need to enhance AI literacy among nursing students. However, limited research has systematically examined the factors that influence AI literacy among undergraduate nursing students.

Objective

This study aims to assess the current level of AI literacy among undergraduate nursing students in China and to investigate whether metacognitive ability mediates the relationship between the learning environment and AI literacy.

Methods

A convenience sample of 439 undergraduate nursing students was recruited from four universities in Anhui Province, China, between January and November 2024. The participants completed self-administered questionnaires designed to assess their demographic characteristics, learning environment, metacognitive abilities, and AI literacy.

Results

The learning environment exhibited a significant direct effect on AI literacy (β = 0.233, 95% CI: 0.142–0.326). Furthermore, metacognitive ability partially mediated the association between the learning environment and AI literacy (β = 0.417, 95% CI: 0.337–0.503).

Conclusion

These findings indicate that optimizing the learning environment and promoting metacognitive abilities among nursing students are essential for improving AI literacy.

Highlights

Artificial intelligence literacy among Chinese nursing students was found to be at a moderate level.

The learning environment had a significant direct effect on artificial intelligence literacy.

Metacognitive ability partially mediated the relationship between learning environment and AI literacy.

Enhancing metacognitive skills can improve students' capacity to acquire artificial intelligence literacy.

Optimizing the learning environment is essential for fostering artificial intelligence competence in nursing education.

1. Introduction

The rapid advancement of AI, fueled by the ongoing scientific and technological revolution, is increasingly transforming a wide range of sectors, especially medicine and healthcare. AI has become increasingly integral to basic medical research, clinical care, and hospital management, driving advancements in intelligent, precise, and personalized healthcare, and fundamentally reshaping healthcare service models [1, 2]. The integration of AI and digital technologies is gradually transforming nurses' approaches to clinical decision-making, patient care, and interprofessional collaboration [3]. As the future workforce of the nursing profession, nursing students must adapt to evolving technologies, proactively develop AI literacy, and effectively integrate AI into clinical practice to fully leverage the opportunities and address the challenges of a technology-driven healthcare landscape [4]. In response to this shift, nursing education has placed increasing emphasis on the integration of AI technologies, and a growing body of research is exploring effective strategies for incorporating AI education into traditional medical curricula [5]. Previous studies indicate that most nursing students show considerable interest in AI and express confidence in their ability to use AI tools [6].

In this context, nursing educators play a pivotal role by equipping students with AI-related competencies and enhancing their technical application skills. Additionally, educators should cultivate students' critical thinking skills, enabling them to make informed, evidence-based decisions in complex and dynamic clinical environments. Furthermore, the ongoing reinforcement of ethical awareness is crucial to ensure that students uphold ethical principles and maintain a strong sense of responsibility when applying AI technologies. This approach is vital for developing well-rounded nursing professionals who have the innovative capacity to adapt to the evolving demands of the future healthcare sector [7]. Moreover, educators must guide students to develop a comprehensive understanding of both the potential and limitations of AI, enabling them to approach AI technologies with critical awareness and to apply them responsibly. Throughout the educational process, active multidisciplinary collaboration is encouraged, involving cooperation with experts from engineering, information technology, and other related fields to promote the effective integration of AI into nursing education. This approach provides nursing students with a more comprehensive and diverse learning experience, better preparing them to adapt to future technological advancements in healthcare and ultimately enhancing the overall competitiveness of the nursing profession [8].

In conclusion, it is the vital responsibility of nursing educators to guide and prepare nursing students to adapt to the transformative changes introduced by AI technology. Structured education and training programs should empower nursing students to efficiently and ethically apply AI technologies in clinical

practice, foster robust professional ethics and clinical judgment, and confidently address the challenges posed by the increasingly intelligent and personalized evolution of the healthcare sector [9].

Amid the increasing integration of AI into healthcare education, AI Literacy has become a core competency crucial to both the individual success and professional development of medical students [10]. AI literacy encompasses the knowledge and skills necessary to critically understand, evaluate, and utilize AI systems and tools for safe and effective participation in an increasingly digital world [11]. For healthcare professionals, AI literacy places greater emphasis on the ability to interact effectively with AI systems and to apply AI tools judiciously in daily healthcare practice [10]. This entails not only understanding AI-generated content but also critically assessing its accuracy, ethical considerations, and practical relevance within healthcare settings [12]. AI literacy empowers nursing students to cultivate adaptive and forward-looking skills, improve their capacity to identify emerging healthcare challenges, and devise innovative solutions [13]. Furthermore, AI literacy endows students with the skills necessary to process complex information, manage substantial datasets, and proficiently implement machine learning methodologies [14].

However, disparities in educational backgrounds, experiences, and cognitive profiles among students contribute to substantial differences in AI literacy levels across diverse student populations [15]. Therefore, an effective AI program should prioritize scientific rigor while also being tailored to meet students' specific needs and accommodate their unique cognitive abilities [16].

In light of the foregoing discussion, incorporating psychological dimensions—such as social cognitive theory (SCT)—into the analysis of AI literacy is of paramount importance. Bandura's social cognitive theory highlights the dynamic and reciprocal interactions among individual behavior, cognition, and the social environment, conceptualized as "triadic reciprocal determinism" (see Fig. 1). Cognitive factors encompass individual cognitive abilities, observational learning capacity, and outcome expectancies, while environmental factors pertain to the external milieu and socio-cultural context. Behavioral factors encompass the observable actions that demonstrate an individual's behavioral competencies. These three factors are characterized by bidirectional interdependence, thus providing a comprehensive theoretical framework for understanding and advancing AI literacy among nursing students [17].

The learning environment comprises a complex and dynamic interplay among individual, social, organizational, and physical elements, collectively constituting a contextual field that is intrinsically linked to both learning processes and the learners. It encompasses not only the hardware and software resources made available by the institution, but also students' subjective perceptions of the learning environment as well as their interactions with peers [18]. A supportive learning environment plays a pivotal role in promoting students' adoption of deep learning strategies. This, in turn, facilitates more effective acquisition and application of new knowledge, while also strengthening their critical thinking and capacity for innovation [19]. For undergraduate nursing students, every aspect of the learning environment—including peers, instructors, and the broader institutional context—exerts a significant influence on their learning behaviors and the development of essential skills. Supportive peer

relationships and faculty mentorship have been shown to enhance students' self-efficacy and motivation for learning, thereby facilitating the acquisition and application of emerging technologies such as AI. Furthermore, the innovative atmosphere and resource allocation fostered by institutions significantly influence students' opportunities to acquire AI-related knowledge and competencies. Thus, the learning environment emerges as a key factor shaping undergraduate nursing students' AI literacy.

Metacognitive ability is defined as an individual's capacity to plan, monitor, regulate, and evaluate their own cognitive processes [20]. Metacognition plays a pivotal role in cognitive functioning and is primarily reflected in five domains: promoting intellectual development, increasing the efficiency of cognitive goal attainment, improving learning proficiency, compensating for limitations in general cognitive abilities, and fostering self-directed learning [21]. These functions not only enhance learners' capacity to acquire knowledge and solve problems but also provide a critical cognitive foundation for engaging with complex learning content, such as AI. Metacognitive skills are essential for undergraduate nursing students in both academic and clinical settings. Through self-awareness, self-monitoring, and self-regulation of cognitive processes, students can more effectively identify knowledge gaps, adjust learning strategies in a timely manner, and continuously evaluate their learning outcomes [22]. This is particularly critical for adapting to the rapidly evolving and increasingly technology-driven healthcare landscape. As students encounter continuously evolving AI tools and clinical application scenarios, strong metacognitive abilities enable them to proactively adapt to new technologies and refine their learning trajectories—both of which are essential for developing AI literacy. This, in turn, enables them to acquire AI-related knowledge and skills with greater efficiency and accuracy. Accordingly, metacognition has been recognized as a critical cognitive determinant in fostering AI literacy among undergraduate nursing students.

Existing research indicates that students' perceptions of the learning environment significantly influence their selection and use of learning strategies. Students who perceive strong support and a positive, stimulating learning environment are more inclined to adopt deep and active learning strategies, including metacognitive behaviors such as self-monitoring and self-regulation. These adaptive learning behaviors allow students to adjust their learning pathways in a timely manner, thereby enhancing overall learning outcomes [23]. This association becomes particularly salient in technology-intensive AI education, where knowledge evolves rapidly and is marked by substantial complexity. As a result, students are required to engage in ongoing self-reflection and self-regulation throughout the learning process. In the context of AI education, educators are expected not only to deliver specialized knowledge but also to foster a supportive and interactive learning environment. Such an environment facilitates deeper comprehension and mastery of AI technologies, ultimately strengthening students' capacity to apply these competencies effectively in clinical practice [24].

The accelerated integration of AI into healthcare underscores the pressing need to enhance AI literacy among nursing students [25]. However, scholarly research on AI literacy among nursing students remains relatively limited. Most existing studies concentrate primarily on the technical applications of AI in clinical decision-making and patient care, whereas broader influencing factors—particularly

educational and psychological dimensions—have received comparatively less empirical attention. Both theoretical frameworks and empirical investigations in this field remain underdeveloped, hindering the systematic innovation of nursing talent development. Therefore, this study aims to assess AI literacy among nursing students and examine its underlying influencing mechanisms through the lens of SCT. This study tested the following hypotheses, as illustrated in Fig. 2: (H1) Metacognitive ability and perceived learning environment are positively associated with AI literacy; (H2) Metacognitive ability mediates the relationship between the perceived learning environment and AI literacy.

2. Methods

2.1. Study design

A cross-sectional study.

2.2. Setting and participants

A convenience sampling approach was used to recruit 439 undergraduate nursing students from four universities in Anhui Province—Wannan Medical College, Bengbu Medical University, Anhui University of Traditional Chinese Medicine, and Anhui University of Medical Sciences—to participate in a questionnaire survey conducted from January to November 2024. The inclusion criteria were as follows: (a) full-time enrollment as an undergraduate nursing student, and (b) provision of informed consent and voluntary participation. Students who, for any reason, did not complete the questionnaire were excluded from the study.

A descriptive cross-sectional design was employed in this study. Following Kendall's [26] recommendation, the sample size was set at five to ten times the number of independent variables. A total of three scales, containing 30 items altogether, were administered, taking into account an anticipated attrition rate of 20%. Therefore, the minimum sample size was determined to be 360 (N = 30 × 5 × [1 + 20%]). Increasing the sample size beyond this minimum enhanced the stability and reliability of the analysis of mediating effects.

2.3. Variables

2.3.1. Descriptive information form

The research team developed a self-designed questionnaire tailored to the objectives of the study. This questionnaire included thirteen items covering aspects such as gender, age, grade level, home address, father's educational background, mother's educational background, average monthly household income, reasons for choosing the nursing major, experience as a student leader, and other relevant factors.

2.3.2. AI Literacy

The assessment of nursing students' AI literacy was conducted using the AI Literacy Competency Scale, which was developed by Zhou et al. in 2024 [27]. The scale contains 25 items distributed over four

dimensions: AI knowledge, AI skills, AI attitudes and values, and AI ethics. Responses are provided on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), with higher scores representing higher levels of AI literacy among undergraduate nursing students. In this study, the scale exhibited excellent internal consistency, with a Cronbach's α coefficient of 0.976.

2.3.3 Learning Environment Scale

Students' learning environment was evaluated using the Learning Environment Scale, which was adapted by Zhang in 2021 [28]. The scale includes 11 items spanning three dimensions: school resources, learning atmosphere, and peer support. Items were rated on a 5-point Likert scale, from "not at all conforming" to "fully conforming," where higher scores indicated a more positive perception of the learning environment among undergraduate nursing students. The scale exhibited excellent internal consistency in this study, as evidenced by a Cronbach's alpha coefficient of 0.956.

2.3.4 Metacognitive Ability Scale

In this study, the Metacognitive Ability Scale developed by Kang et al. [29] in 2005 was employed to evaluate the metacognitive ability of undergraduate nursing students. The scale comprises 24 items distributed across four dimensions: metacognitive planning, monitoring, regulation, and evaluation. Each item is rated on a 5-point Likert scale, ranging from 1 ("never") to 5 ("always"). Higher total scores reflect a greater level of metacognitive competence among undergraduate nursing students. In this study, the scale exhibited excellent internal consistency, as evidenced by a Cronbach's alpha coefficient of 0.98.

2.4. Data collection

Data were collected between January and November 2024 using an electronic questionnaire administered through an online survey platform (https://www.wjx.cn/). The questionnaire began with an informed consent form. Participants who provided consent completed all required items following the instructions, which took approximately 10–15 minutes. To ensure data integrity, only one valid submission was permitted per IP address. All items were mandatory to prevent missing data, and questionnaires exhibiting clear response patterns were excluded from the final analysis.

2.5. Ethical consideration

Ethical approval

for this study was obtained from the Ethics Committee of Wannan Medical College (Approval No. LL-2024BH15).Prior to data collection, participants were informed of the purpose and procedures of the study by the researcher. The principles of anonymity and voluntary participation were emphasized, and participants were informed that they could withdraw from the study at any time without penalty. Only participants who provided written informed consent were granted access to the questionnaire. To ensure participant privacy and data security, no personally identifiable information (e.g., name, university, identification number) was collected in the questionnaire.

2.6. Statistical analysis

Statistical analyses were conducted using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA). According to the criteria proposed by Curran et al. [30], data were considered approximately normally distributed when skewness values ranged from − 2 to 2 and kurtosis values ranged from − 7 to 7. In this study, skewness values of the continuous variables ranged from − 0.016 to 0.437, and kurtosis values ranged from − 0.915 to 0.616, indicating approximate normality. Descriptive statistics were presented as mean ± standard deviation for continuous variables and as frequencies and percentages for categorical variables. Independent samples t-tests and one-way analysis of variance (ANOVA) were performed to assess group differences. Pearson correlation analysis was used to examine associations among the learning environment, metacognitive competence, and AI literacy. After standardizing all variables, mediation analysis was conducted using multiple linear regression and Model 4 of the PROCESS macro. The bootstrap method was applied with 5,000 resamples to generate 95% confidence intervals. Statistical significance was set at a two-sided p-value < 0.05.

3. Results

3.1. Demographic characteristics

A total of 439 questionnaires were collected, of which 434 were retained after excluding 5 invalid responses, yielding a valid response rate of 97.8%. Table 1 presents the demographic and study-related characteristics of the participants. Among the 434 undergraduate nursing students, the majority were female (76.0%) and younger than 20 years of age (72.8%). Significant differences in AI literacy scores were observed between students with and without prior AI education ($t = -3.127$, $p < 0.001$), and between those who reported interest in AI and those who did not ($t = -5.293$, $p < 0.001$).

3.2 Scores on Learning Environment, Metacognitive Ability, and AI Literacy

The mean total AI literacy score among undergraduate nursing students was 122.82 ± 21.21. Among the four dimensions, "AI ethics" had the highest mean score (40.41), while "AI knowledge" had the lowest mean score (14.63). The mean score for the learning environment was 41.84 ± 7.19, and the mean total score for metacognitive competence was 87.78 ± 14.28. Detailed mean scores for each dimension of these scales are presented in Table 2.

3.3. Correlations between variables

The means, standard deviations, and correlation coefficients among the study variables are presented in Table 2. Significant positive correlations were observed between undergraduate nursing students' AI literacy and the learning environment ($r = 0.649$, $p < 0.001$), as well as between AI literacy and metacognitive competence ($r = 0.739$, $p < 0.001$).

3.4. Structural equation model

In the mediation analysis, the learning environment was specified as the independent variable, metacognitive competence as the mediating variable, and AI literacy as the dependent variable (Fig. 3). Significant demographic variables, AI education experience, and interest in AI were included as control variables in the regression and mediation analyses. The results showed that both the learning environment and metacognitive competence had significant effects on AI literacy (Table 3). The inclusion of metacognitive competence in the model increased the explained variance in AI literacy from 44.4% to 58.1%, indicating that metacognitive competence partially mediates the relationship between the learning environment and AI literacy among undergraduate nursing students. Bootstrap analysis further confirmed that the learning environment had a significant direct effect on AI literacy (direct effect = 0.233, 95% CI: 0.142–0.326), while metacognitive competence exhibited a significant partial mediating effect (indirect effect = 0.417, 95% CI: 0.337–0.503)(Table 4).

4. Discussion

The AI literacy among undergraduate nursing students has attracted growing attention from scholars worldwide. This study examined the learning environment, metacognitive abilities, and AI literacy of Chinese undergraduate nursing students, and investigated the interactions among these variables. The study posited that both the learning environment and metacognitive abilities would positively influence nursing students' AI literacy.

The findings revealed that the mean AI literacy score among undergraduate nursing students was 122.82 ± 21.21. Notably, within the subdomains, the score for AI knowledge (14.63 ± 3.08) was substantially lower than that for AI ethics (40.41 ± 7.50).

This is likely attributable to the limited integration of AI-related content within the current medical curricula and instructional materials. As a result, most undergraduate students receive limited training in medical AI and lack a comprehensive understanding of its practical applications in healthcare. Notably, Mousavi et al. [32] reported that students in developed countries generally demonstrate higher levels of AI knowledge compared to those in developing countries, underscoring the tangible impact of the digital divide on AI-related competencies. Strategic investments and capacity-building initiatives are crucial to ensuring that students worldwide develop proficiency in AI applications. Furthermore, the incorporation of AI into medicine represents not only a technological advancement but also introduces critical ethical and legal considerations. Yang et al. [33] observe that, due to the inherent emphasis on patient privacy and medical ethics in nursing, undergraduate nursing students who receive early education in nursing ethics typically demonstrate a high degree of moral sensitivity. This heightened sensitivity allows them to navigate ethical decision-making in clinical practice with greater efficacy and fosters the development of ethical awareness in AI applications. As AI technology becomes increasingly integrated into healthcare, there is a pressing need for nursing education systems to improve students' AI literacy and ethical awareness through interdisciplinary collaboration, curriculum reform, and faculty development. The integration of AI into nursing education resources is crucial for enhancing students' understanding and practical application of AI technologies.

This study identified several factors that influence AI literacy among undergraduate nursing students. Students who had received AI education exhibited significantly higher AI literacy scores, indicating that AI education plays a pivotal role in enhancing students' AI literacy.

Through a structured program, students can systematically acquire knowledge of AI fundamentals, its practical applications, and the associated risks [34]. A significant positive correlation was identified between nursing students' interest in AI and their AI literacy skills. This finding aligns with the results of Almarzouki et al. [35] and Wood et al. [36]. Wu et al. [37] emphasize that academic interest acts as a major catalyst for continuous learning and professional development, particularly within the field of medicine. Cultivating students' interest is essential for enhancing the learning experience and facilitating better academic achievement [38]. In the present era of rapid advancements in AI, students' keen interest in this field serves as a driving force, encouraging them to actively acquire AI-related knowledge and skills. Moreover, this interest motivates students to seek supplementary training and learning opportunities to further improve their proficiency in AI. Therefore, when designing AI literacy training programs, educators should implement instructional strategies that actively engage and stimulate students' interest in AI. Such approaches can effectively enhance students' learning motivation and promote the development of their professional competence [39].

The findings of this study largely support the hypothesis that the learning environment exerts both direct and indirect influences on AI literacy. The educational climate within an institution significantly affects the quality and effectiveness of nursing education [40]. Given the unique demands of nursing education, students are required not only to have a solid foundation in medical theory but also to continuously develop their technical skills and foster humanistic care practices. Incorporating AI-related coursework and practical experiences into the educational environment can better equip nursing students with the competencies required for the future healthcare landscape [24]. Xu et al. [41] emphasized that supportive and resource-rich learning environments offer students essential theoretical knowledge and practical experience, thereby playing a crucial role in their career development and personal growth. A supportive learning atmosphere and a positive social environment can stimulate students' motivation and increase their engagement in learning [42–43]. Liu et al. [44] demonstrated that students' positive perceptions of the educational environment foster higher levels of learning engagement. Furthermore, a favorable learning environment fosters students' interest in learning, clarifies learning objectives, promotes the adoption of effective learning strategies and efficient time management, and enhances concentration throughout the learning process. When students exhibit high levels of learning motivation, they are more likely to actively explore and acquire proficiency in emerging technologies, including AI. This, in turn, strengthens both their foundational knowledge and practical application of AI. Consequently, educational institutions should continue to promote the seamless integration of cutting-edge technologies, such as generative AI, into nursing education by fostering supportive and innovative learning environments [45].

This study revealed that the learning environment influences AI literacy among undergraduate nursing students, with metacognitive ability acting as a mediating factor. Metacognitive ability is a key

component of self-regulated learning, encompassing planning, goal setting, organization, self-monitoring, and self-assessment throughout the process of knowledge acquisition [46].

Supportive learning environments and positive social interactions encourage students to engage in reflection, actively self-monitor, and assess their progress throughout the learning process, thereby effectively promoting metacognitive regulation. Gou et al. [47] observed that various educational factors—including the campus environment (e.g., hardware facilities and institutional support), faculty-related elements (such as instructional investment, teaching methods, and effectiveness), and student-related factors (such as learning experience, satisfaction, and outcomes)—can all influence students' self-regulation in online learning settings. Enhancing metacognitive ability allows students to more effectively regulate and optimize their own learning processes, which in turn improves learning outcomes [48]. El-Sayed et al. [13] noted that metacognitive ability can help students identify and understand core concepts and skills in AI learning, comprehend their applications and social impacts, and critically assess the effectiveness, strengths, weaknesses, and potential limitations of AI tools.

By self-monitoring and adjusting their learning strategies, students are able to promptly identify issues in the use of AI technologies and implement appropriate modifications.

The findings of this study indicate that both the learning environment and metacognitive ability play a significant role in fostering the development of AI literacy. This highlights the necessity for nursing educators to emphasize not only the delivery of technical knowledge but also the creation of supportive environments that foster reflection and autonomous learning among nursing students within the context of AI education. Consistently guiding students in self-monitoring and self-assessment throughout the learning process helps them acquire knowledge more effectively and facilitates the development of metacognitive ability. This interactive approach enables students to adapt more quickly and make informed decisions when faced with emerging technologies.

5.Limitation

This study has several limitations. Firstly, it heavily relied on self-reported data, which may be prone to subjectivity and recall bias. To enhance the reliability of future research, it is recommended that a more diverse sample be included and objective measures incorporated. Additionally, although the cross-sectional design facilitates the identification of associations between variables, it is limited in its capacity to infer causality. Given the rapid advancement of AI technology, students' AI literacy levels may evolve over time. Therefore, longitudinal studies are recommended to further investigate the interactions and trends among variables such as AI literacy, the learning environment, and metacognitive abilities. Furthermore, qualitative research methods, such as interviews, could provide deeper insights into undergraduate nursing students' attitudes toward and perceptions of AI.

The participants in this study were Chinese undergraduate nursing students, and thus, the findings may be constrained by the particularities of the local educational system and cultural context. To improve the generalizability of the results, future studies should seek to expand the sample size by including

participants from diverse geographical and educational backgrounds. Furthermore, exploring the effects of specific contextual factors—such as institutional support and clinical exposure to AI technologies—could provide valuable insights for the development of targeted nursing education interventions, thereby enhancing the global applicability of these programs.

6.Conclusion

This study demonstrated that the learning environment significantly influenced AI literacy among undergraduate nursing students, with metacognitive skills mediating this relationship. The future of nursing education necessitates the ongoing optimization and enhancement of the learning environment. Importantly, it also underscores the systematic development of metacognitive abilities, enabling students to effectively learn and apply AI technologies. These educational reforms cultivate a new generation of nurses equipped with technological resilience and critical thinking skills, enabling them to confidently tackle challenges in an increasingly technology-driven healthcare landscape. This study provides a novel theoretical perspective for the future of nursing education, while expanding both the theoretical framework and practical approaches to AI integration in nursing.

Implications for nursing students

Given the accelerating integration of AI in healthcare, this study highlights critical implications for nursing students in the digital age. Firstly, as the findings revealed a significant direct relationship between the learning environment and AI literacy, nursing students should proactively engage with enriched educational settings that support digital learning and technological exploration. Moreover, because metacognitive ability was shown to partially mediate this relationship, students are encouraged to develop skills such as self-monitoring, reflective thinking, and adaptive learning strategies. These abilities not only enhance academic performance but also empower students to critically evaluate and apply AI tools in clinical practice. Therefore, by fostering a positive learning environment and strengthening metacognitive capacity, nursing students can better prepare for the AI-driven transformation of the healthcare system. Ultimately, nursing education programs should integrate AI content and metacognitive training into curricula to support students' readiness for future clinical challenges.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Wannan Medical College (Approval No. LL-2024BH15) and follows the Declaration of Helsinki. The researchers explained the purpose and methods of the study to all participants, emphasizing anonymous participation and voluntary withdrawal. All participants signed informed consent forms.

Consent for publication

Not applicable.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to their proprietary and confidential nature as records of the School of Nursing, Wannan Medical College. However, data access is available from the corresponding author upon reasonable request, subject to institutional review and approval.

Competing interests

None.

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Authors' contributions

Yingying Wang: Conceptualization, Methodology, Investigation, Project administ ration, Formal analysis, Writing - Original Draft, Writing - Review & Editing. Xueyan Wang: Conceptualization, Methodology, Investigation, Formal analysis, Writing - Review & Editing. Wanyu Ding:Conceptualization, Methodology, Investi gation, Formal analysis.Xinyue Chen:Writing - Review & Editing.Liqun Zhu: Conceptualization, Methodology, Project administration, Writing- Review & Editing.Mingfen Tao:Conceptualization, Methodology, Project administration, Formal analysis, Writing- Review & Editing. Min Tan: Conceptualization, Methodology, Project a dministration, Formal analysis, Writing- Review & Editing.Shaoyong Ma: Conceptualization, Methodology, Project administration, Funding acquisition, Writing Review & Editing.

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References

1. Schwartz WB, Patil RS, Szolovits P. Artificial intelligence in medicine. Where do we stand? N Engl J Med. 1987;316:685–8. https://doi.org/10.1056/NEJM198703123161109.
2. Esmaeilzadeh P. Challenges and strategies for wide-scale artificial intelligence (AI) deployment in healthcare practices: A perspective for healthcare organizations. Artif Intell Med. 2024;151:102861. https://doi.org/10.1016/j.artmed.2024.102861.
3. Abuzaid MM, Elshami W, Fadden SM. Integration of artificial intelligence into nursing practice. Health Technol (Berl). 2022;12:1109–15. https://doi.org/10.1007/s12553-022-00697-0.

4. Simms RC. Generative artificial intelligence (AI) literacy in nursing education: A crucial call to action. Nurse Educ Today. 2025;146:106544. https://doi.org/10.1016/j.nedt.2024.106544.
5. Singla R, Pupic N, Ghaffarizadeh S-A, et al. Developing a Canadian artificial intelligence medical curriculum using a Delphi study. NPJ Digit Med. 2024;7:323. https://doi.org/10.1038/s41746-024-01307-1.
6. O'Connor S. Artificial intelligence and predictive analytics in nursing education. Nurse Educ Pract. 2021;56:103224. https://doi.org/10.1016/j.nepr.2021.103224.
7. De Gagne JC. The State of Artificial Intelligence in Nursing Education:Past, Present, and Future Directions. Int J Environ Res Public Health. 2023;20:4884. https://doi.org/10.3390/ijerph20064884.
8. Buchanan C, Howitt ML, Wilson R, et al. Predicted Influences of Artificial Intelligence on Nursing Education: Scoping Review. JMIR Nurs. 2021;4:e23933. https://doi.org/10.2196/23933.
9. O'Connor S. Teaching artificial intelligence to nursing and midwifery students. Nurse Educ Pract. 2022;64:103451. https://doi.org/10.1016/j.nepr.2022.103451.
10. Laupichler MC, Aster A, Meyerheim M, et al. Medical students' AI literacy and attitudes towards AI: a cross-sectional two-center study using pre-validated assessment instruments. BMC Med Educ. 2024;24:401. https://doi.org/10.1186/s12909-024-05400-7.
11. Shen Y, Cui W. Perceived support and AI literacy: the mediating role of psychological needs satisfaction. Front Psychol. 2024;15:1415248. https://doi.org/10.3389/fpsyg.2024.1415248.
12. Chan CKY, Colloton T, Generative. AI in Higher Education: The ChatGPT Effect. London: Routledge; 2024. https://doi.org/10.4324/9781003459026.
13. El-Sayed BKM, El-Sayed AAI, Alsenany SA, et al. The role of artificial intelligence literacy and innovation mindset in shaping nursing students' career and talent self-efficacy. Nurse Educ Pract. 2025;82:104208. https://doi.org/10.1016/j.nepr.2024.104208.
14. Loureiro F, Sousa L, Antunes V. Use of Digital Educational Technologies among Nursing Students and Teachers: An Exploratory Study. J Pers Med. 2021;11:1010. https://doi.org/10.3390/jpm11101010.
15. Hornberger M, Bewersdorff A, Nerdel C. What do university students know about Artificial Intelligence? Development and validation of an AI literacy test. Computers Education: Artif Intell. 2023;5:100165. https://doi.org/10.1016/j.caeai.2023.100165.
16. Xia Q, Chiu TKF, Lee M, et al. A self-determination theory (SDT) design approach for inclusive and diverse artificial intelligence (AI) education. Comput Educ. 2022;189:104582. https://doi.org/10.1016/j.compedu.2022.104582.
17. Locke EA, Bandura A. Social Foundations of Thought and Action: A Social-Cognitive View. Acad Manage Rev. 1987;12:169. https://doi.org/10.2307/258004.
18. Jessee MA, Russell RG, Kennedy BB, et al. Development and Pilot Testing of a Multidimensional Learning Environment Survey. Nurse Educ. 2020;45:E50–4. https://doi.org/10.1097/NNE.0000000000000824.

19. Han T, Xu G. The Relationship Between Learning Environment Perception, Achievement Goals, and the Undergraduate Deep Learning Approach: A Longitudinal Mediation Model. J Intell. 2025;13:19. https://doi.org/10.3390/jintelligence13020019.
20. Ghafili A, Gantare A, Lobet-Maris C, et al. Towards the Elaboration of a Non-Technical Skills Development Model for Midwives in Morocco. Healthc (Basel). 2022;10:1683. https://doi.org/10.3390/healthcare10091683.
21. Chen Z, Zhang X. The Relationship Between Mindful Agency and Self-Leadership of Chinese Private College Undergraduates: Mediating Effect of Metacognitive Ability. Front Psychol. 2022;13:847229. https://doi.org/10.3389/fpsyg.2022.847229.
22. Hong WH, Vadivelu J, Daniel EGS, et al. Thinking about thinking: changes in first-year medical students' metacognition and its relation to performance. Med Educ Online. 2015;20:27561. https://doi.org/10.3402/meo.v20.27561.
23. Artino AR, Dong T, DeZee KJ, et al. Achievement goal structures and self – regulated learning: relationships and changes in medical school. Acad Med. 2012;87:1375–81. https://doi.org/10.1097/ACM.0b013e3182676b55.
24. Devraj R, Covvey JR, Arif SA. Bridging the Digital Divide:The Importance of Techquity in Pharmacy Education. Am J Pharm Educ. 2025;89:101380. https://doi.org/10.1016/j.ajpe.2025.101380.
25. Zhu J, Xie X, Pu L, et al. Relationships between professional identity, motivation, and innovative ability among nursing intern students: A cross-sectional study. Heliyon. 2024;10:e28515. https://doi.org/10.1016/j.heliyon.2024.e28515.
26. Kendall M. Multivariate analysis. London: Griffin; 1975.
27. Zhou Q, Xu YP. Cai YC.Multidimensional analysis of the current situation and influencing factors of artificial intelligence literacy competence of college students. Doc Inform Knowl. 2024;41:38–48. https://doi.org/10.13366/j.dik.2024.03.038. in Chinese.
28. Zhang JW. A study of the relationship between college students' commitment to learning and their motivation and learning environment. [Master's thesis].Wuhan University; 2021(in Chinese).
29. Kang ZH. The Preliminary Construction of the Scale for College Student's Metacognitive Ability [Master's thesis]. Shanxi University; 2005(in Chinese).
30. Curran PJ, West SG, Finch JF. The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. Psychol Methods. 1996;1(1):16. https://doi.org/10.1037/1082-989X.1.1.16.
31. Jackson P, Ponath Sukumaran G, Babu C, et al. Artificial intelligence in medical education - perception among medical students. BMC Med Educ. 2024;24:804. https://doi.org/10.1186/s12909-024-05760-0.
32. Mousavi Baigi SF, Sarbaz M, Ghaddaripouri K, et al. Attitudes, knowledge, and skills towards artificial intelligence among healthcare students: A systematic review. Health Sci Rep. 2023;6:e1138. https://doi.org/10.1002/hsr2.1138.

33. Yang Y. Influences of Digital Literacy and Moral Sensitivity on Artificial Intelligence Ethics Awareness Among Nursing Students. Healthc (Basel). 2024;12:2172. https://doi.org/10.3390/healthcare12212172.
34. Levingston H, Anderson MC, Roni MA. From Theory to Practice: Artificial Intelligence (AI) Literacy Course for First-Year Medical Students. Cureus. 2024;16:e70706. https://doi.org/10.7759/cureus.70706.
35. Almarzouki AF, Alem A, Shrourou F, et al. Assessing the disconnect between student interest and education in artificial intelligence in medicine in Saudi Arabia. BMC Med Educ. 2025;25:150. https://doi.org/10.1186/s12909-024-06446-3.
36. Wood EA, Ange BL, Miller DD. Are We Ready to Integrate Artificial Intelligence Literacy into Medical School Curriculum: Students and Faculty Survey. J Med Educ Curric Dev. 2021;8:23821205211024078. https://doi.org/10.1177/23821205211024078.
37. Wu H, Zheng J, Li S, et al. Does academic interest play a more important role in medical sciences than in other disciplines? A nationwide cross-sectional study in China. BMC Med Educ. 2019;19:301. https://doi.org/10.1186/s12909-019-1737-1.
38. Harackiewicz JM, Smith JL, Priniski SJ. Interest Matters: The Importance of Promoting Interest in Education. Policy Insights Behav Brain Sci. 2016;3:220–7. https://doi.org/10.1177/2372732216655542.
39. Montejo L, Fenton A, Davis G. Artificial intelligence (AI) applications in healthcare and considerations for nursing education. Nurse Educ Pract. 2024;80:104158. https://doi.org/10.1016/j.nepr.2024.104158.
40. Abusaad FES, Mohamed ES, El-Gilany AH. Nursing Students' Perceptions of the Educational Learning Environment in Pediatric and Maternity Courses using DREEM Questionnaire. J Educ Pract. 2015;6(29):26–32. http://hdl.handle.net/10019.1/41542.
41. Xu F-R, Yang Y. Public Health Graduates' Perceptions of the Educational Environment Measured by the DREEM. Front Public Health. 2022;10:738098. https://doi.org/10.3389/fpubh.2022.738098.
42. Alizadeh M, Saramad A, Rafiepoor H, et al. Effect of virtual case-based learning (CBL) using the flipped class and peer instruction on the motivation to learn basic sciences. BMC Med Educ. 2024;24:1230. https://doi.org/10.1186/s12909-024-06229-w.
43. Wong FMF. A phenomenological research study: Perspectives of student learning through small group work between undergraduate nursing students and educators. Nurse Educ Today. 2018;68:153–8. https://doi.org/10.1016/j.nedt.2018.06.013.
44. Liu Y, Hu H, Wang L, et al. Medical education environment perception and learning engagement in undergraduate nursing students: The mediating effect of self-regulated learning ability. Nurse Educ Pract. 2023;72:103793. https://doi.org/10.1016/j.nepr.2023.103793.
45. Simms RC. Generative artificial intelligence (AI) literacy in nursing education: A crucial call to action. Nurse Educ Today. 2025;146:106544. https://doi.org/10.1016/j.nedt.2024.106544.

46. Mccombs BL. Self-regulated learning and academic achievement: An overview. Educational Psychol. 1990;25(1):3–17. https://doi.org/10.1007/978-1-4612-3618-4_3.
47. Gou YT, Jia WJ. Research on the influencing factors of college students' self-regulation ability in online learning. High Educ Res. 2021;44:63–71. https://doi.org/10.3969/j.issn.1672-8874.2021.03.011. 90 in Chinese.
48. Stanton JD, Sebesta AJ, Dunlosky J. Fostering Metacognition to Support Student Learning and Performance. CBE Life Sci Educ. 2021;20:fe3. https://doi.org/10.1187/cbe.20-12-0289.

Tables

Tables 1 to 4 are available in the Supplementary Files section.

Figures

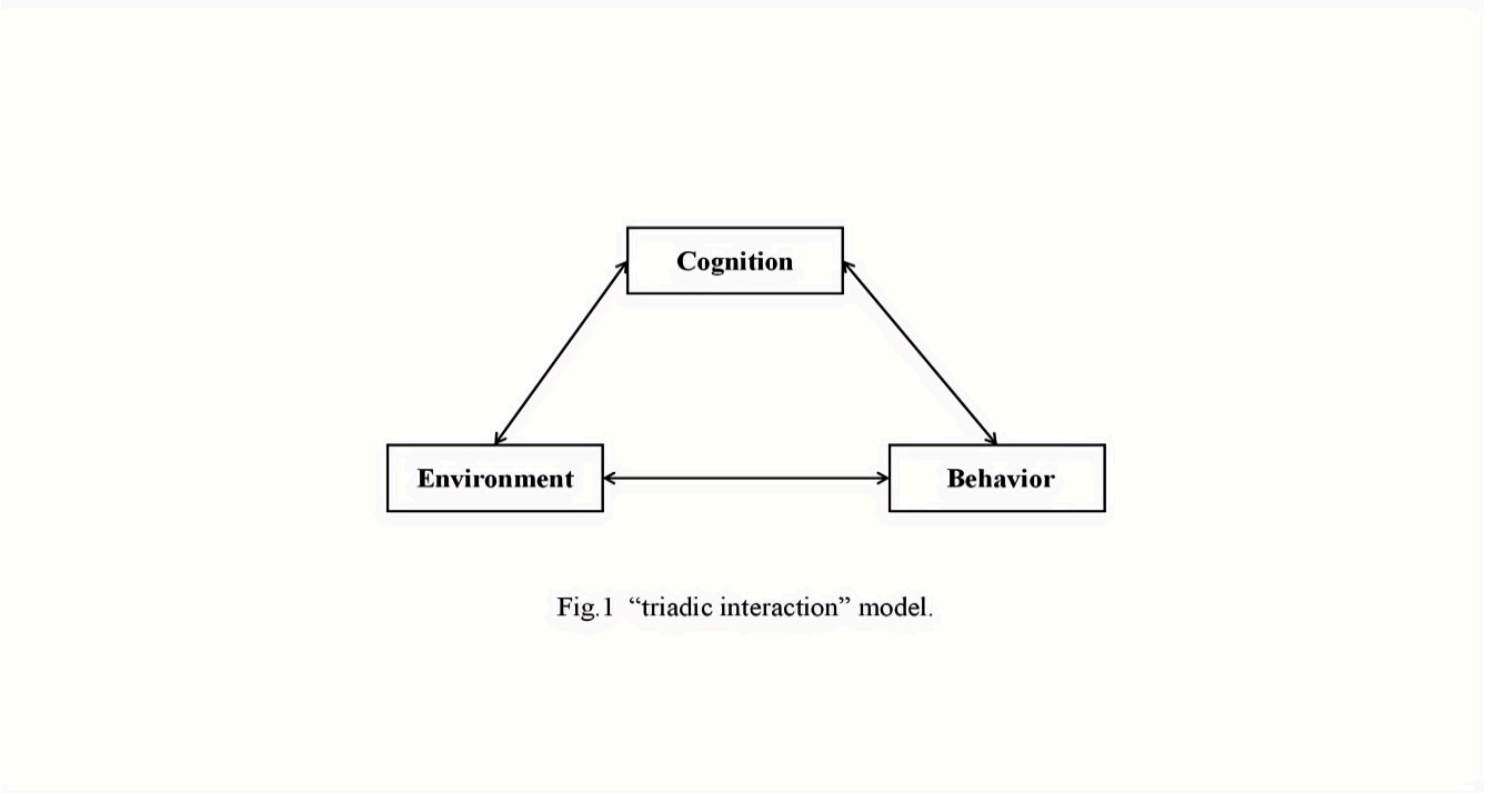


Figure 1

See image above for figure legend.

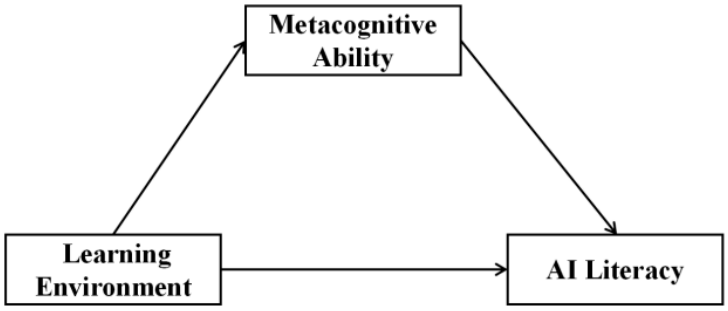


Fig.2 Hypothetical mode.

Figure 2

See image above for figure legend.

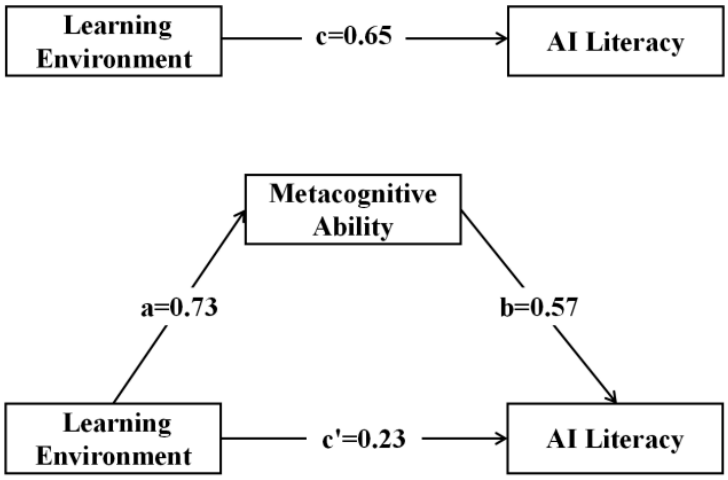


Fig.3 Total effect model and mediation model.

Figure 3

See image above for figure legend.

Supplementary Files

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