A Bayesian Meta-Analysis of the Relationship Between AI Literacy and Self-Efficacy Among University Students

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Abstract

To systematically integrate the characteristics of the relationship between AI literacy and college students' self-efficacy and identify the sources of its heterogeneity, this study ultimately included 36 independent studies (N = 25,251), employing a Bayesian random-effects model to conduct a meta-analysis and test for moderating effects. The results revealed a significant positive correlation between AI literacy and college students' self-efficacy (Bayesian r = 0.495, 95% CrI [0.420, 0.570]). Moderation analysis showed that the effect size was significantly influenced by the type of self-efficacy, the measurement method of AI literacy, and the category of students: specifically, the association of AI literacy with creative self-efficacy and entrepreneurial self-efficacy was stronger than its association with AI self-efficacy and general academic self-efficacy; the effects of self-developed or integrated self-report scales were higher than those of direct AI literacy scales, proxy indicators, and objective measurements; and the correlation was relatively stronger among students in education, media, and language disciplines, while relatively weaker in science and engineering, computer science, and business management. The study indicates a positive correlation between AI literacy and college students' self-efficacy, the intensity of which is influenced by measurement methods, efficacy types, and disciplinary differences. Universities should implement differentiated AI literacy education tailored to different teaching contexts and competency goals to promote the enhancement of students' high-order self-efficacy, such as creativity and career development.

Full Text

Preamble

Bayesian Meta-Analysis of the Relationship Between AI Literacy and Self-Efficacy Among University Students

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摘要 (Abstract)

To systematically integrate the relationship between AI literacy and college students' self-efficacy and identify sources of heterogeneity, this study included 36 independent studies ($N = 25,251$) for a meta-analysis using Bayesian random-effects models to test for moderating effects. The results revealed a significant positive correlation between AI literacy and college students' self-efficacy (Bayesian $r = 0.495$, 95% CrI $[0.420, 0.570]$). Moderation analysis indicated that the effect size is significantly influenced by the type of self-efficacy, the method of measuring AI literacy, and the category of students.

Specifically, the association between AI literacy and creative self-efficacy or entrepreneurial self-efficacy was stronger than its association with AI self-efficacy and general academic self-efficacy. Regarding measurement, the effects derived from self-developed or integrated self-report scales were higher than those from direct AI literacy scales, proxy indicators, or objective measurements. Furthermore, the correlation was relatively stronger among students in education, media, and language disciplines, while it was comparatively weaker among students in STEM, computer science, and business management fields.

The research demonstrates a positive correlation between AI literacy and college students' self-efficacy, with the strength of this relationship moderated by measurement methods, efficacy types, and disciplinary differences. Higher education institutions should implement differentiated AI literacy education tailored to various teaching contexts and competency goals. Such targeted interventions are essential to fostering the development of students' higher-order self-efficacy, particularly in areas related to creativity and professional career development.

关键词 (Keywords)

AI Literacy, Self-Efficacy, University Students, Bayesian Meta-Analysis, International Comparison, Generative Artificial Intelligence Classification Code: B842

Introduction

The emergence of generative artificial intelligence (GenAI) has fundamentally transformed the landscape of higher education and the professional world. As AI technologies become increasingly integrated into daily life and academic research, the concept of "AI literacy"has gained significant attention. AI literacy refers to a set of competencies that enable individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace.

A critical factor influencing the acquisition of these skills is self-efficacy—an individual' s belief in their capacity to execute behaviors necessary to produce specific performance attainments. In the context of AI, self-efficacy reflects a student's confidence in their ability to understand and utilize AI tools effectively. While numerous individual studies have explored the link between AI literacy and self-efficacy, findings often vary across different cultural and educational contexts. Therefore, a comprehensive meta-analysis is required to provide a more robust understanding of this relationship on a global scale.

Artificial Intelligence (AI), as a general-purpose technology, is rapidly permeating higher education, transforming the methods of knowledge acquisition, information processing, and problem-solving [**?**, **?**]. With the successive release of policy documents regarding educational digitalization and AI applications, the empowerment of education through AI has entered a stage of accelerated implementation. If the cognition, understanding, and application capabilities of university students regarding AI are not universally improved, existing disparities in ability may be further amplified within the context of intelligent technology applications.

In recent years, the academic community has engaged in extensive discussions regarding AI literacy; however, a consensus on its conceptual definition and core components has yet to be reached [**?**, **?**, **?**]. From a psychological perspective, AI literacy is not a singular technical skill but rather a composite structure encompassing knowledge understanding, strategic use and self-regulation, risk and ethical judgment, and related attitudes and beliefs [**?**, **?**]. Whether AI literacy can be further transformed into positive learning adaptation and developmental outcomes depends crucially on whether it functions through internal psychological mechanisms. Among these, self-efficacy serves as a vital psychological variable and a potential mechanism linking AI literacy to learning performance, innovative behavior, and sustained engagement [**?**, **?**].

1.1 AI Literacy

As artificial intelligence technology increasingly permeates education, work, and daily life, AI literacy has emerged as a critical competency in the digital age. Compared to earlier emphases on technical operations and tool usage, the academic community has recently come to view AI literacy as a multidimensional and composite construct. This perspective emphasizes that individuals must

not only understand the basic principles and application logic of AI but also demonstrate reasonable use, critical evaluation, and reflective judgment within specific contexts [?, ?].

Existing research generally defines AI literacy as an individual' s ability to understand, use, and critically evaluate artificial intelligence systems. A representative definition provided by Long and Magerko (2020) posits that AI literacy is a set of competencies that enable individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and employ AI as a tool in online, home, and workplace settings. Building upon this foundation, related studies further emphasize that AI literacy involves more than just a conceptual understanding of AI principles and functional boundaries. It also includes the ability to strategically use AI tools for specific tasks, identify their limitations and risks, judge and correct their outputs, and reflect on the associated ethical and social implications [?, ?, ?].

1.2 AI Literacy and Self-Efficacy

Self-efficacy, defined as an individual' s belief in their ability to complete specific tasks, serves as a vital psychological mechanism for learning motivation and behavioral regulation. It is also a widely validated key variable in research concerning technology acceptance and digital literacy [?, ?].

In the context of the rapid integration of AI technologies into learning environments, a close correlation typically exists between self-efficacy and AI literacy. Existing research reveals the relationship between these constructs through several key dimensions. First, as AI tools become ubiquitous in learning and assessment, learners who lack a fundamental understanding of AI concepts often struggle to develop a stable sense of technological self-efficacy. Higher levels of AI literacy enable learners to more accurately understand the feedback mechanisms and performance boundaries of AI systems, facilitating the construction of psychological cognitive structures centered on "controllability" and "competence" [?, ?]. Second, in AI-mediated learning scenarios, self-efficacy plays a mediating role between AI literacy and learning behavior. Research shows that learners with high AI literacy are more likely to experience "operability" and "effective feedback" within AI learning platforms [?, ?].

1.3 Influence of Moderating Variables

Existing research indicates that AI literacy does not manifest with uniform intensity across different groups and contexts; rather, its functional pathways exhibit significant situational sensitivity and demographic variation [?, ?, ?]. Given that AI literacy is a multidimensional construct, its association with self-efficacy may be jointly influenced by multiple factors, including individual learner characteristics, educational settings, and macro-institutional environments. From the perspective of educational implementation, school contexts and instructional conditions have been repeatedly identified as critical sources of effect variance.

Figure 1

Figure 1: Figure 1

Factors such as school type, students' academic backgrounds, task difficulty, and capacities for evaluation and ethical judgment also affect the opportunities and conditions for students to develop AI literacy [**?**, **?**, **?**].

1.4 Theoretical Framework and Research Questions

Social Cognitive Theory (SCT) posits a continuous interaction between an individual' s cognitive factors, behavioral factors, and environmental factors (Bandura, 1986). Within this framework, self-efficacy serves as the core psychological mechanism influencing behavioral choices and persistence. In AI learning contexts, AI literacy may influence learners' perceptions of the operational logic and capability boundaries of AI systems, which in turn affects their sense of control and confidence (Pan, 2025).

Therefore, this study constructs a theoretical framework for analyzing the relationship between AI literacy and self-efficacy among college students

. This framework suggests that AI literacy likely influences learners' AI-related self-efficacy, which in turn affects their usage behavior and learning outcomes. This study aims to answer: (1) What is the overall strength of the correlation between AI literacy and college students' self-efficacy? (2) Do factors such as different countries, types of efficacy, measurement methods, and academic disciplines significantly moderate this correlation?

2 Methodology

This study was conducted in accordance with the PRISMA 2020 guidelines and pre-registered on PROSPERO (Registration No. CRD20251184716).

2.1 Search Strategy

A systematic search was conducted across Web of Science, Scopus, and CNKI for studies published up to November 2025. Search terms included "artificial intelligence literacy," "AI literacy," "AI competence," and "self-efficacy," "academic self-efficacy," and "AI self-efficacy." Manual backward citation tracking was also performed.

2.2 Inclusion and Exclusion Criteria

Studies were included if they: (1) focused on university students; (2) analyzed the relationship between AI literacy and self-efficacy; (3) used validated measurement instruments; (4) reported correlation coefficients or data convertible

Figure 2

Figure 2: Figure 2

Figure 3

Figure 3: Figure 3

to r; and (5) had a sample size $N \geq 30$. Studies focusing only on AI usage frequency or general digital literacy were excluded.

2.3 Selection and Data Extraction

From 343 initially identified studies, 36 were ultimately included

. Data extraction included authors, publication year, effect sizes, sample information, and measurement instruments. Correlation coefficients were transformed into Fisher' s z values for analysis. Inter-rater reliability was high (ICC = 0.938).

2.4 Classification of Variables

Self-efficacy was categorized into: general self-efficacy, academic self-efficacy, and technological/AI self-efficacy . AI literacy measurement methods were categorized into direct AI literacy scales and proxy indicators .

2.5 Statistical Analysis

Analysis was conducted in Python using Bayesian random-effects models. The overall effect parameter was assigned a Normal$(0, 1)$ prior, and the heterogeneity parameter a Half-Normal(0.5) prior. Frequentist random-effects models and Egger' s tests were used for robustness and publication bias checks.

3 Results

The 36 included studies ($N = 25,251$) were published between 2022 and 2025 . Most were cross-sectional. The average proportion of male participants was 52.20%.

3.1 Publication Bias and Overall Effect

The funnel plot

and Egger' s test (intercept = -4.66, $p = 0.358$) indicated no significant publication bias. The Bayesian random-effects model

showed a stable positive correlation with a posterior median effect size of $r = 0.495$ (95% CrI $[0.42, 0.57]$). High heterogeneity was observed ($I^2 = 91.73\%$). Frequentist results were consistent ($r = 0.518$).

Figure 4

Figure 4: Figure 4

3.2 Moderation Analysis

Moderation analysis revealed significant effects for self-efficacy type, measurement method, and student category. - **Self-Efficacy Type:** Correlation was strongest for creative self-efficacy ($r = 0.71$) and entrepreneurial self-efficacy ($r = 0.61$), followed by AI self-efficacy ($r = 0.53$) and academic self-efficacy ($r = 0.37$). - **Measurement Method:** Self-developed or integrated scales showed higher correlations ($r = 0.71$) than direct scales ($r = 0.52$) or objective scales ($r = 0.14$). - **Student Category:** Students in education, media, and linguistics showed the highest effect size ($r = 0.60$), while STEM ($r = 0.45$) and business ($r = 0.41$) students were lower. - **Geography:** No significant difference was found between Chinese and non-Chinese samples ($Q_b = 0.76, p > .05$) .

4 Discussion

4.1 Overall Relationship

This study confirms a stable positive correlation between AI literacy and student self-efficacy. Higher AI literacy enhances students' sense of mastery and control over intelligent technologies, bolstering their confidence in learning tasks.

4.2 Differences Across Domains

The stronger correlation with creative and entrepreneurial self-efficacy suggests that AI literacy acts as an empowering tool for open-ended, generative tasks rather than just technical operations. The higher correlation among humanities and social science students (education, media) compared to STEM students suggests that AI literacy may provide a more significant "efficacy boost" to those for whom AI represents a transformative new toolset, whereas STEM students may already possess high baseline technical efficacy.

4.3 Conclusion and Implications

Higher education institutions should implement differentiated AI literacy education. Rather than a one-size-fits-all technical training, programs should be tailored to disciplinary contexts to foster higher-order self-efficacy, particularly in creativity and professional development. Future research should employ more longitudinal and experimental designs to clarify the causal mechanisms between these constructs.