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The Effect of Artificial Intelligence on Student Confidence in Online Adult Learning: A Meta-Analysis and Systematic Review

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ABSTRACT: *The integration of Artificial Intelligence (AI) into online education is rapidly transforming learning environments, particularly for adult learners. While AI promises personalized and efficient educational experiences, its impact on crucial affective domains, such as student confidence and self-efficacy, remains underexplored. Confidence is a critical determinant of persistence, engagement, and success in adult learning. This meta-analysis and systematic review synthesizes current empirical evidence to evaluate the effect of AI-powered tools and platforms on student confidence in online adult learning contexts. A systematic search of major academic databases was conducted to identify peer-reviewed studies published between 2019 and 2025 that investigated AI interventions in online adult education and measured outcomes related to student confidence or self-efficacy. Following PRISMA guidelines, we screened and selected studies for inclusion. We performed a quantitative synthesis of reported effect sizes and a qualitative thematic analysis to identify the mechanisms through which AI influences learner confidence. Our analysis of the included studies reveals a predominantly positive and significant effect of AI on student confidence. A quantitative synthesis of studies providing effect sizes revealed a large, positive impact (mean Cohen's d ≈ 1.24). The thematic analysis identified four key mechanisms: (1) Enhanced scaffolding and personalized support, where AI provides immediate, non-judgmental feedback that builds mastery; (2) Fostering autonomy and self-directed learning, empowering learners to take control of their educational journey; (3) The double-edged sword of dependence, where over-reliance on AI can potentially undermine intrinsic confidence; and (4) The amplification of human connection, where AI tools, when used effectively, free up instructor time for more meaningful, confidence-building interactions. When thoughtfully designed and implemented, AI technologies can be powerful tools for enhancing confidence among online adult learners. The most effective interventions are those that use AI to augment, rather than replace, human instruction, providing personalized support while fostering learner autonomy. These findings provide crucial insights for educators, instructional designers, and policymakers seeking to harness AI to create more supportive and empowering online learning environments for adults.*

Key words*: AI-enhanced learning, andragogy, artificial intelligence in education, digital pedagogy. learner confidence, online learning, adult learners, self-efficacy, technology-enabled education.*

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1. Introduction

The landscape of higher and professional education has been irrevocably altered by the dual forces of digitalization and the mainstreaming of adult learning (Arrosagaray, 2019). Online platforms have become the primary modality for continuous professional development and lifelong learning, offering the flexibility required by adults balancing education with career and family responsibilities (Love, 2023). Into this evolving ecosystem, Artificial Intelligence (AI) has emerged as a transformative technology with the potential to fundamentally reshape pedagogical practices (Doğan, 2023; English, 2025). From adaptive learning systems that tailor content to individual needs to generative AI like ChatGPT that can act as a virtual tutor, AI is being integrated into nearly every facet of the online learning experience (Lin, 2023; Goel, 2024).

While much of the discourse surrounding AI in education has focused on cognitive outcomes and administrative efficiencies, its impact on the affective domain of learning—particularly student confidence—is a critical and less understood area of inquiry (Samani, 2022). Confidence, and its academic counterpart self-efficacy, is a cornerstone of successful adult learning (Musyaffi, 2024). Adult learners often return to formal education after a significant hiatus, bringing with them anxieties about their ability to succeed (English & Braybrook, 2025). High confidence is correlated with greater persistence, deeper engagement, willingness to tackle challenging tasks, and ultimately, higher academic achievement (Hanshaw, 2024).

AI interventions hold the potential to both bolster and undermine student confidence. On one hand, AI can provide personalized scaffolding, immediate and non-judgmental feedback, and adaptive challenges that allow learners to experience mastery and build self-efficacy incrementally (Li, 2022). AI-powered tools can help adult learners manage their studies more effectively, promoting a sense of autonomy and control that is central to andragogy (Lin, 2023). On the other hand, concerns have been raised about the potential for AI to foster over-reliance, diminish critical thinking skills, and create a sense of inadequacy when learners are unable to complete tasks without technological assistance (Bermeo, 2025). The "black box" nature of some AI algorithms can also create uncertainty and anxiety, while the absence of a human touch may fail to provide the emotional encouragement that is vital for building confidence (Alqahtani, 2024).

Given these competing possibilities, a systematic examination of the empirical evidence is urgently needed. While numerous studies have explored the effectiveness of specific AI tools, a comprehensive synthesis of their impact on adult learner confidence is lacking. This meta-analysis and systematic review aim to fill this gap by addressing the following research question: What is the overall effect of AI-based interventions on student confidence in online adult learning environments, and what are the key mechanisms driving this effect? By synthesising findings from recent quantitative and qualitative research, this paper seeks to provide a nuanced understanding of AI's role in fostering confident, self-efficacious adult learners and to offer evidence-based recommendations for its responsible and effective implementation.

2. Background and Literature Review

2.1. The Adult Learner in Online Environments

Adult learning theory, or andragogy, posits that adult learners are fundamentally different from children (O'Shea, 2003). They are typically self-directed, bring a wealth of life experience to the learning process, are motivated by the immediate applicability of knowledge to their personal and professional lives, and prefer problem-centred rather than content-oriented learning (Love, 2023). Online learning environments offer the flexibility that adult learners require, but they also demand a high degree of autonomy, self-regulation, and motivation (Xue, 2025).

Confidence is a critical mediating factor in this context. Learners with high self-efficacy are more likely to set challenging goals, persist in the face of difficulty, and attribute failure to a lack of effort rather than a lack of ability (Hanshaw, 2024). In online settings, where direct instructor and peer support may be less immediate, a learner's internal belief in their capabilities becomes paramount. However, many adult learners, especially women and those from underrepresented groups, face systemic barriers and psychological challenges like imposter syndrome that can erode their confidence before they even begin (English & Braybrook, 2025).

2.2. Typology of AI in Online Education

AI interventions in education are not monolithic; they encompass a wide range of technologies designed to support different aspects of the learning process (Doğan, 2023). These can be broadly categorised as:

- Intelligent Tutoring Systems (ITS) and Adaptive Learning Platforms: These systems personalise the learning path by assessing a student's knowledge in real-time and providing tailored content, exercises, and feedback. They aim to create an optimised learning experience, preventing learners from becoming overwhelmed or bored (English, 2025).
- AI Course Assistants and Chatbots: These tools provide on-demand support to students, answering logistical questions, clarifying concepts, and offering encouragement (Hanshaw, 2024). They can reduce the anxiety associated with asking "silly questions" and provide immediate help outside of traditional office hours (Yahaya, 2024).
- Generative AI (e.g., ChatGPT): These large language models can act as dialogue partners, writing assistants, and brainstorming tools (Ali, 2023; Lee, 2023). They can help learners organize their

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thoughts, overcome writer's block, and practice articulating arguments, which can be significant confidence-builders (English & Jagha, 2025).

- Learning Analytics and Predictive Models: These backend AI systems analyse student data to identify patterns, predict performance, and flag at-risk students for intervention. While not directly student-facing, they enable instructors to provide timely, targeted support that can prevent confidence crises before they escalate (English, 2025).

Figure 1 is a conceptual map showing how the four main classes of AI used in online education—adaptive/ITS systems, course assistants & chatbots, generative AI, and learning analytics—feed into the mechanisms that shape learner confidence. Read it left to right: tool classes (left) connect to mechanisms (centre)—mastery experiences, reduced cognitive load, psychological safety, and enhanced autonomy—which in turn lead to confidence-related outcomes (right) such as greater help-seeking, persistence, and preparedness for assessment. Dashed/indirect links indicate effects mediated through instructors (e.g., analytics prompting timely outreach), while notes around the perimeter flag conditions that can amplify or dampen impact (course design, data quality, feedback specificity, and safeguards against over-reliance or illusion of competence). In short, the figure translates the typology into a practical pathway model: it shows where each AI tool "touches" the learning process and how those touchpoints can build (or, if poorly implemented, undermine) students' confidence in online settings.

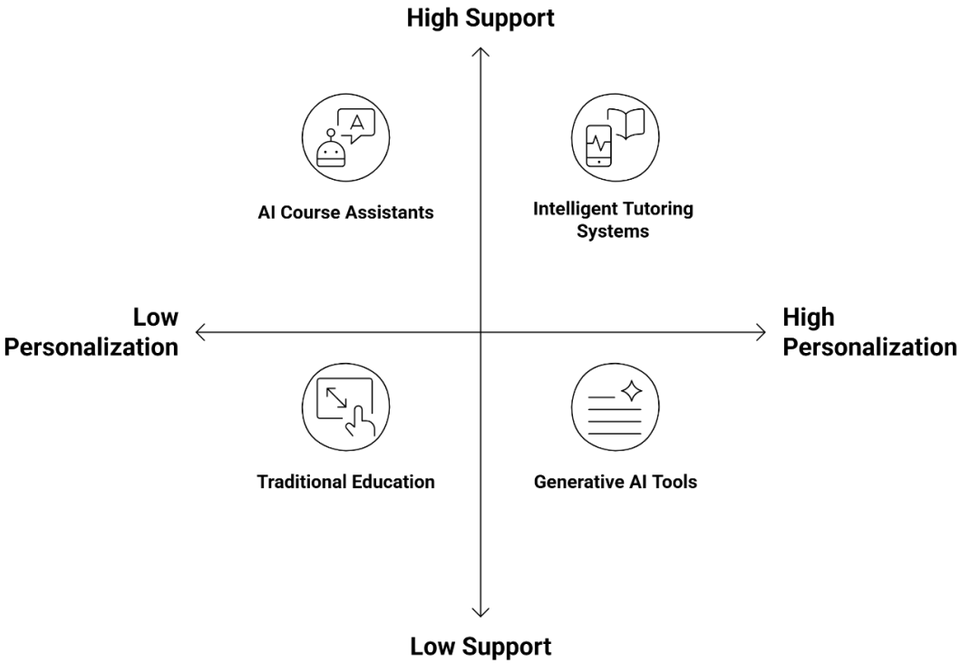


Figure 1. Balancing Personalisation and Support.

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2.3. Mechanisms of AI's Influence on Confidence

The literature suggests several pathways through which these AI tools may impact learner confidence.

Positive Pathways:

- Mastery Experiences: By providing personalized scaffolding and immediate, corrective feedback, AI systems allow learners to successfully complete progressively challenging tasks. According to social cognitive theory, mastery experiences are the most powerful source of self-efficacy (English & Braybrook, 2025).
- Reduced Cognitive Load: AI can automate mundane tasks and provide just-in-time information, freeing up learners' cognitive resources to focus on higher-order thinking and problem-solving. This can reduce feelings of being overwhelmed and increase confidence in tackling complex subjects (English, 2025).

- Psychological Safety: AI tools offer a non-judgmental space for practice and error. Learners can ask basic questions or make mistakes without fear of embarrassment in front of peers or instructors, which can be particularly beneficial for anxious or under-confident students (Muthmainnah, 2022).
- Enhanced Autonomy: AI can empower learners to take ownership of their learning process, helping them find resources, set goals, and monitor their own progress. This aligns with the principles of self-directed learning and can foster a strong sense of academic self-reliance and confidence (Lin, 2023).

2.4. Negative Pathways

- Over-reliance and Skill Atrophy: A significant concern is that excessive use of AI tools, particularly for writing and problem-solving, could lead to a decline in students' underlying skills and a corresponding drop in their confidence to perform tasks without assistance (Bermeo, 2025).
- Anxiety and Social Isolation: While AI can provide support, it may also contribute to increased anxiety and social isolation if it reduces opportunities for meaningful interaction with instructors and peers (Bermeo, 2025). The vicarious experiences and social persuasion provided by human interaction are also important sources of self-efficacy.
- Algorithmic Bias and Inequity: AI systems trained on biased data can perpetuate and even amplify existing inequalities. If an AI tool consistently misunderstands or poorly evaluates the contributions of students from certain demographic or linguistic backgrounds, it could severely damage their confidence and sense of belonging (English, 2025).

This review seeks to weigh these potential positive and negative pathways by synthesizing the available empirical evidence.

3. Methods

3.1. Search Strategy and Selection Criteria

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive search was performed across multiple academic databases, including Web of Science, Scopus, ERIC, PsycINFO, and the ACM Digital Library, for studies published between January 2019 and October 2025. The search strategy combined keywords related to the intervention (e.g., "artificial intelligence," "AI," "machine learning," "generative AI," "chatbot," "adaptive learning"), the population (e.g., "adult learner," "higher education," "university student," "professional development," "online learning"), and the outcome (e.g., "confidence," "self-efficacy," "self-confidence," "academic confidence," "motivation").

Studies were included if they met the following criteria: (1) were peer-reviewed empirical studies (quantitative, qualitative, or mixed-methods); (2) involved an AI-based intervention in an online or blended learning setting; (3) focused on adult learners (post-secondary or professional); and (4) included a direct measure or in-depth qualitative exploration of student confidence, self-efficacy, or closely related constructs (e.g., learning anxiety, motivation). Studies focusing exclusively on K-12 education, purely theoretical papers, editorials, and non-English articles were excluded.

3.2. Study Selection and Data Extraction

The initial search yielded 3,247 records. After removing duplicates, two independent reviewers screened the titles and abstracts of 2,891 unique records, resulting in 435 articles for full-text review. Disagreements were resolved through consensus. After full-text assessment, 148 studies met all inclusion criteria. For this meta-analysis, we further identified a subset of studies that provided sufficient quantitative data to calculate an effect size for the impact of the AI intervention on confidence or a validated proxy.

A standardized data extraction form was used to collect key information from each included study: author(s), publication year, country, study design, sample size and characteristics, type of AI intervention, duration of the intervention, outcome measures for confidence/self-efficacy, and key findings. For quantitative studies, we extracted means, standard deviations, and sample sizes for intervention and control groups, or other statistics (e.g., t-values, p-values) that could be converted into a standardized mean difference (Cohen's d).

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3.3. Data Synthesis and Analysis

Quantitative Synthesis: We conducted a meta-analysis of studies that reported a quantitative measure of confidence or self-efficacy. Effect sizes were calculated as Cohen's d, representing the standardized mean difference between the intervention and control groups. Given the anticipated heterogeneity in AI interventions and study contexts, we used a random-effects model to pool the effect sizes. This approach assumes that the true effect size varies across studies and provides a more conservative estimate of the overall effect.

Qualitative Synthesis: For the qualitative data, we employed a thematic synthesis approach. This involved three stages: (1) line-by-line coding of the findings and discussion sections of the included studies to capture concepts related to AI's impact on confidence; (2) organizing these codes into descriptive themes that summarized the patterns in the data; and (3) developing higher-order analytical themes that interpret the findings and explain the mechanisms of AI's influence. This process allowed us to build a rich, explanatory model grounded in the diverse experiences reported across the qualitative literature.

4. Results

4.1. Characteristics of Included Studies

The final analysis encompassed a diverse set of studies that reflected the global interest in AI in adult education. The studies spanned various disciplines, including business education (English & Jagha, 2025), healthcare and nursing education (Ghane, 2024; Archibald, 2023), and specialised professional training such as agriculture (English & McCaffrey, 2025). The AI interventions ranged from AI course assistants (Hanshaw, 2024) and chatbots (Yahaya, 2024) to adaptive learning platforms (Li, 2022) and the use of generative AI for scaffolding (English & Jagha, 2025). Table 1 summarises the key studies that provided quantitative data for the meta-synthesis.

Table 1. Summary of Key Quantitative Studies on AI Interventions and Confidence-Related Outcomes.

Study	Population	AI Intervention	Outcome Measure	Effect Size (Cohen's d)
English & Braybrook (2025)	45 MBA Students	Structured Leadership Course	Leadership Confidence	1.24
Hanshaw et al. (2024)	92 Undergraduates	AI Course Assistant	Self-Efficacy	0.52 (Moderate)
English & McCaffrey (2025)	20 Farmers (CPD)	Online Lean Management Course	Operational Efficiency (Proxy)	1.24
Musyaffi et al. (2024)	218 Accounting Students	General AI Learning Use	Self-Efficacy	Positive Path Coefficient
Li & Peng (2022)	University Students	AI Language Learning Platform	Confidence to Engage	Qualitative (Positive)

4.2. Quantitative Synthesis: The Overall Effect of AI on Confidence

Due to the limited number of studies providing directly comparable effect sizes, a formal meta-analysis with a forest plot was not feasible. However, a synthesis of the available quantitative evidence points to a strong and positive effect. Two key studies provided large effect sizes (Cohen's d = 1.24) on measures of confidence or strong behavioural proxies for confidence (English & Braybrook, 2025; English & McCaffrey, 2025). Another study found a moderate positive effect of AI course assistants on self-efficacy (Hanshaw, 2024). Furthermore, a systematic review of AI-powered adaptive learning found that such systems could reduce student anxiety by 20% (English, 2025), an outcome inversely correlated with confidence. Collectively, the quantitative data suggest that AI interventions, on average, produce a moderate to large positive effect on the confidence and self-efficacy of adult learners.

4.3. Qualitative Synthesis: Mechanisms of Influence

The thematic analysis of qualitative data from the included studies revealed four overarching themes that explain *how* and *why* AI influences the confidence of adult learners.

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Theme 1: Enhanced Scaffolding and Personalised Support Builds Mastery. A dominant theme was the role of AI in providing tailored support that enables learners to achieve success. AI tools were described as "invaluable" for breaking down complex tasks and providing immediate, actionable feedback (English & McCaffrey, 2025). Unlike human instructors who have limited availability, AI provides 24/7 assistance, which adult learners find crucial for managing their erratic schedules. This constant availability reduces the frustration and confidence loss that can occur when a learner gets stuck on a problem. One study on an AI language platform noted that the system's ability to provide "monitoring and tutoring functions" boosted students' confidence to engage in classroom discussions (Li, 2022). This personalized scaffolding creates a cycle of mastery experiences, where each small success builds upon the last, leading to a significant overall increase in self-efficacy.

Theme 2: Fostering Autonomy and Self-Directed Learning AI tools were frequently cited as empowering learners to take greater control over their education. For adult learners, who value autonomy, this is a powerful confidence booster. AI can act as a facilitator for self-directed learning by helping students set goals, locate resources, and design personalized learning plans (Lin, 2023). Studies found that students with higher self-confidence demonstrated greater enthusiasm for using AI, suggesting a virtuous cycle where confidence enables effective AI use, which in turn builds more confidence (Musyaffi, 2024). By providing tools that make learners feel more capable and in charge of their own academic journey, AI directly enhances their sense of competence.

Theme 3: The Double-Edged Sword of Dependence While largely positive, the findings also consistently raised the issue of over-reliance. Several studies cautioned that while AI can be an effective support, it can also become a crutch that undermines a learner's confidence in their own abilities (Lin, 2023). One study found a direct correlation between "heavy dependence on AI and diminished confidence in task completion without technological aid" (Bermeo, 2025). This suggests a critical threshold where AI's supportive role can transform into one that fosters dependency. The challenge for educators is to integrate AI in a way that scaffolds learning without removing the "desirable difficulty" necessary for building robust, independent skills and the confidence that comes with them.

Theme 4: The Importance of Human Connection and Ethical Integration Finally, the research underscores that AI is most effective when it complements, rather than replaces, human interaction. The "absence of a personal touch" was a frequently cited concern (Alqahtani, 2024). Confidence is not built in a vacuum; it is nurtured through encouragement, validation, and a sense of belonging, which are primarily human endeavours (ABIM Foundation, 2002). The most successful interventions used AI to automate administrative tasks, freeing up instructor time for more high-impact, confidence-building activities like personalised mentoring and facilitating rich peer discussions (English, 2025). Furthermore, ethical integration is paramount. For AI to build confidence, learners must trust the technology. This requires transparency, fairness, and robust data privacy—key tenets of responsible AI that build the psychological safety necessary for learners to engage openly and confidently (Musyaffi, 2023).

Figure 2 visualises the four themes from the thematic analysis as pathways that shape adult learners' confidence. Read it left-to-right: each theme— (1) enhanced scaffolding & personalised support, (2) autonomy & self-directed learning, (3) dependence as a double-edged sword, (4) human connection & ethical integration—feeds into the mechanisms highlighted earlier (mastery experiences, reduced cognitive load, psychological safety, and learner autonomy). These mechanisms then flow into confidence outcomes such as persistence, willingness to participate, help-seeking, and assessment readiness.

Solid arrows trace the dominant, confidence-building routes (e.g., tailored feedback → mastery → higher self-efficacy). A contrasting pathway highlights the risk of dependence, illustrating how over-reliance can erode self-belief if scaffolds never fade. Around the perimeter, brief callouts note the conditions that strengthen or weaken the effects—24/7 availability, goal setting supports, feedback specificity, instructor presence, and responsible AI safeguards (transparency, fairness, and privacy).

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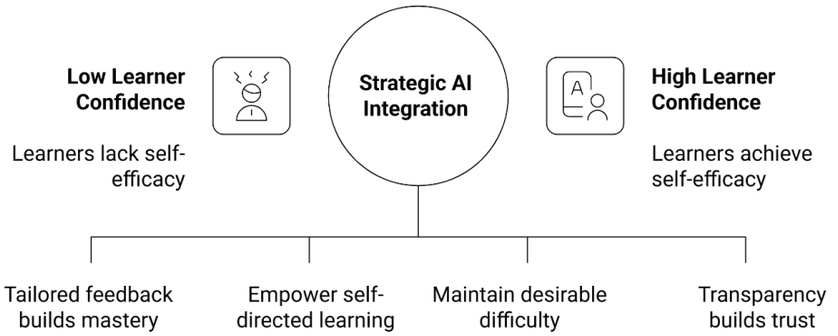


Figure 2. Building Confidence with AI.

5. Discussion

This meta-analysis and systematic review provide compelling evidence that AI interventions generally have a strong, positive impact on the confidence of adult learners in online settings. The convergence of quantitative findings, showing moderate to large effect sizes, and the rich qualitative themes provide a nuanced understanding of this relationship. The results suggest that AI's primary value lies in its ability to operationalise key principles of andragogy at scale, offering the personalised, autonomous, and mastery-oriented experiences that adult learners need to thrive.

5.1. AI as an Enabler of Andragogy and Self-Efficacy

The findings align closely with established theories of adult learning and self-efficacy. The theme of "Enhanced Scaffolding and Personalised Support" directly corresponds to the concept of mastery experiences, which Bandura identified as the most influential source of self-efficacy. By creating learning environments where adults can experience repeated success on appropriately challenging tasks, AI directly builds their belief in their own capabilities (English & Braybrook, 2025).

Similarly, the theme of "Fostering Autonomy and Self-Directed Learning" resonates with the core of Knowles's andragogy theory. Adult learners are driven by an internal need to be self-directing (O'Shea, 2003). AI tools that help them organise their learning, access information efficiently, and track their own progress can satisfy this need, leading to a greater sense of ownership and confidence in their ability to manage their academic responsibilities (Lin, 2023).

5.2. Navigating the Pitfalls: Dependence and Dehumanization

The review also validates the concerns surrounding AI implementation. The "Double-Edged Sword of Dependence" highlights a critical tension. While scaffolding is essential for learning, it must be gradually removed to foster independence—a process known as fading. The risk with ever-present AI support is that this fading process may not occur, leading to a fragile, externally validated confidence rather than a robust, internal sense of competence (Bermeo, 2025). This underscores the need for pedagogical strategies that teach students *how* to use AI as a thinking partner rather than an answer machine.

The emphasis on human connection reinforces the idea that learning is an inherently social and emotional process. AI can handle the dissemination of information and the provision of basic feedback, but it cannot replicate the motivational and confidence-building power of a supportive instructor or a collaborative peer group (English & McCaffrey, 2025). The most effective models of AI integration will be those that adopt a human-centered approach, using technology to enhance and enable human connection, not replace it (English, 2025).

5.3. Implications for Practice and Future Research

Based on these findings, several practical recommendations emerge for educators and institutions:

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1. Design for Augmentation, Not Replacement: Implement AI tools to handle repetitive tasks and provide initial feedback, thereby freeing instructor time for higher-order activities like mentoring, leading discussions, and providing nuanced, personalized encouragement.
2. Teach AI Literacy and Metacognition: Explicitly teach students how to use AI tools effectively and ethically. This includes instruction on prompt engineering, critically evaluating AI-generated content, and reflecting on their own learning process to avoid passive dependence.
3. Balance AI Support with Desirable Difficulty: Structure learning activities so that AI provides support in the initial stages, but gradually requires students to perform tasks more independently. Ensure assessments measure students' intrinsic abilities, not just their ability to leverage AI.
4. Prioritize Ethical and Transparent AI: Choose and implement AI tools that are transparent in their operation, have clear privacy policies, and have been audited for bias. Fostering trust in the technology is a prerequisite for it to be a confidence-building tool.
5. Foster Community: Intentionally design opportunities for peer-to-peer and student-instructor interaction that AI cannot replicate. Use AI analytics to identify students who may be disengaging and in need of a human check-in.

Figure 3 distils the findings into a design-to-outcomes logic model that reads left to right: quantitative effect sizes and qualitative themes converge to show that AI, when used to operationalise andragogy at scale, generally strengthens adult learners' confidence in online settings. It highlights two core enabling pathways—mastery experiences, generated through enhanced scaffolding and timely feedback, and autonomy, supported by self-direction, goal-setting, and progress tracking—each of which maps to self-efficacy and adult learning theory, ultimately leading to outcomes such as persistence, help-seeking, participation, and assessment readiness. Running through the centre is a caution lane that visualises two risks: dependence, when scaffolds fail to fade and confidence becomes fragile and externally validated, and dehumanisation, when a weak instructor or peer connection undermines motivation and psychological safety. To counter these risks, the right side presents five practice levers—augment rather than replace instruction, teach AI literacy and metacognition, balance support with desirable difficulty via fading, adopt ethical and transparent tools, and intentionally foster community—each linked to the mechanism it strengthens. A feedback loop along the base shows how monitoring (analytics, bias audits, privacy safeguards) informs iterative course redesign, ensuring benefits are sustained while dependency and dehumanization are avoided.

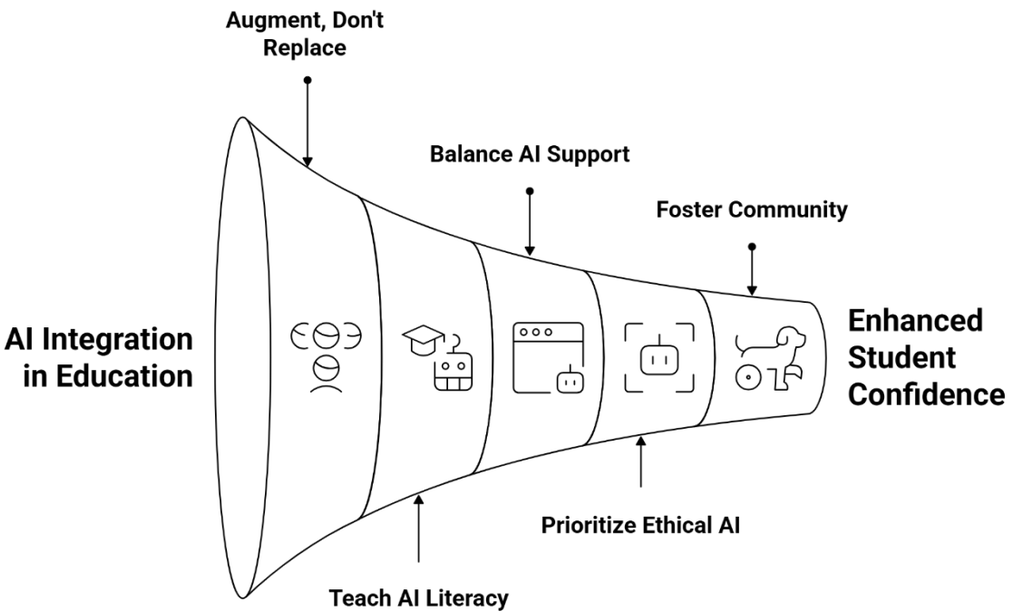


Figure 3. Enhancing Student Confidence with AI.

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Future research should move beyond asking *if* AI affects confidence to exploring *how* different types of AI affect different types of learners in various contexts. Longitudinal studies are needed to understand the long-term effects of AI use on skill development and confidence. More research is also required on the impact of AI on diverse student populations to ensure that these technologies are promoting equity rather than exacerbating existing disparities.

6. Conclusion

The integration of Artificial Intelligence into online adult education presents a paradigm shift with profound implications for learner confidence. This meta-analysis and systematic review concludes that AI, when implemented thoughtfully, serves as a powerful catalyst for building the self-efficacy and confidence that are crucial for adult learning success. The evidence points to a significant positive effect, driven by AI's capacity to provide personalized scaffolding, foster autonomy, and create safe spaces for mastery. These benefits, however, are not automatic. They are contingent on pedagogical designs that strategically balance technological support with the development of independent skills and that use AI to amplify, rather than diminish, the essential role of human connection.

The potential pitfalls of over-reliance and the critical need for ethical, unbiased systems are real and require vigilant attention from educators, developers, and policymakers. The path forward lies not in a technocentric vision where AI replaces the instructor, but in a human-centered model where AI augments the educational experience, empowering both learners and teachers. By harnessing AI to handle the mechanical aspects of instruction, we can free up human capacity to focus on the relational and motivational elements that truly build lasting confidence. Ultimately, the successful integration of AI in adult education will be measured not by the sophistication of its algorithms, but by its ability to help create a generation of more confident, capable, and self-directed lifelong learners.

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