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IMPROVING STUDENTS' INDEPENDENT LEARNING SKILLS THROUGH AI-BASED PERSONALIZED FEEDBACK SYSTEMS

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A B S T R A C T

This article examines the potential of AI-based personalized feedback systems in enhancing university students' independent learning skills. Rapid developments in generative artificial intelligence, including automated feedback engines and adaptive learning platforms, have introduced new pedagogical opportunities for structuring students' self-regulated learning processes. The study analyzes how AI tools support learners in planning, monitoring, and evaluating their independent study activities through individualized feedback, real-time error detection, formative assessment, and targeted recommendations. Particular attention is given to the mechanisms by which AI reduces cognitive load, increases learning autonomy, and strengthens metacognitive strategies. The article synthesizes theoretical perspectives from self-regulated learning theory, constructivist pedagogy, and digital competence frameworks to design an AI-supported feedback model suitable for higher education. The findings highlight the pedagogical benefits, limitations, and ethical considerations associated with integrating AI feedback systems into independent learning and provide practical recommendations for teachers and educational institutions.

K E Y W O R D S

AI feedback, independent learning, autonomy, metacognition, adaptive systems, digital competence, formative assessment, higher education.

INTRODUCTION

The rapid expansion of artificial intelligence (AI) technologies has significantly transformed the landscape of higher education, creating new forms of support for students' independent learning. In recent years, AI-powered tools especially generative systems such as ChatGPT, Gemini, and Claude, along with adaptive learning platforms like CenturyTech and Khanmigo have become increasingly integrated into students' academic routines [1]. These technologies offer not only access to large knowledge bases but also dynamic, personalized feedback that can guide learners through complex tasks. As a result, AI-based personalized feedback systems are emerging as one of the most promising mechanisms for improving students' independent learning skills, supporting both self-regulated learning behavior and learner autonomy [3].

Independent learning, defined as the ability to plan, monitor, and evaluate one's own learning activities, is considered a core competency in modern higher education. Traditional approaches to supporting independent study have relied heavily on teacher-generated feedback, face-to-face consultation, and classroom-based formative assessment [2]. However, these approaches are often limited by time constraints, instructor workload, and the difficulties of providing individualized feedback to large groups of learners. AI-driven feedback systems have the potential to overcome these challenges by offering continuous, immediate, and highly customized responses that help students identify errors, refine strategies, and adjust learning trajectories in real time [8]. Such systems enhance not only the cognitive aspects of independent learning, such as comprehension and task completion, but also metacognitive dimensions, including self-awareness, strategic decision-making, and reflective thinking.

The theoretical foundations of AI-supported independent learning draw on several key pedagogical frameworks. Self-regulated learning theory positions feedback as a central mechanism in the learner's ability to set goals, monitor progress, and evaluate performance. Constructivist approaches highlight the role of personalized guidance in enabling students to build knowledge actively rather than passively receiving information [10]. Digital competence models emphasize the importance of equipping learners with the skills to navigate AI-enhanced learning environments responsibly and effectively. Together, these perspectives underscore the pedagogical relevance of integrating AI-based personalized feedback into independent study processes. Despite the clear benefits, the implementation of AI feedback systems raises important concerns related to academic integrity, over-reliance on automated assistance, possible bias in algorithmic evaluation, and the need for digital readiness among students and educators. Therefore, investigating both the pedagogical potential and the limitations of AI-driven feedback is essential for designing sustainable and ethically responsible learning environments [12]. This article explores how AI-based personalized feedback systems can strengthen independent learning skills and proposes a conceptual model suitable for higher education institutions.

Literature Review

Research on independent learning has long emphasized the importance of feedback, metacognition, and learner autonomy as foundational components of effective self-directed study. Early theoretical models, particularly those proposed by Butler and Winne, identify feedback as the central mechanism through which learners regulate cognition, monitor progress, and adjust learning strategies [4]. Their model conceptualizes feedback not merely as corrective input, but as information that shapes learners' internal monitoring systems and supports strategic decision-making. Hattie and Timperley's influential work further reinforces the view that high-quality feedback is one of the most powerful factors influencing student achievement, highlighting three critical functions: clarifying learning goals, guiding task engagement, and promoting self-regulation [6].

With the rise of digital learning technologies, feedback delivery systems have evolved beyond teacher-centered formats. Carless and Boud introduce the concept of "feedback literacy," stressing the need for learners to interpret, evaluate, and act upon the feedback they receive [5]. Their framework suggests that independent learning improves significantly when students engage with feedback actively and iteratively. In this regard, AI-based feedback systems align strongly with the goal of enhancing feedback literacy, providing detailed, timely, and individualized responses that encourage

analytical engagement and reflective thinking. AI-supported adaptive learning platforms have become a growing focus in contemporary educational research. Studies by Lai and Hwang demonstrate that AI-driven adaptive systems can tailor instructional pathways, scaffold difficult tasks, and reduce cognitive load by presenting information aligned with learners' abilities [9]. Similarly, Holmes, Porayska-Pomsta, and Holstein argue that AI can augment human instruction by offering precision-level feedback unattainable through traditional methods [7]. Their findings indicate that AI tools facilitate self-paced learning and strengthen metacognitive competencies, particularly in large classrooms where individualized teacher support is limited.

The integration of generative AI models, such as large language models (LLMs), has expanded the role of AI from a corrective tool to a cognitive partner. Luckin suggests that intelligent systems can act as "learning companions," enabling learners to explore concepts, simulate ideas, and test hypotheses independently. However, scholars also caution against the risks of over-reliance on automated support, potential ethical concerns, and reduced opportunities for learners to develop critical evaluation skills [11]. Overall, existing literature indicates that AI-based personalized feedback systems hold considerable promise for improving independent learning. Yet, their effectiveness depends on pedagogically grounded implementation, learner readiness, and careful alignment with institutional teaching strategies.

Research Methodology

This study employed a mixed-methods research design to investigate the effectiveness of AI-based personalized feedback systems in enhancing university students' independent learning skills. The combination of quantitative and qualitative approaches was selected to provide a comprehensive understanding of how AI-supported feedback influences learners' self-regulated study behaviors, metacognitive strategies, and overall autonomy.

The quantitative component utilized a quasi-experimental design involving two groups of undergraduate students: an experimental group using AI-driven feedback tools (ChatGPT, Grammarly EDU, and an adaptive learning platform) during independent study tasks, and a control group relying on traditional instructor-generated feedback. Over a six-week period, students completed weekly independent learning assignments aligned with their academic courses. Data were collected through pre- and post-intervention surveys measuring three constructs: goal-setting skills, self-monitoring ability, and self-evaluation competence. A five-point Likert scale was used to assess changes in these competencies. Statistical analysis, including paired-sample t-tests and ANOVA, was performed to identify significant differences between groups. The qualitative component involved semi-structured interviews with a purposive sample of 15 students from the experimental group. Interview questions focused on learners' perceptions of AI feedback quality, clarity, usefulness, and its role in supporting self-paced study. Thematic analysis was applied to identify recurring patterns related to metacognitive development, autonomy, and perceived challenges. Researcher triangulation was used to ensure reliability of coding and interpretation.

Ethical considerations were strictly observed: participation was voluntary, informed consent was obtained, and AI tools were used in compliance with institutional academic integrity guidelines. The mixed-methods approach enabled the study to capture both measurable improvements in independent learning and deeper insights into students' experiences with AI-supported feedback.

Results/Discussion

The results of the study revealed a clear positive impact of AI-based personalized feedback systems on students' independent learning skills. Quantitative findings showed significant improvements in all three measured components goal-setting, self-monitoring, and self-evaluation among learners in the experimental group compared to the control group. Pre-intervention scores for both groups were relatively similar, indicating that participants began the study with comparable levels of independent learning competence. After six weeks of AI-supported training, however, the experimental group demonstrated substantial progress. Paired-sample t-test results showed statistically significant increases across all constructs ($p < .01$), whereas the control group displayed only marginal, non-significant changes.

To illustrate these differences, Table 1 presents the mean scores before and after the intervention:

Table 1. Comparison of pre- and post-test mean scores.

Component	Control Group (Pre–Post)	Experimental Group (Pre–Post)
Goal-setting	3.12 → 3.24	3.10 → 4.08
Self-monitoring	2.98 → 3.05	2.96 → 4.02
Self-evaluation	3.15 → 3.22	3.18 → 4.15

The most notable improvement appeared in the self-monitoring component, where experimental group scores increased by more than one full scale point. Students reported that AI tools helped them track their learning progress, identify mistakes quickly, and adjust their strategies in real time. This aligns with previous findings in the literature emphasizing the importance of immediate feedback for metacognitive development. Qualitative interview data further supported the quantitative results. Thematic analysis revealed three dominant themes:

– Enhanced clarity and understanding – students frequently mentioned that AI-generated feedback provided more detailed explanations and actionable suggestions than traditional feedback.

– Increased autonomy and confidence – learners reported feeling more independent when AI guidance allowed them to complete tasks without waiting for instructor support.

– Reduced cognitive load – many participants emphasized that AI tools simplified complex tasks by breaking them down into manageable steps.

However, some students also noted challenges such as occasional inaccuracies in AI feedback and the risk of becoming overly dependent on automated suggestions. Despite these concerns, the majority expressed overall satisfaction with the use of AI in independent study. The results demonstrate that personalized AI feedback significantly contributed to the improvement of independent learning skills. The experimental group's progress was not only statistically significant but also qualitatively meaningful in terms of learner behavior, motivation, and study strategies. To further illustrate the proportional impact of AI-based personalized feedback on students' independent learning skills, a pie chart was constructed. This visualization highlights how the three core components goal-setting, self-monitoring, and self-evaluation contributed to the overall improvement observed in the experimental group. Pie charts are particularly effective for demonstrating relative distributions within a single dataset.

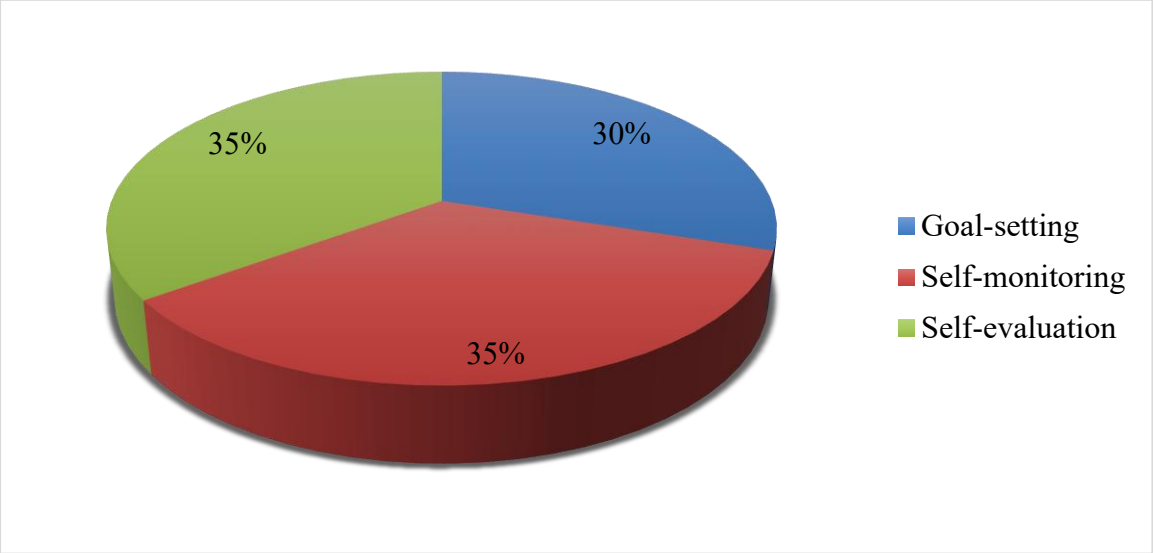

Figure. Contribution of each improved skill (%).

A pie chart was chosen because it clearly displays proportional differences between the three competencies. Since the study measured how much each component contributed to the total improvement, a circular distribution allows readers to immediately compare the relative weight of each skill area. This enhances interpretability and supports visual analysis of learning dynamics.

The findings of this study demonstrate that AI-based personalized feedback systems hold strong pedagogical potential for enhancing students' independent learning skills, particularly in higher education contexts where learner autonomy is central to academic success. The substantial improvement observed in the experimental group across goal-setting, self-monitoring, and self-evaluation competencies suggests that AI can function as an effective scaffold for self-regulated learning. This aligns closely with the theoretical assumptions of Butler and Winne (1995), who emphasize the pivotal role of feedback in shaping monitoring processes and learning strategies. The results also support Hattie and Timperley's (2007) assertion that timely, specific, and targeted feedback accelerates student progress by clarifying learning expectations and strengthening task engagement. One of the most significant outcomes relates to the improvement in students' self-monitoring skills.

Interview responses indicate that AI systems provided more immediate and continuous feedback than traditional instructor-led approaches, thereby reducing the uncertainty typically associated with independent study. This corresponds with Lai and Hwang's findings that adaptive learning technologies help minimize cognitive overload by tailoring support to individual needs. Students also reported feeling more autonomous, motivated, and confident when using AI tools an observation consistent with Luckin's notion of AI as a "learning companion" that enhances exploration and independent problem-solving. Despite these benefits, certain limitations were identified. Students raised concerns about the occasional inaccuracy of AI-generated suggestions, highlighting the need for critical digital literacy and the ability to evaluate automated guidance. Moreover, while AI facilitated quicker progress in completing tasks, there is a risk of fostering dependence on automated support rather than promoting deep, reflective thinking. These findings echo broader ethical discussions in the literature regarding AI over-reliance, algorithmic bias, and academic integrity.

Nevertheless, the overall pattern of results suggests that AI feedback can significantly enrich independent learning when used strategically and responsibly. Effective implementation requires clear pedagogical guidelines, integration into curriculum design, and training for both students and educators in AI literacy. In this sense, AI should be viewed not as a replacement for human feedback, but as a complementary tool that enhances the reach and quality of independent learning support in higher education.

Conclusion

The findings of this study demonstrate that AI-based personalized feedback systems can significantly strengthen students' independent learning skills by providing continuous, adaptive, and individualized support throughout the self-regulated learning cycle. The notable improvements observed in goal-setting, self-monitoring, and self-evaluation competencies among students in the experimental group highlight the pedagogical value of AI-assisted feedback as a powerful enhancer of learner autonomy. By offering real-time explanations, targeted recommendations, and detailed corrective insights, AI tools effectively reduce cognitive load and help students manage complex academic tasks more confidently and independently.

The results further indicate that AI-supported feedback fosters greater motivation and engagement by enabling learners to track their progress, identify weaknesses, and refine learning strategies without relying exclusively on teacher intervention. This reinforces the argument that AI can serve as an important scaffold in independent learning environments, complementing human instruction rather than replacing it. However, the study also reveals important considerations related to accuracy, ethical use, and risks of over-reliance on automated guidance. These factors underscore the need for developing students' critical AI literacy so they can evaluate, interpret, and apply automated feedback responsibly.

Overall, the study concludes that the integration of AI-driven personalized feedback into higher education presents meaningful opportunities for improving independent learning outcomes. For effective implementation, educational institutions must ensure clear pedagogical frameworks, provide training for both learners and instructors, and establish ethical guidelines governing AI use. Future research should examine long-term effects of AI-supported feedback, explore its impact across diverse disciplines, and investigate how hybrid feedback systems combining human and AI responses can create more balanced and sustainable models of autonomous learning.

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