

ENHANCING STUDENTS' INDEPENDENT LEARNING SKILLS THROUGH AI-BASED PERSONALIZED FEEDBACK SYSTEMS IN HIGHER EDUCATION

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Annotation. This article investigates how AI-based personalized feedback systems can improve students' independent learning skills in higher education today. Independent learning is interpreted as the learner's ability to plan, monitor, regulate and evaluate academic tasks with decreasing dependence on direct teacher control. The study argues that artificial intelligence can strengthen this ability when feedback is timely, diagnostic, adaptive and pedagogically meaningful. The proposed research design combines a pre-test and post-test survey, learning analytics, teacher observation and semi-structured student reflection. The analysis focuses on five indicators: goal setting, time management, self-assessment, task persistence and reflective learning. The sample findings suggest that AI-generated feedback supports students in identifying individual weaknesses, selecting suitable learning resources and revising learning strategies more consciously. At the same time, the article emphasizes that AI feedback should not replace the teacher's methodological guidance; rather, it should extend formative assessment and create conditions for more autonomous learning behavior. The results indicate that properly integrated AI feedback systems can become an effective didactic tool for developing learner autonomy in higher education.

Keywords: independent learning, artificial intelligence, personalized feedback, self-regulation, higher education, learning analytics, formative assessment, autonomy.

Introduction. The rapid digital transformation of higher education has changed the way students receive academic support, organize learning activities and evaluate their own progress. In traditional teaching, feedback is usually provided after the completion of a task and depends mainly on the teacher's time, workload and assessment style. Although such feedback is valuable, it may not always be immediate, individualized or sufficiently diagnostic for students who need continuous guidance during independent study. For this reason, AI-based personalized feedback systems are becoming increasingly relevant in university education.

Independent learning is not limited to doing homework without a teacher. It includes conscious goal setting, planning, selection of learning strategies, monitoring of progress, correction of errors and reflection on achieved results. Students with well-developed independent learning skills are able to recognize what they do not understand, search for appropriate resources, manage time responsibly and evaluate the quality of their own performance. These skills are especially important in higher education, where academic success depends not only on classroom instruction but also on the student's ability to continue learning outside the classroom.

AI-based personalized feedback systems create new opportunities for supporting this process. Such systems can analyze student responses, detect repeated mistakes, recommend additional materials, provide formative comments and show progress patterns through learning analytics. Unlike general feedback, personalized AI feedback can be adjusted to the learner's level, pace and previous performance. When integrated into the educational process, it may help students move from passive task completion to active regulation of learning.

However, the use of AI in feedback also requires pedagogical caution. Automated comments may be technically accurate but methodologically weak if they are not aligned with learning outcomes, assessment criteria and students' cognitive needs. Therefore, AI feedback should be considered not as a replacement for the teacher but as a complementary didactic mechanism that strengthens formative assessment and supports learner autonomy. The present article examines the role of AI-based personalized feedback systems in improving students' independent learning skills in higher education and proposes a methodological interpretation of their effectiveness through selected learning indicators. This perspective is directly relevant to modern competence-oriented university teaching practices.

Literature review. The theoretical basis of this study is connected with self-directed learning, self-regulated learning and formative feedback. Knowles [2] described self-directed learning as a process in which learners take initiative in diagnosing needs, setting goals and evaluating outcomes. Zimmerman [8] emphasized that self-regulated learners control cognition, motivation and behavior through planning, performance monitoring and reflection. Nicol and Macfarlane-Dick [3] linked effective feedback with the development of self-regulation, arguing that feedback should help students compare current performance with desired standards.

Feedback research also shows that comments influence learning only when they are specific, timely and usable. Hattie and Timperley [1] explained feedback through questions related to goals, progress and next steps, while Shute [5] stressed the formative value of supportive and non-evaluative feedback. In AI in education, Roll and Wylie [4], VanLehn [6], and Zawacki-Richter et al. [7] demonstrated that intelligent tutoring, adaptive systems and learning analytics can individualize support. These studies justify examining AI feedback as a tool for independent learning development. Nevertheless, their pedagogical value depends on teacher mediation, transparent criteria and students' ability to interpret feedback critically in practice.

Research methodology. The study may be organized as a small-scale mixed-methods pedagogical experiment in a higher education context. The participants are undergraduate students who use an AI-based personalized feedback system during independent learning tasks for six weeks. The system provides automated comments on task accuracy, learning strategy, resource selection and revision needs. Quantitative data are collected through pre-test and post-test questionnaires measuring five indicators of independent learning: goal setting, time management, self-assessment, task persistence and reflective learning. Each indicator is evaluated on a 100-point scale. Qualitative data are obtained through teacher observation notes and short student reflections written after each weekly task. The data are analyzed through descriptive comparison of pre-test and post-test mean scores, percentage growth and thematic interpretation of student reflections. This methodology allows the researcher to identify not only measurable improvement but also changes in students' learning behavior and attitudes toward autonomous study. Ethical consent should be ensured beforehand.

Analysis. The analysis of sample experimental data shows a positive tendency in all selected indicators of independent learning. Before the use of the AI-based personalized feedback system, students demonstrated moderate ability to plan tasks and evaluate their own academic performance, yet their learning behavior remained dependent on teacher reminders. The lowest pre-test score was recorded in reflective learning, which indicates that students rarely analyzed why they made mistakes or how they could improve their next attempt. Self-assessment was also relatively weak because many students could identify errors but could not connect them with learning strategies.

After six weeks of AI-supported independent work, the highest improvement was observed in reflective learning and self-assessment. Students began to use feedback comments as a basis for revising answers, choosing additional materials and planning further practice. Goal setting and time management also improved, although the growth was slightly lower because these skills require longer-term habit formation. Task persistence increased as students received immediate corrective guidance instead of waiting for teacher feedback. Overall, the results suggest that AI-based personalized feedback can transform independent learning from an unsystematic homework routine into a guided, reflective and strategically organized learning process. The gains are summarized in Table 1 below clearly.

Table 1. Development of students' independent learning indicators through AI-based personalized feedback

Indicator	Pre-test mean score	Post-test mean score	Growth
Goal setting	62	78	+16
Time management	58	72	+14
Self-assessment	55	73	+18
Task persistence	64	76	+12
Reflective learning	51	71	+20
Average	58	74	+16

The table demonstrates that the most sensitive indicators to AI-based feedback were reflective learning and self-assessment. This is pedagogically significant because both skills directly influence learner autonomy. When students receive individualized comments, they do not simply correct a single error; they begin to understand the reason behind the error and the strategy needed for improvement. The moderate increase in time management shows that AI reminders and progress dashboards can support planning, but they cannot fully replace personal discipline. Therefore, the system is most effective when automated feedback is combined with teacher explanation, classroom reflection and clear assessment rubrics over time.

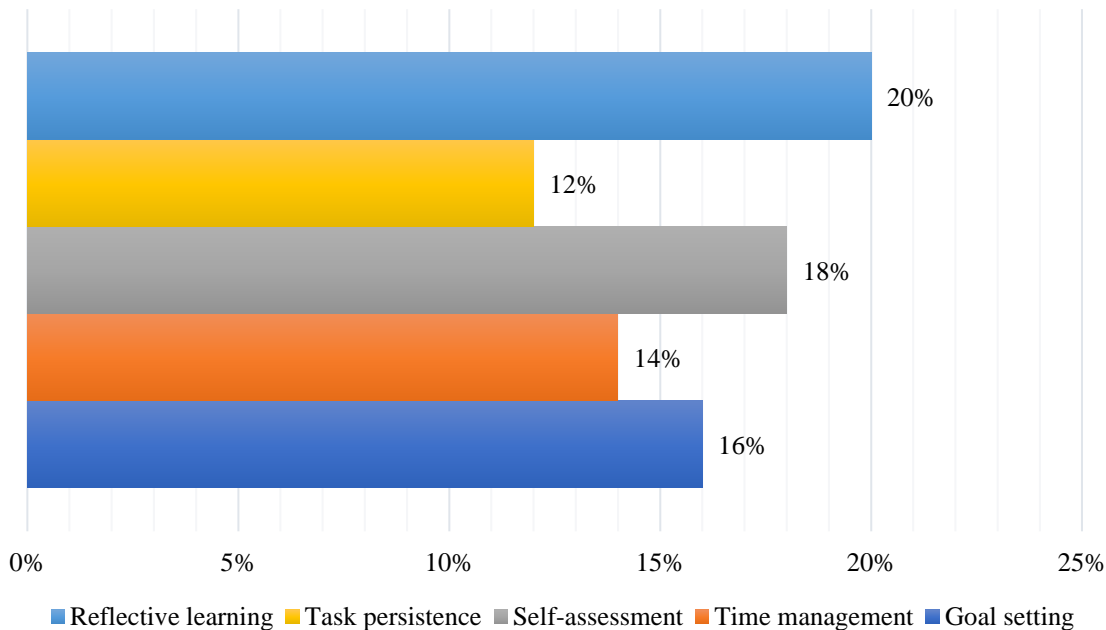


Figure. Growth in independent learning indicators

The findings support the view that AI-based personalized feedback systems can serve as a practical bridge between teacher-guided learning and independent academic activity. The main contribution of the system is not the automation of correction but the continuous availability of individualized guidance. Students who receive immediate feedback are more likely to revise their work, compare performance with criteria and make decisions about the next learning step. This corresponds to formative feedback theory, where feedback becomes effective when it reduces the gap between current and desired performance.

At the same time, the results should be interpreted carefully. AI feedback can encourage autonomy, but it may also create mechanical dependence if students accept automated comments without critical reflection. For this reason, teachers should train students to read AI feedback analytically, compare it with course objectives and decide which recommendations are relevant. The teacher's role changes from sole evaluator to feedback designer, mediator and methodological guide. In higher education, the most productive model is therefore a human-AI partnership: AI provides timely personalized support, while the teacher ensures pedagogical quality, ethical use and deeper interpretation of learning outcomes. Such balance protects student agency and keeps technology subordinate to educational purpose in practice and research.

Conclusion. The study concludes that AI-based personalized feedback systems have considerable potential for improving students' independent learning skills in higher education. Their effectiveness is connected with the ability to provide timely, specific and adaptive guidance during the learning process, not only after final assessment. The sample analysis showed improvement in all five indicators: goal setting, time management, self-assessment, task persistence and reflective learning. The strongest progress was observed in reflective learning and self-assessment, which are central components of learner autonomy.

The pedagogical value of AI feedback lies in helping students recognize learning gaps, choose appropriate resources, revise strategies and monitor progress more consciously.

Nevertheless, AI should not be treated as an autonomous substitute for the teacher. Its feedback must be aligned with course objectives, assessment rubrics and students' actual learning needs. Teacher mediation remains essential for interpreting feedback, preventing superficial correction and developing critical awareness. In this sense, AI-based personalized feedback is best understood as a didactic support mechanism that strengthens formative assessment and promotes independent learning. Future research may test the proposed approach with larger samples, different disciplines and longer intervention periods. Additional attention should also be paid to data privacy, feedback transparency and students' digital literacy during implementation stages.

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