Impact of Artificial Intelligence-assisted Learning Intensity on College Students' Self-directed Learning Ability

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Abstract. AI's rapid integration into education has boosted learning efficiency but raised concerns about its impact on college students' self-directed learning (SDL) abilities. This study uses qualitative literature analysis to explore the link between AI-assisted learning intensity and SDL, grounded in Zimmerman's self-regulated learning theory. It reviews academic sources to build theoretical coherence and ensure methodological rigor. Key findings reveal a "double-edged sword" effect: moderate AI use enhances SDL through personalized goal management, real-time feedback, and motivation reinforcement, improving time management, critical thinking, and self-efficacy. Conversely, overreliance on AI leads to cognitive outsourcing, diminished goal-setting capacity, and superficial reasoning. This study proposes a "boundary-adaptive pairing" model, advocating for adaptive AI intervention strategies tailored to learners' metacognitive levels and educational stages. Educators should balance technological empowerment with autonomy preservation, ensuring AI serves as a scaffold rather than a replacement. These insights provide a theoretical foundation for optimizing AI integration in higher education to foster sustainable, self-regulated learning outcomes.

1. Introduction

The education sector is undergoing profound changes with the rapid development of artificial intelligence (AI) technology. AI-assisted learning tools (e.g., intelligent tutoring systems, adaptive learning platforms, etc.) have significantly improved learning efficiency through personalized recommendations, instant feedback, and automated management.

However, this technology-driven education model has triggered a controversy: whether the ‘intensity’ of AI-assisted learning (frequency, depth, and dependency) will affect the self-directed learning (SDL) of university students, which is one of the core goals of higher education and emphasizes the importance of learners' initiative and independence. SDL is one of the core goals of higher education, which emphasizes learner initiative, independence, self-regulation (time management, goal setting), critical thinking, motivation, and self-efficacy.SDL is closely related to the core goals of higher education. Higher education aims to cultivate talents with independent thinking and self-management abilities, and SDL

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embodies such abilities. Zimmerman's self-regulated learning theory provides theoretical support for SDL, emphasizing that learning is a dynamic process of interaction among individuals, behaviors, and environments, and highlighting the learner's initiative and self-monitoring abilities. In higher education, the cultivation of SDL helps students independently cope with complex social environments after graduation and achieve lifelong learning. The performance of AI tools in optimizing learning effects in a short period includes: personalized recommendations that provide students with learning resources that match their learning progress and abilities, helping to efficiently master knowledge; instant feedback allows students to keep abreast of their learning and adjust their strategies; and automated management reduces the organization of learning and the time Automated management reduces the burden of organizing and scheduling learning. However, this short-term optimization has led to controversy over its long-term impact. This study aims to explore the dynamic interaction between AI-assisted learning intensity and college students' self-directed learning ability, specifying AI-assisted learning intensity as the independent variable and self-directed learning ability as the dependent variable. The study will analyze the non-linear relationship between AI-assisted learning intensity on the dimensions of self-regulation ability, critical thinking, learning motivation, and self-efficacy, providing a theoretical basis for the rational use of AI tools in higher education.

2. Literature Review

Artificial intelligence-assisted learning is a method that uses advanced AI technologies to dynamically tailor the learning experience to each student's unique needs, abilities, and pace. Its core lies in realizing the personalization, automation, and efficiency of the learning process through intelligent means, to improve the quality and effect of learning [1]. AI-assisted learning can intelligently recommend suitable learning resources and course content based on students' learning data and behavioral habits, and provide customized learning paths [2]. It can also serve as a virtual teaching assistant, offering 24-hour online tutoring, answering questions, and providing instant feedback to help students better understand and master knowledge [3]. These tools stimulate students' interest through personalized learning paths and rich resources, provide accurate suggestions and recommendations according to students' progress and needs, and enhance their independent learning ability. However, some students may rely excessively on AI-assisted learning tools, potentially degrading their independent learning ability. Conversely, other researchers argue that when used appropriately, these tools can enhance independent learning skills by providing necessary support and guidance to build students' confidence and competence [4]. Additionally, there may be data privacy and ethical issues related to student data during the use of AI-assisted learning tools [5].

The impact of AI-assisted learning on college students' self-directed learning ability is confirmed by many studies, yet how it affects this ability remains controversial [6]. Self-directed learning ability refers to students' ability to independently plan, monitor, and evaluate their learning, actively acquire knowledge and skills, and self-regulate their learning behaviors. It is a core competence in modern education. Intrinsic learning motivation, a key driver of self-directed learning, prompts students to learn actively. Self-efficacy, or students' confidence in completing learning tasks, also significantly affects self-directed learning ability.

Research indicates that AI-assisted education enhances university students' independent learning capabilities through several key mechanisms. Firstly, it offers intelligent and personalized support, creating an efficient and flexible learning environment. Secondly, AI

tools stimulate students' interest and intrinsic motivation by providing engaging and interactive experiences. Empirical studies have shown that these features lead to improved learning outcomes and increased self-directed learning skills among college students [7]. AI tools can provide personalized learning content based on student's interests and needs, helping them better understand and master knowledge, thus increasing their confidence and motivation. AI can also provide personalized learning paths and resource recommendations to help students make more efficient use of learning resources. Through intelligent algorithms, AI can dynamically adjust the difficulty and depth of learning content based on students' progress and feedback, enhancing learning efficiency. AI-assisted learning systems can track students' progress in real-time and provide instant feedback and learning suggestions. This mechanism helps students monitor their learning process, reflect on their methods, and make adjustments based on feedback, thus enhancing their metacognitive abilities.

AI tools can guide students through professional discussions by employing natural language processing (NLP) and machine learning algorithms. These techniques enable AI to understand and produce human-like responses that promote effective communication and critical thinking. For example, AI can prompt students to ask more probing questions, explore different solutions, and consider issues from multiple perspectives. Empirical studies have shown that such interactive AI tools can significantly improve student engagement and critical thinking skills. For example, a study by Chi et al. (2024) showed that an AI-driven discussion platform increased student engagement and depth of analysis in professional discussions by 30% compared to traditional methods. This suggests that AI tools can be a powerful complement to traditional learning environments. The interactive process not only enhances students' critical thinking skills but also promotes their creativity [8].

3. The effect of AI-assisted learning intensity on college students' self-regulation ability

3.1 Self-regulation ability

Self-Regulated Learning (SRL) enables students to actively manage their learning cognitively, motivationally, and behaviorally, thereby enhancing their learning abilities. Its four core dimensions are goal setting, strategy selection, process monitoring, and self-evaluation. Learners need to define their own learning goals, select appropriate learning strategies based on the goals, continuously monitor the implementation of the strategies during the learning process, and finally self-evaluate the learning outcomes to determine whether they have achieved the set goals.

Zimmerman's self-regulated learning (SRL) model comprises three interrelated stages: planning, implementation, and reflection. In the planning stage, learners set goals, plan schedules, and select strategies. AI assistance can offer personalized goal-setting suggestions and strategy recommendations based on learners' metacognitive levels and educational stages. During the implementation stage, learners execute their plans. AI provides real-time feedback and adjusts learning paths dynamically, helping students stay on track and enhancing their self-monitoring abilities. In the reflection stage, learners evaluate outcomes and strategies. AI analyzes learning data to highlight effective strategies and areas for improvement, aiding students in refining their approaches for future learning. This integration of AI assistance across SRL stages supports learners in developing robust self-regulation skills, crucial for effective learning.

3.2 Current research: the bidirectional role of AI-assisted learning and college students' self-regulation ability

Recent studies indicate that AI-assisted learning significantly impacts college students' self-regulation ability (SRL) in a dual-edged manner, closely related to educational scenarios, technology use intensity, and individual differences. AI's influence on SRL varies across different educational contexts. In language learning, AI serves as a mind tool, enhancing students' strategic employment via algorithms and systems, particularly benefiting higher education students at or above the intermediate level [9]. In online learning, AI applications support metacognitive, cognitive, and behavioral regulation in various SRL areas but are less effective in regulating motivation [10].

The intensity of technology use is also crucial. Moderate AI assistance offers students the necessary support without overwhelming their self-regulation abilities. However, over-reliance on AI may reduce self-regulation skills as students might depend excessively on AI-generated suggestions and feedback. Individual differences further complicate AI's impact on SRL. Students with high self-efficacy are more likely to benefit from AI-assisted learning, effectively using AI tools to enhance learning strategies and monitor progress. Conversely, those with low self-efficacy may struggle to engage with AI applications for self-regulation, potentially becoming more reliant on external factors [10]. Balancing AI-assisted learning is essential. Developing personalized AI intervention strategies based on students' metacognitive levels and educational stages can maximize AI's positive effects on SRL and minimize its drawbacks, ultimately fostering students' self-regulation abilities across various learning contexts.

3.2.1 Positive effect: technological empowerment and efficiency enhancement

AI-assisted learning has shown many positive effects in improving the self-regulation ability of college students. First, machine learning-based AI tools (e.g. DeepSeek-R1) dynamically generate personalized study plans by analyzing data such as students' records of wrong questions and knowledge mastery, helping students refine their goals and optimize time allocation. For example, when students leverage AI tools to develop revision plans, their learning efficiency increases, and their knowledge acquisition channels expand. AI systems assess students' learning data, such as their progress, strengths, and weaknesses, to produce customized review schedules. These tools can suggest specific topics or resources for targeted practice, enabling students to concentrate on areas requiring improvement. Some AI platforms employ machine learning algorithms to adjust the difficulty and content of review materials in real time, maintaining continuous engagement and ensuring optimal learning. This personalized method not only enhances the productivity of review sessions but also introduces students to a variety of learning resources, thereby expanding their knowledge base [11]. Such tools strengthen students' goal-setting and strategy selection abilities through adaptive recommendations, which is in line with the core requirements of the "planning stage" in Zimmerman's self-regulated learning model. In addition, AI helps students to establish objective self-perception through quantitative learning outcomes (e.g., mastery rate and task completion), which in turn enhances their confidence in learning.

3.2.2 Negative challenges: cognitive outsourcing and subjectivity crisis

However, AI-assisted learning has drawbacks. Over-reliance on AI can cause students to skip deep thinking and get answers directly, undermining their goal-setting and strategy reflection.

When AI readily offers solutions, students may reduce their goal-setting efforts and skip reflecting on their problem-solving strategies, as AI's immediate answers lessen the need for post-task strategy evaluation. Long-term reliance on "cognitive outsourcing" can lead to a loss of subjectivity, which is manifested in "technology-driven disempowerment" and "cognitive fragmentation"[12]. For example, some students' winter holiday homework is generated by AI, which leads to the degradation of scientific reasoning and argumentation, especially in mathematics and logic subjects.

3.3 Factors influencing the intensity of AI-Assisted learning on SRL

Intensity of AI Assistance (IAA) indicates how frequently, deeply, and widely students use AI tools in learning. "Depth" reflects the extent of AI's involvement in learning, such as providing in-depth analysis and feedback. "Range of scenarios" denotes the diversity of learning contexts where AI is applied, like classroom, online, and independent learning. These aspects jointly influence Self - Regulated Learning (SRL) in various ways. Firstly, the adaptability of personalized learning paths is one of the key influencing factors; AI generates dynamic learning plans based on the analysis of learning data, which can help students refine their goals and optimize their time management, but may also inhibit students' willingness to explore on their own due to the over-adaptation of solidified learning paths. However, in interdisciplinary learning, AI only recommends learning content based on students' majors, and students may neglect interdisciplinary knowledge exploration due to over-reliance on recommendations, limiting the expansion of knowledge horizons and the cultivation of innovative thinking.

Second, the timeliness and quality of immediate feedback have a significant impact on SRL. Real-time error correction by AI strengthens the ability of strategy adjustment in the execution phase, but mechanized feedback may ignore the complexity of the context, leading to shallow reflection. In the process of programming debugging, when students make grammatical errors or logical loopholes, AI can instantly locate the problem and provide modification suggestions to help students timely correct the logical faults in problem-solving, optimize programming strategies, and improve the correctness and operational efficiency of the code. However, for thesis writing, although AI can point out grammatical errors and structural irrationalities, for the depth of thesis arguments, innovativeness, and compatibility with the academic frontier dynamics, etc., due to the lack of in-depth academic thinking ability, the feedback is relatively superficial, so that the students' reflection stays on the surface.

Establishing clear boundaries in human-machine role allocation is essential. AI demonstrates superior performance in low-order tasks such as knowledge retrieval and computation, yet goal planning and innovation argumentation should remain under human control. If not properly managed, "cognitive dissonance" may arise. This manifests as diminished confidence in students' knowledge, diminished learning initiative, and difficulty reconciling their actions with their beliefs when AI-driven decisions clash with their understanding. In research projects, AI can quickly sift through massive amounts of literature and process complex data calculations, providing students with a foundation for their research. However, when determining the direction of research and constructing innovative theoretical frameworks, students will lack the training of independent scientific research thinking if they are handed over to AI, making it difficult for them to form unique academic viewpoints and innovative results, and hindering the improvement of academic literacy [12].

4. The effect of AI-assisted learning intensity on college students' critical thinking skills

4.1 Critical thinking ability

In higher education, critical thinking (CT) is a vital ability that enables students to make systematic judgments about information, opinions, or problems through rational analysis, logical reasoning, reflection, and evaluation. CT allows students to critically engage with complex academic material and diverse perspectives, moving beyond surface-level comprehension. When approaching scholarly texts and research projects, CT helps students identify and formulate relevant questions, promoting a deeper understanding of the subject matter. It enables the dissection of arguments in academic papers, allowing students to assess premise validity and evaluate the author's conclusions. Furthermore, CT aids in evaluating the credibility and relevance of research evidence, determining the robustness of data collection methods, sample representativeness, and finding generalizability. Ultimately, CT fosters innovative thinking in academia, inspiring students to develop novel problem-solving approaches, propose original research questions, and meaningfully contribute to scholarly discussions in their fields. In higher education, critical thinking is not only a core skill for academic research but also a key competency for students to cope with complex social issues and achieve knowledge innovation [13].

4.2 The "double-edged sword" effect of AI on critical thinking

Recent years have witnessed a growing body of domestic and international research on the impact of AI-enhanced learning on critical thinking ability, which has exposed a significant divergence of opinion. This divergence is primarily divided into two camps: the technology-enabling school and the risk-warning school.

The technology-enabling school highlights that AI can enhance critical thinking by personalizing learning, boosting engagement, and supporting higher-order cognitive activities through tools like adaptive platforms and intelligent tutoring systems. They argue that AI can merge cross-disciplinary resources, including literature, case bases, and multimodal data, equipping students to examine problems multi-dimensionally and stimulating deep thinking. This is achieved via advanced technologies such as big data analysis and knowledge graphs, which enable AI to process and connect vast amounts of information from various fields. For example, AI systems can use knowledge graphs to visually map complex relationships between concepts and subjects, enabling students to grasp intricate topics holistically. Moreover, AI can mine large datasets to uncover hidden patterns and insights beyond traditional methods, further bolstering students' critical and creative thinking abilities. In addition, AI's instant feedback function, such as logical loophole hints and argument structure analysis, can help students identify the limitations of their thinking and promote the improvement of metacognitive ability.

Conversely, the risk-warning school cautions that over-reliance on AI may undermine critical thinking. They point out that students may depend on AI for guidance rather than actively engaging with the material, reducing opportunities for self-regulated learning and deep analytical thinking. This negative impact is particularly evident in low-stakes tasks, where critical thinking is significantly less engaged. A joint study by Microsoft and Carnegie Mellon University (2025) found that the higher the confidence in AI, the more inclined users are to adopt its outputs directly, rather than proactively assessing logical soundness. Furthermore, generative AI tools, such as ChatGPT, generate content based on existing data

patterns, which may lead to the convergence of students' thinking paths. Students who rely on AI for a long time are more likely to fall into "template expression" in essay writing, weakening the generation of original ideas.

4.3 Contradictions of AI-Assisted learning

First of all, the diversity and adaptability of learning resources are important influencing factors, AI can recommend personalized learning resources (e.g. cross-disciplinary literature, controversial cases) through big data analysis, helping students to expand cognitive boundaries and stimulate multi-perspective thinking. The cultivation of problem awareness relies on diversified knowledge input, and AI can act as a "knowledge navigator" in this process. However, over-reliance on AI recommendation algorithms may lead to an "information cocoon", limiting students to a specific knowledge framework and inhibiting critical exploration.

Second, the feedback mechanism's depth and interactivity are vital for critical thinking skills development. AI tools provide instant feedback via various methods, like analyzing the logical structure of students' arguments to find breaks or weaknesses in the logic chain and evaluating evidence strength by checking source credibility and information relevance. This helps students identify reasoning gaps and improve. However, this mechanistic feedback has limitations, as AI may not fully grasp complex contexts such as cultural nuances or implicit assumptions, yielding feedback that may be overly simplistic and overlook important aspects relevant to the argument. If the AI only offers standardized advice, for example, grammatical error correction, students might neglect deeper logical discourse, resulting in superficial critical thinking.

Further, the human-computer division of labor in task design is also a key influence. Studies have shown that AI is efficient in low-order tasks such as information retrieval and data processing, but if it excessively replaces students' higher-order tasks (e.g., problem posing and innovative argumentation), it will weaken their critical thinking training opportunities.

Finally, the variability of individual cognitive styles cannot be ignored. Students with high autonomy are better at using AI tools as "thinking scaffolds" to maintain active criticism in resource integration and logical verification, while students with high dependence are prone to fall into a passive acceptance mode, leading to degradation of thinking [14].

5. The effect of artificial intelligence-assisted learning intensity on college students' self-efficacy

5.1 Definition of self-efficacy

Self-efficacy, a central concept in Bandura's social cognitive theory, reflects an individual's belief in their capacity to perform a specific task. The strength of this belief directly influences learning goal setting, effort investment, and frustration tolerance. This concept stems from four key sources: direct experience, such as prior task success; alternative experience, like observing others' achievements; social persuasion, including instructor feedback; and physiological states, such as effective emotion regulation.

In higher education, motivation and self-efficacy are key predictors of academic performance. Students with high self-efficacy tend to choose challenging tasks and adjust learning strategies to overcome difficulties, while those with low motivation are more likely

to procrastinate or adopt shallow learning patterns. Artificial Intelligence (AI) can not only help us understand and assess self-efficacy and its impact on academic performance but also intervene in these sources through technological means, thereby reshaping the psychological mechanisms of students' learning.

5.2 Bidirectional impact of AI on self-efficacy

The impact of AI-assisted learning on college students' self-efficacy presents a significant dynamic balance feature, and its direction of action is regulated by the intensity of technology use, task type, and individual differences.

In the field of education, AI is essential for goal setting and path visualization. Personalized learning plans, like consolidating wrong questions and prioritizing knowledge points via data analysis, are generated by it. It also aids students in breaking down complex tasks into manageable short-term goals, strengthening their learning direction sense. Recent research has emphasized AI's effectiveness in developing personalized, coherent learning paths that boost learning efficiency and engagement. For example, studies indicate that combining large language models with prompt engineering can greatly improve the adaptability, interactivity, and transparency of personalized learning path planning. Moreover, AI's educational big data analysis capability allows for more precise and effective learning path recommendations, catering to individual learners' diverse needs and characteristics. Shanghai Jiao Tong University's AI specifications stress that AI-assisted learning should support the "adaptive learning mode". Dynamically adjusting objective difficulty, enhances students' sense of control.

AI-assisted learning carries certain negative risks. Over-reliance on AI-guided learning paths can erode students' goal-setting initiative. Should AI fully take over students' learning steps, their self-efficacy would be confined to passive task execution, lessening their self-involvement-steered cognitive activities, and hindering the development of higher-order decision-making skills [12]. In addition, the high frequency of error correction by AI may cause students to form "instant correction dependency" and reduce their tolerance for uncertainty. For example, some students are overly concerned about the score ranking of AI feedback and neglect the process of knowledge internalization, resulting in anxiety when facing open-ended tasks [13].

5.3 Influence factors of artificial intelligence-assisted learning on college students' self-efficacy

Artificial intelligence-assisted learning tools, through their powerful data analysis capabilities, can tailor-made personalized learning plans and goals for students according to their learning progress, historical performance, and knowledge mastery. These goals are not only specific and clear but also challenging and achievable, in line with Vygotsky's "zone of nearest development" theory. For example, AI tools can break down complex subject knowledge into multiple modules, and dynamically adjust the difficulty and content of subsequent learning objectives according to students' mastery of each module. This kind of personalized learning goal setting can help students better understand and plan their learning paths, enhance their sense of direction and control in learning, and thus improve their sense of self-efficacy [15].

AI tools can monitor students' learning behaviors and learning outcomes in real-time and give timely feedback. This instant feedback mechanism has obvious advantages over traditional learning assessment methods. It not only helps students to quickly understand their

learning situation and identify and correct errors promptly, but also enhances their sense of control and participation in the learning process. For example, in language learning, AI tutors can correct students' grammar and pronunciation errors in real-time, allowing students to make continuous progress in communication. This timely feedback helps students establish a clear sense of progress and enhances their self-confidence and self-efficacy in learning [16].

AI-powered interactive learning environments and gamified learning designs can greatly increase students' participation in learning. Virtual labs and interactive simulations, like MIT's ThreeDWorld and the Beaconing Project, are instances of technology-enhanced tools that engage students in immersive learning. ThreeDWorld uses AI to adjust content based on user performance and feedback, while the Beaconing Project incorporates game elements such as quests and challenges to inspire and involve learners. Not only do these AI-enhanced tools make learning more attractive and effective, but they also provide hands-on experiences that are often hard to achieve in conventional classrooms, particularly in STEM subjects. This contextualized learning not only stimulates students' interest and curiosity but also enables them to better understand and apply their knowledge in practice. Furthermore, AI-driven gamified learning employs dopamine incentives to heighten students' engagement and motivation through breakthrough tasks and virtual achievement systems. However, overly entertaining designs may divert from the essence of learning, causing students to gradually lose their intrinsic interest in and desire to explore knowledge as they pursue extrinsic rewards, which can ultimately impact the sustainable development of their self-efficacy.

6 . Future directions and limitations of artificial intelligence-assisted learning intensity on college students' self-directed learning ability

6.1 Directions for future research

Future research could focus on the differential impact of AI-assisted learning on the ability to contribute to college students' self-directed learning in different cultural contexts. The role of AI tools may be significantly different in highly competitive educational environments in East Asia (e.g., China, South Korea) versus autonomy-oriented environments in Europe and the United States (e.g., Finland, the United States). For example, East Asian students may be more susceptible to short-term efficacy due to the "precise goal management" of AI tools but also face higher levels of "data anxiety", whereas European and American students may use AI tools inefficiently due to excessive autonomy. In addition, for different learning style groups (e.g., "AI advocates" and "technology skeptics"), differentiated intervention strategies should be designed, such as matching the openness of AI tools with cognitive style scales (e.g., the Kolb Learning Styles Model) to better meet diverse learning needs.

Long-term tracking studies are critical to understanding the far-reaching impact of AI-assisted learning. Establish a tracking database with a 5-10 year span to analyze the impact of AI-assisted learning on career development and lifelong learning ability, e.g., compare the degradation rate of critical thinking and the difference in autonomous decision-making ability between heavy AI users and light users. In addition, quantify the threshold of students' dependence on AI tools through behavioral economics experiments (e.g., "AI evacuation simulation"), identify addictive use characteristics, and provide a basis for developing interventions.

6.2 Limitations of current research

The current study has certain limitations. Firstly, cultural bias and sample homogeneity are prominent issues. Most empirical studies primarily use European and American university samples, which may introduce cultural bias and restrict the generalizability of the findings. This overreliance on Western data can lead to a skewed understanding of AI's impact on education, potentially ignoring the needs of non-Western students. The lack of data from regions like Africa and South Asia further limits the development of culturally responsive AI tools that could be more effective and inclusive for a global student population.

Secondly, there is a significant problem with technological tool homogenization. Most experiments use standardized AI products, such as ChatGPT, without adequately considering the impact of customized tools like discipline-specific AI. This overdependence on mainstream platforms may result in a one-size-fits-all approach in AI-assisted learning, potentially neglecting the unique requirements of various academic disciplines and limiting the exploration of more specialized and effective AI applications in education.

Finally, there is insufficient control of variables. When studying the impact of AI use intensity, it is often mixed with other factors like individual cognitive styles and teacher interventions, making it difficult to isolate the independent effects of AI and affecting the accuracy of the findings. These confounding variables can obscure the true influence of AI on learning outcomes, leading to potential misinterpretations of the data and hindering the development of targeted educational strategies that fully leverage AI's capabilities.

6.3 Suggestions

Cultivating students' metacognitive skills is the key to improving their independent learning ability. By mandating a self-assessment step in AI-assisted tasks, e.g., after using AI to generate an essay, students are required to write an "AI Logic Chain Critical Analysis Report", which strengthens the endogenous source of self-efficacy through reflection. In addition, experiments are designed to let students compare the differences between their independent and AI-assisted assignments, to further strengthen students' self-efficacy through difference analysis, and to encourage them to be more active and confident in the learning process.

In AI-assisted learning, teachers are critical and need training to critically assess AI-generated content's credibility, logical structure, data bias, and argument depth. They should attend workshops like "Critical Rewriting of AI-generated Essays" to boost AI literacy and learn to allocate tasks rationally between humans and machines. For example, AI can handle repetitive tasks such as homework correction, while teachers focus on emotional support and higher-order thinking guidance. To evaluate the credibility of AI content, teachers can compare it with authoritative sources, check for consistency and accuracy, assess the logic and evidence, and consider the context and purpose. They can also seek peer reviews or expert opinions when needed. Specific training methods include workshops and seminars on AI content assessment, case analysis of AI-generated content, practice sessions with AI tools followed by discussions and feedback, developing assessment rubrics and checklists, and collaborating with AI experts and experienced educators. These approaches help teachers effectively leverage AI tools while maintaining educational quality and integrity.

7 . Conclusion

This study investigates the impact of AI-assisted learning intensity on college students' self-directed learning ability (SDL) and uncovers a significant "double-edged sword" effect. The research demonstrates that AI-assisted learning can boost SDL through personalized learning paths and instant feedback, yet excessive reliance might diminish SDL by lowering intrinsic motivation and critical thinking. Moderate AI use enhances SDL via personalized goal management, such as dynamic study plans, and immediate feedback reinforcement, like visualizing knowledge mastery. This leads to better time management, deeper thinking, and higher self-efficacy. However, over-reliance on AI can cause negative effects like cognitive outsourcing, weakening goal-setting ability, thinking inertia leading to shallow arguments, and motivational alienation increasing data anxiety. Thus, AI-assisted learning's direction and intensity should be dynamically adapted to individual learners' characteristics.

This paper combines Bandura's Self-Efficacy Theory and Zimmerman's Self-Regulated Learning Theory with existing research questionnaire data, uncovering the non-linear correlation between AI-assisted learning intensity and SDL core competencies (time management, critical thinking, and self-efficacy). Consequently, this paper presents a "boundary-adaptive pairing" model. The model stresses that educators must adjust AI intervention strategies according to learning stages (e.g., from knowledge accumulation to innovation practice). For learners with low metacognition, AI can offer structured support to build basic learning abilities, while autonomous learners need some "room for error" to stimulate exploratory motivation and innovation. This study offers a robust theoretical foundation and actionable strategies for universities to develop differentiated intelligent education programs, promoting educational reform and enhancing education quality and talent development.

Future educational practices should balance technological integration with student autonomy cultivation to ensure long-term educational development. The "phased withdrawal" strategy is recommended. For example, in programming courses, the AI code error correction function can be enabled initially to help students quickly grasp basic syntax and logic. Later, automation support can be gradually turned off to guide students in strengthening their independent debugging ability, and to cultivate their independent problem-solving thinking and skills.

To achieve sustainable educational development, three-dimensional synergy is crucial. First, dynamically adjust AI intervention. Educators need to tailor AI tool selection and intervention intensity based on students' proficiency levels. For instance, struggling students may initially need more AI-driven guidance, which can be reduced as their skills improve. Second, strengthen ethical constraints. Implement ethical guidelines for AI use in education, such as ensuring data privacy, preventing algorithmic bias, and maintaining transparency in AI-driven assessments. This builds trust and fairness in AI-assisted learning environments. Third, focus on student ability cultivation. AI should complement and enhance human capabilities. By fostering critical thinking, creativity, and self-directed learning skills, educators can help students become adept at using AI tools while retaining essential human competencies.

This approach creates a sustainable education ecology where AI enhances rather than replaces human elements. It lays the foundation for nurturing innovative, competent talents and promotes educational advancement, adapting to future society's complex needs.

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