ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION: SUPPORTING SELF-DIRECTED LEARNING AND STUDENT AUTONOMY

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ABSTRACT

Integrating artificial intelligence (AI) into higher education can revolutionise traditional learning paradigms by enhancing self-directed learning and fostering student autonomy. This systematic research paper examines the role of AI in supporting these educational shifts, analysing its impact on student engagement, personalised learning experiences and academic performance. Through a comprehensive review of existing literature, this study explores various AI-driven tools and applications that enable students to take greater control of their learning processes. The promise of AI in fostering student autonomy is significant, with key focus areas that include adaptive learning systems, AI-powered feedback mechanisms, and intelligent tutoring systems, all of which contribute to a more personalised and autonomous learning environment. The findings underscore AI's transformative potential to reshape higher education, highlighting its ability to empower students through personalised learning pathways and cultivate essential 21st-century skills. This potential of AI to enhance students' performance should instil a sense of optimism about the future of education.

Keywords: Artificial intelligence, self-directed learning, higher education, student autonomy, adaptive learning technologies, student engagement.

INTRODUCTION

Artificial intelligence (AI) in higher education empowers students to take control of their educational journeys, fostering autonomy and self-directed learning (SDL) abilities by providing tailored guidance, insightful analysis and readily accessible information. Its significant role in education has led to its integration into the curriculum in various ways to support students' learning autonomy and the development of SDL skills. AI is critical in adaptive learning, intelligent tutoring systems and personalised learning (Lin et al., 2023; Vimbwandu et al., 2023). Van der Vorst and Jelicic (2019) note that AI in personalised learning reduces teachers' workloads by allowing them to focus on individual student needs without needing one-on-one instruction. AI allows students to navigate the curriculum independently, progressing at their own pace and

level. In other words, Van der Vorst and Jelicic (2019) suggest that AI systems are sophisticated because they can analyse student data to tailor educational content to individual learning styles, speeds and preferences. Consequently, students can focus on areas where they need to improve and explore topics of interest in more detail (Vimbwandu et al., 2023). Additionally, AI in personalised learning equips students with all the required input sources and output devices to communicate and operate optimally while taking advantage of the wirelessly connected technologies (Kashive et al., 2020; Lin et al., 2023).

Intelligent tutoring systems represent a key area of AI that allows instructional activities and strategies to be customised based on the students' characteristics and needs (Graesser et al., 2012; Vimbwandu et al., 2023). Kashive et al. (2020) support this view, stating that AI enables intelligent tutoring systems to deliver adaptive guidance and instruction, evaluate students, define and update student models, and classify or cluster students. These AI-powered tutoring systems provide personalised guidance and support for students outside the traditional classroom setting, offering feedback, explanations and additional resources to help students grasp complex concepts. However, Lin et al. (2023) point out that, despite their advantages, intelligent tutoring systems are less frequently used in specific courses, particularly experimental courses that emphasise problem-solving and decision-making.

The Role of AI in Complementing SDL

It is clear from the previous synopsis that adaptive learning platforms are an important field in AI. These platforms highlight the importance of individual differences in modelling the ideal online learning environment (Almohammadi et al., 2017). They recognise that students have different study preferences. Prithishkumar and Michael (2014) support this perspective, claiming that the VARK (Visual, Aural, Read/write, Kinaesthetic) learning style model identifies each student's preferred sensory modality during the learning process. To foster SDL, giving students access to adaptable learning platforms is important.

SDL empowers students to take control of their learning processes in various ways, such as fostering critical thinking, learner autonomy and lifelong learning skills. This approach promotes accountability and responsibility and enhances motivation and engagement (Morris, 2019). Ultimately, empowerment through SDL enables students to assume ownership of and take the initiative in their educational journey. SDL encompasses goal setting, resource discovery, strategy selection and autonomous development assessment (Vimbwandu et al., 2023). Onah et al. (2021) echo this sentiment, stating that with a strong focus on autonomy and self-motivation, SDL allows students to tailor their educational experiences to meet their personal and professional needs. Furthermore, SDL enables learners to think and perform adaptively (Morris, 2019). This approach equips students, specifically those in higher education, with the skills, perspectives and motivation they require to thrive personally and professionally in a constantly changing world.

When discussing SDL, it is essential to acknowledge the rich and diverse history of educational approaches that support SDL and student autonomy (Servant-Miklos & Noordegraaf-Eelens, 2019). These authors emphasise that this history reflects shifts in pedagogical philosophies over time. Notably, the history of the educational approaches that support SDL can be traced back to the 14th to 17th centuries during the Renaissance Humanist movement, when humanist educators emphasised the development of individual potential and the importance of a broad education. This period focused on self-reflection and critical thinking, promoting a more personalised approach to learning. In the late 20th century, inquiry-based and project-based learning emerged, followed by competency-based education and online and blended learning in the 21st century (Reed, 2002). Throughout this historical epoch, these educational approaches have shifted the focus from teacher-centred and standardised curricula to student-centred learning, emphasising the importance of autonomy, critical thinking and self-direction in the educational process.

Integration of AI into Higher Education to Support SDL

Several AI tools and systems have been developed to support SDL and enhance student autonomy by providing personalised learning experiences, resources and guidance. Intelligent tutoring systems, adaptive learning platforms, AI-powered educational apps and learning management systems with AI features have been instrumental in promoting SDL (Kim et al., 2014). These AI tools empower students to take charge

of their learning by offering personalised support and resources that enhance SDL and foster autonomy. By leveraging AI, students can engage in more meaningful and effective educational experiences, tailored to their unique needs and goals.

Integrating AI into higher education to support SDL and student autonomy aims to bridge gaps in traditional education methods by offering personalised, adaptive and data-driven learning experiences (Vimbwandu et al., 2023). By leveraging AI technologies effectively, institutions can empower students to become independent learners capable of navigating complex knowledge landscapes and adapting to lifelong learning challenges (Lin et al., 2023). This research direction thus contributes to a deeper understanding of how AI can transform educational practices to meet the evolving needs of learners in the digital age.

From the above brief review, it becomes evident that AI has the potential to significantly enhance higher education by supporting SDL and student autonomy. Its impact on educational practices, policy development and the quality of higher education can lead to more personalised, efficient and equitable learning experiences (Kashive et al., 2020). To fully realise these benefits, ethical concerns must be addressed, equitable access must be ensured, and appropriate support for educators must be provided (Graesser et al., 2012). By leveraging AI thoughtfully and strategically, higher education institutions can improve learning outcomes, foster lifelong learning and drive innovation in the educational landscape.

Studies on the role of AI in promoting SDL in higher education reveal a growing body of research that highlights both the potential benefits and the challenges of integrating AI technologies (Lin et al., 2023). However, there is limited research on the long-term effectiveness of AI tools in sustaining SDL and on issues of equity and inclusivity, ethical and privacy concerns, and their impact on students' overall academic performance and career success (Kerr et al., 2022). Continued research is essential to address these gaps.

Addressing the research gap regarding AI's impact on SDL and student autonomy in higher education is crucial for optimising the use of AI technologies. Such research helps ensure that AI tools are used effectively to enhance learning experiences, support student autonomy, and ultimately improve educational outcomes. By focusing on these specific effects, researchers can offer valuable insights that contribute to developing more effective educational practices and policies.

Challenges and Opportunities of Integrating AI in Higher Education Institutions

Implementing AI in education presents several challenges that need careful consideration to ensure that these technologies are used effectively and ethically (Zha et al., 2024). Key issues include ethical concerns, data privacy, the digital divide, and AI's potential to support and hinder student autonomy (Kashive et al., 2020). By addressing these challenges, educational institutions can better harness AI's potential to support SDL and create more equitable, effective, and student-centred educational environments.

In addition to the gaps and challenges posed by AI, it offers significant opportunities for creating more personalised and student-centred learning experiences, transforming how education is delivered and experienced (Kashive et al., 2020). By harnessing the power of AI, educational institutions can create more personalised, engaging and compelling learning experiences that meet each student's unique needs and goals, ultimately enhancing educational outcomes and fostering a more student-centred approach.

Further research at the intersection of AI, SDL, and student autonomy is essential to maximising the potential benefits of AI technologies while addressing the challenges and ensuring equitable and effective implementation. By exploring these areas, researchers can help create a more personalised, inclusive, and student-centred educational environment that leverages AI to support and enhance the learning experience.

Effectively utilising AI to support educational objectives is essential for maximising the benefits of technology, enhancing student outcomes, and creating a more equitable and engaging learning environment (Zha et al., 2024). By understanding how AI can be leveraged to address diverse needs, support SDL and improve teaching effectiveness, educators and policymakers can make informed decisions that contribute to the overall success of educational initiatives (Lin et al., 2023; Darwin et al., 2023).

The integration of AI into higher education, particularly in supporting SDL and student autonomy, can transform educational practices, influence policy development and enhance the overall quality of education

(Kashive et al., 2020; Zha et al., 2024). By personalising learning experiences, improving efficiency and driving innovation, AI can foster a more effective, equitable and engaging educational environment. However, addressing challenges such as data privacy, ethical considerations, and equitable access is essential to ensure that the benefits of AI are realised across all aspects of higher education (Kashive et al., 2020).

Understanding the role of AI in supporting SDL and student autonomy has the potential to revolutionise teaching and learning strategies in several impactful ways, including targeted instructional design, enhanced learner autonomy, improved feedback mechanisms, facilitation of collaborative learning and adaptive learning environments. Understanding how AI supports SDL and student autonomy equips educators with the tools and insights to develop more effective teaching and learning strategies. According to Lin et al. (2023), leveraging AI to personalise learning experiences inspires students, enhances feedback and adapts instruction to individual needs. This enables educators to create more engaging and effective educational environments that foster greater learner independence and success.

THEORETICAL FRAMEWORK

Two theories underpinned the study:

Zone of Proximal Development (ZPD)

This study employed the ZPD as an appropriate theoretical lens to explore how AI supports SDL and student autonomy in higher education. Within their ZPD, individuals can work with others to complete tasks, and this interpersonal experience can assist them in digesting and internalising concepts, helping them to create an intrapersonal experience (Saetra, 2022). This suggests that, within the ZPD, AI can serve as a dynamic scaffolding tool, offering learners just-in-time support to progress from their present comprehension level to greater levels of mastery. Ghimire et al. (2024) reinforce this idea by highlighting the significant role of Vygotsky's ZPD theory in supporting peer interaction and fostering student autonomy. This brief overview of this theoretical framework shows that it is crucial in educational settings as it helps identify the appropriate levels of challenge and support necessary for effective learning and skill development.

Self-determination Theory (SDT)

SDL is closely related to the autonomy aspect of SDT because it explains why autonomously motivated students thrive (Reeve, 2002). AI-powered educational tools can enhance autonomy by allowing students to choose learning activities, set learning goals and pace their studies (Mahendra et al., 2023). AI systems that offer personalised feedback and scaffolded support also contribute to students' sense of competence, helping them feel more confident in their ability to succeed.

RESEARCH METHODOLOGY

This study used six systematic literature review methodological steps proposed by Mengist et al. 2020. These steps included protocol, search, appraisal, synthesis, analysis and reports. Each step was analysed carefully to ensure the research process's transparency, transferability and replicability. Developed in 2009, it was designed to meet the requirement for a standardised and transparent approach to presenting the results of systematic reviews and meta-analyses in conventional research (Cotton et al., 2023). The rationale was to help minimise the biased nature of possible outcomes by conducting an extensive literature search. The PRISMA methodology, or Preferred Reporting Items for Systematic Reviews and Meta-Analyses, is widely used for comprehensive analyses, especially in academic research papers.

Selecting the most appropriate keywords for article searches is known as keyword identification. Keywords are crucial for improving the accuracy of search results. The search strategy and delivery underpinned this phase. In this regard, appropriate search strings and identities should be aligned with the following databases: Scopus, Science Direct, and Google Scholar, to generate relevant documentation. For this study,

five important keywords were selected for the search string and items: GenAI, higher education, self-directed learning, student autonomy, and student engagement. To diversify the keywords, synonyms, related terms and variations of the main keywords were explored in an online database, along with research keywords from previous studies and expert opinions (Zhai, 2022).

Therefore, the broad search strategy used was refined during the pilot stage. This was to identify strengths and weaknesses in the literature of documents from these databases. The final search was restrictive to only articles published between 2020 and 2024. All modules and programs were fully digitised and migrated to the online platform. The reason was that the ODeL institution under the spotlight moved online during the 2020- 2024 academic years. These articles met the following strict requirements: predefined keywords, papers published in scientific peer-reviewed journals, and papers written in English. The exclusion criteria focused on all articles with the following characteristics: papers published before 2020, not original /primary research, inaccessible, or reviewed papers or meta-data.

Data Collection and Analysis

The importance of systematic reviews is well-documented, as they can tackle questions that individual studies cannot answer and identify issues in primary research that need to be addressed in future studies. Moreover, they can develop or evaluate theories that explain the occurrence of phenomena. Synthesising the current state of knowledge in a field is valuable because it helps determine future research priorities. As a result, systematic reviews play a crucial role in generating diverse knowledge for various users, including patients, healthcare professionals, academics, and policymakers (Firat, 2023).

In the screening phase, we selected appropriate articles using inclusion and exclusion criteria to create a systematic literature review (SLR) (Chiu, 2022). The screening process involved several articles successfully obtained during the identification step. Initially, we only considered articles published within the last three years (2020–2024) to ensure that the information extracted was current. This time frame was chosen because it aligns with research maturity, as numerous relevant papers have collected trustworthy data during this period.

To ensure readability and comprehension, only articles published in English and those accessible through open access were chosen. This decision was made due to the substantial increase in publications related to the topics covered in the current research article ("Artificial intelligence in higher education: Supporting self-directed learning and student autonomy"). Moreover, to prioritise identifying past research findings over reviews, only articles containing relevant empirical data were included, while review articles were excluded.

Eligibility Criteria

The eligibility criteria that were applied when extracting the articles can be summarised as follows:

1. Articles published between the years 2020 and 2024.
2. Articles published only in English.
3. Articles with specific keywords include AI, higher education, self-directed learning, student autonomy and student engagement.
4. Articles with open access.
5. Articles containing pertinent empirical data.

Final Selection

Eighteen studies were selected for the research. These studies were included because they were relevant to the topic. However, several other studies from the Scopus database were not included based on the inclusion and exclusion criteria. This way, only the most suitable studies for addressing the research questions were chosen.

Data Analysis

Data generated were systematically analysed in line with the six phases Braun and Clarke (2006) developed for data analysis. These phases involve (1) familiarising with data by first transcribing and reading through, (2) generating initial codes, identifying preliminary codes, (3) searching for themes, (4) reviewing themes, and (5) defining and naming themes.

FINDINGS

Theme 1: AI-Driven Personalized Learning Fostering Self-directed Learning

In today's world, characterised by rapidly changing social conditions and technological advancement, SDL is recognised as a fundamental competency for adults and a significant 21st-century skill (Morris, 2019). This recognition has intensified with the growing awareness of the possible applications of generative AI (GenAI) technologies in various fields. The rising popularity of AI technologies has sparked both interest and concerns regarding their potential usage in learning and teaching, highlighting the importance of focusing on SDL, a crucial skill for navigating an evolving educational environment and fostering lifelong learning (Wang & Bonk, 2024).

AI-powered educational tools, such as adaptive learning platforms and intelligent tutoring systems, have been found to significantly support SDL by creating personalised learning pathways tailored to individual student needs. Katiyar et al. (2024) concur that AI-driven personalised learning systems leverage machine learning, natural language processing, knowledge representation and learning analytics to adapt instruction based on learner interactions and performance data dynamically. These systems can provide targeted content recommendations, intelligent tutoring, adaptive assessments and customised feedback to support and optimise learning for every student, thereby ensuring SDL. By tailoring education to individual needs, AI-powered personalisation can improve learning outcomes, enhance engagement and motivation, increase efficiency and promote educational equity by meeting the diverse needs of all learners (Katiyar et al., 2024).

Theme 2: Enhanced Student Engagement and Motivation

The study revealed that AI-enhanced learning environments increase student engagement and motivation by providing immediate, adaptive feedback and support. This is supported by Xu (2024), who argues that AI technologies offer individualised support, real-time feedback and adaptive learning pathways, enhancing student engagement, motivation and academic achievements. In addition, according to Kurni et al. (2023), AI technology can help enhance engagement by enabling personalised and flexible study schedules and providing immediate feedback. Personalised learning powered by AI involves tailoring educational content and experiences to cater to each student's unique needs, learning styles and preferences (Kamalov et al., 2023).

This approach enables students to learn independently, enhancing their engagement and learning outcomes. A study by Almasri (2024), which explored science teachers' and students' perceptions regarding the integration of AI, found multifaceted perspectives on integrating AI in science education among students and teachers. The effectiveness of AI tools in augmenting learning experiences garnered students' attention. In addition, students displayed increased engagement and improved subject understanding through AI-based interventions, indicating positive perceptions of AI's efficacy in enhancing learning outcomes (Ferrarelli & Iocchi, 2021; Ledesma & Garcia, 2017). AI tools can potentially improve student success and engagement, particularly among those from disadvantaged backgrounds (Almasri, 2024). This increased engagement is closely linked to higher levels of autonomy, as students are more likely to take responsibility for their learning when they feel supported and motivated by the technology.

Theme 3: Development of Critical Thinking and Problem-solving Skills

AI tools that facilitate SDL, such as virtual labs, simulation software and AI-driven research assistants, contribute to developing critical thinking and problem-solving skills. According to Jia and Tu (2024), the impact of AI on critical thinking has drawn attention from various fields. Early research showed that AI has the potential to facilitate SDL, critical thinking and problem-solving skills by providing new perspectives. Muthmainnah et al. (2022) further demonstrated that AI can enhance individual cognitive abilities, thus fostering SDL. These tools allow students to experiment, explore and reflect on their learning processes, promoting deeper cognitive engagement. The autonomy provided by these AI tools encourages students to approach problems independently, fostering a more self-reliant and reflective learning style.

The benefits of AI in developing critical thinking are highlighted by a series of studies, confirming the improved higher-order cognitive skills attributed to adopting 21st-century education (Darwin et al., 2023). The renewed interest in promoting problem-based learning methods enhanced by SDL has the potential to foster critical thinking and innovation as required by GenAI in education settings. Many studies purport that critical thinking abilities encapsulate a myriad of cognitive abilities and dispositions which demand truth-seeking and self-regulation in problem-solving situations (Dwyer, 2023). The knowledge accrued from using AI tools during learning and academic writing activities calls for analysing writing skills and pushes students to seek higher levels of scholarship. The demand for creative writing, coupled with student autonomy, cannot be over-emphasised as this increases SDL and problem-solving skills. Despite the excitement borne out of GenAI, there are deep-seated concerns that cannot be left unchallenged in the quest to promote specific vital skills. These include AI dialogue that inadvertently weakens users' cognitive abilities by promoting a culture of over-dependency and uncritical acceptance of generated content.

Theme 4: Challenges in Implementing AI for Self-directed Learning

While AI presents numerous benefits, the research also identifies significant challenges in its implementation. In a study by Namjoo et al. (2023), students reported positive effects of AI on engagement and learning outcomes, including enhanced knowledge retention and skill development. However, technical issues, content limitations and concerns about data privacy were highlighted as significant challenges. Support from AI in tutoring and guidance was deemed beneficial, while perceptions of AI in education ranged from optimism about future possibilities to concerns about ethical implications. AI tools can significantly enhance SDL by providing personalised and interactive learning experiences that cater to individual student needs. Yu (2024) argues that as a language processing tool, ChatGPT can answer user questions, complete user-specified tasks, and even continuously optimise task performance. However, while possessing powerful features, ChatGPT also has some shortcomings that need improvement, such as accuracy in answering questions, data pollution issues, ethical and safety concerns, and the risk of knowledge plagiarism. In promoting educational reforms, ChatGPT brings both opportunities and challenges for SDL. ChatGPT can also be used to enhance education, provided that its limitations are recognised.

Michel-Villarreal et al. (2023) observe that a growing body of literature has started documenting the potential challenges and opportunities ChatGPT poses. Among the critical issues that accompany the use of ChatGPT in education, accuracy, reliability and plagiarism are regularly cited (Kasneci et al., 2023; Lim et al., 2023). Issues related to accuracy and reliability include relying on biased data (i.e. the limited scope of data used to train ChatGPT), having limited up-to-date knowledge (i.e. training stopped in 2021) and generating incorrect/fake information (e.g. providing fictitious references) (Lim et al., 2023). It is also argued that the risk of overreliance on ChatGPT could negatively affect students' critical thinking and problem-solving skills (Kasneci et al., 2023). Regarding plagiarism, evidence suggests that essays generated by ChatGPT can bypass conventional plagiarism detectors (Lo, 2023). ChatGPT can also successfully pass graduate-level exams, potentially making some types of assessment obsolete (Lim et al., 2023). Key issues include the potential for over-reliance on AI, which can lead to reduced human interaction and critical engagement, and the risk of exacerbating existing educational inequalities due to varying access to AI technologies. GenAI tools cannot assess content validity and determine whether their output contains falsehoods or misinformation, making SDL a process that needs to be guided. Thus, their use requires human oversight (Lubowitz, 2023).

Theme 5: Student Perceptions of AI in Learning

The study found that students perceive AI as a positive addition to their learning experience, particularly valuing its flexibility, personalisation and immediate feedback. In higher education, GenAI is used to enhance students' learning experiences, responding to user prompts to create original content. Text-to-text AI generators such as ChatGPT can benefit non-native English-speaking students by helping them generate ideas and receive writing feedback (Atlas, 2023). Additionally, text-to-image AI generators such as DALL-E and Stable Diffusion are valuable for teaching technical and artistic concepts in arts and design (Dehouche & Dehouche, 2023).

GenAI tools are helpful for assisting research by generating ideas, consolidating information and summarising large amounts of text to assist researchers in analysing data and composing their writing (Berg, 2023; Chan & Zhou, 2023). This improves publishing efficiency (Kitamura, 2023; Van Dis et al., 2023). Another area where GenAI can be advantageous is in learning assessment (Crompton & Burke, 2023). Tools like the Intelligent Essay Assessor are used to evaluate students' written work and provide feedback on their performance (Landauer, 2003). Mizumoto and Eguchi (2023) investigated the reliability and accuracy of ChatGPT as an automated essay scoring tool, finding that ChatGPT reduced grading time, ensured consistency in scoring and was capable of providing immediate scores and feedback on students' writing skills thereby fostering SDL. A study by Akgun and Greenhow (2022) found that AI has the potential to assist teachers and students in various ways. These include delivering instruction in mixed-ability classrooms, providing students with comprehensive and prompt feedback on their written work, and allowing teachers more flexibility to support their students while they observe, discuss and gather information during collaborative knowledge-building processes (Hrastinski et al., 2019; Roll & Wylie, 2016). However, there is also a degree of apprehension about the potential loss of human interaction and the complexities of navigating AI-driven systems. Students emphasised the need for a balanced approach, where AI supplements rather than replaces traditional learning methods (Sundar, 2020; Williamson & Prybutok, 2024).

Theme 6: Recommendations for Future Research and Practice

Based on these findings, the research recommends a holistic approach to integrating AI in higher education, one that considers students' diverse needs and addresses the ethical, practical and pedagogical challenges identified. Chan and Hu (2023) suggest that educators can improve the integration of GenAI tools into the learning process by understanding students' readiness and apprehensions about their use. This will ensure that these technologies complement and enhance traditional teaching methods. Integrating GenAI into education can result in better learning outcomes because students are more likely to engage in deep learning when they see GenAI as a valuable and supportive tool. Students' perspectives can offer insights into their AI literacy, which is crucial for the responsible use of GenAI technologies.

Future research should explore the long-term effects of AI on student autonomy, investigate strategies to ensure equitable access to AI technologies, and develop frameworks for the ethical use of AI in educational settings. The current practice of introducing ChatGPT holds excellent potential for higher education, where student autonomy can be preserved. At the same time, different tools and technologies continue to effect positive change in how information is accessed and presented. Despite these positive developments, there is a need to rethink how GenAI innovation can be monitored and ethically aligned to enhance the quality of education and development. New strategies that leverage AI capabilities must be developed while remaining mindful of their limitations to cultivate robust critical thinking skills among students.

DISCUSSION

The findings emphasise the great potential of AI in supporting SDL and promoting student independence in higher education. Using SDT and Vygotsky's ZPD as the conceptual framework enabled a better understanding of how AI tools can create a learning environment that improves student motivation, engagement, critical thinking and problem-solving skills. While these tools can advance SDL, it is essential to address significant obstacles to maximise their potential fully.

According to SDT, which emphasises autonomy, competence and relatedness as critical factors in promoting intrinsic motivation, AI-powered personalised learning platforms can support self-regulated learning (Bandhu et al., 2024; Chiu, 2022). AI-based systems allow learners to control their learning speed and adjust content and feedback to suit their needs. In addition, it leverages data-driven algorithms and AI to dynamically adjust the content, delivery and pace of instruction based on learners' performance and engagement. (Gligorea et al., 2023). This approach aligns with students' natural desire for independence, a crucial aspect of SDT. It is important to remember that while AI can help foster independence, it should not replace the need for students to develop their learning strategies. When students perceive themselves as being in charge of their learning journeys, they are more likely to demonstrate self-regulated behaviours, such as setting goals, seeking learning resources and self-evaluating (Feldman-Maggor et al., 2024).

Moreover, AI tools function within the students' ZPD by offering timely, adaptable assistance that aligns with the learners' abilities beyond their current level (Kohnke, 2024). Vygotsky's ZPD underscores the significance of scaffolding in helping students bridge the gap between what they can do independently and what they achieve with guidance (Chaiklin, 2003). AI serves as an intelligent support system that provides cues, clarification and personalised feedback to promote SDL and cognitive development, while personalised (Owan et al., 2023; Seo et al., 2021) AI systems have the potential to encourage self-guided learning. However, there are concerns about students becoming excessively reliant on AI tools, which may impede their ability to overcome challenges independently. It is essential to recognise that AI should complement traditional approaches rather than replace them, ensuring that human educators continue to play a central role in guiding SDL. This balanced use of AI can foster student independence and connections while offering support and guidance.

The research findings show that learning environments encompassing AI support significantly increase student engagement and motivation, which are crucial aspects of SDT. AI tools offer immediate and adaptable feedback, helping students track their progress in real-time and making them feel more capable, thus fulfilling their need for competence (Almasri, 2024; Kamalov et al., 2023; Kurni et al., 2023; Xu, 2024). This sense of competence is essential for fostering internal motivation. The independence provided by AI tools also enhances student motivation, as learners can guide their learning paths, set personalised goals and achieve milestones at their own pace. Furthermore, the ability of AI tools to create personalised learning experiences that cater to individual learning styles promotes deeper engagement. This aligns with the notion of the ZPD, as learners consistently operate within their optimal learning zone, challenging the limits of their understanding without being overwhelmed by material that is too difficult or uninteresting by content that is too easy (Yang, 2016). The integration of AI with both SDT and ZPD suggests that these tools can establish highly engaging and motivating learning environments that encourage SDL.

AI-powered tools like virtual labs and simulations are vital for improving critical thinking and problem-solving skills (Jia & Tu, 2024; Muthmainnah et al., 2022). According to the ZPD framework, these tools enable students to experiment and reflect on their processes in a secure and structured environment, fostering independent learning and problem-solving (Masava et al., 2023). With the help of AI, students can tackle challenging tasks that they might otherwise find too difficult. Additionally, SDT suggests that promoting autonomy and competence leads to more engaged, self-motivated learners willing to take intellectual risks (Ryan & Deci, 2020). Therefore, AI-driven environments enable students to explore different perspectives and methods, thus promoting critical thinking. By combining immediate feedback and independence, students can refine their problem-solving approaches, becoming more thoughtful and self-reliant learners. However, some researchers have warned that there is a risk that AI tools may inadvertently impede students' critical thinking if they rely excessively on AI for answers instead of engaging deeply with the material themselves (Jia & Tu, 2024).

The advantages of AI in promoting SDL are clear, but there are also significant challenges in its implementation (Michel-Villarreal et al., 2023; Namjoo et al., 2023; Yu, 2024). From a ZPD perspective, AI may not provide the necessary support when faced with technical constraints or inaccuracies in content. These challenges can lead to frustration and disengagement, especially when learners encounter tasks beyond their current abilities without adequate support. Similarly, SDT indicates that if AI systems consistently fail to instil a sense of competence and autonomy in learners, their motivation could decrease. Concerns regarding the ethical implications of AI in education also align with the emphasis of SDT on connectedness. As students

increasingly rely on AI tools, there is a risk that reduced human interaction could undermine the social aspects of learning, which are crucial for a comprehensive educational experience (Hu et al., 2022; Selwyn, 2019). Additionally, concerns like data privacy, AI biases and the potential for academic misconduct raise significant issues about the responsible utilisation of AI in education (Chan, 2023a; Namjoo et al., 2023).

Students generally see AI as a positive addition to their learning experience, particularly regarding adaptability, customisation and immediate feedback (Atlas, 2023; Berg, 2023; Chan & Zhou, 2023; Dehouche & Dehouche, 2023; Kitamura, 2023; Van Dis et al., 2023). These views align with the emphasis of SDT on autonomy and competence. When students believe that AI tools improve their learning experience by enabling them to learn at their own pace and receive personalised feedback, they are more likely to engage deeply with the material. However, research also emphasises the importance of balance, as students have expressed concerns about the potential reduction in human interaction (Sundar, 2020; Williamson & Prybutok, 2024). From an SDT perspective, the feeling of connection plays a crucial role in learning (Orsini et al., 2015). While AI can provide valuable assistance, it cannot fully replicate the interpersonal connections that promote student growth and development (Williamson & Prybutok, 2024). Therefore, the integration of AI in higher education should be approached in a way that complements rather than replaces human interaction, ensuring that students continue to feel a sense of connection and support.

According to these findings, it is recommended that AI be incorporated into higher education in a manner that respects students' independence, abilities and connections. Teachers should strive to establish blended learning environments where AI tools complement traditional teaching methods rather than replace them. This approach would ensure that students receive personalised support from AI while still participating in meaningful interactions with educators and peers. Future research should investigate the long-term effects of AI on student independence and SDL while also focusing on establishing ethical guidelines for its use in educational settings. Additionally, addressing the challenges related to equitable access to AI technologies will be crucial to ensure that all students, regardless of their backgrounds, can benefit from these advancements.

CONCLUSION

AI has enormous potential for higher education, as it can significantly enhance SDL and foster student independence. AI-powered personalised learning platforms offer students tailored learning experiences, improving engagement, motivation and critical thinking skills. These platforms support SDL by providing immediate feedback, personalised learning paths and interactive tools that encourage independent problem-solving and deeper cognitive engagement. However, there are still challenges to the widespread adoption of AI in educational settings. Issues related to technical limitations, data privacy and ethical considerations, especially regarding AI-generated content, must be carefully addressed. It is crucial to balance leveraging AI's benefits while ensuring human oversight to maintain academic integrity, critical thinking, and equitable access to AI technologies.

The ZPD and SDT provide valuable perspectives on the role of AI in education. The ability of AI to support learning within the ZPD allows students to advance beyond their current skills. At the same time, the customisation and independence facilitated by AI technologies align with the SDT focus on competence, autonomy and connectedness as crucial motivators for learning. Future research is crucial for addressing the ethical, pedagogical and practical challenges posed by AI in education. It is essential to ensure fair access to AI tools, establish responsible usage guidelines and understand their long-term effects on student independence. This ongoing exploration is critical for realising the potential of AI to transform higher education while ensuring its integration supports and enhances traditional teaching and learning methods rather than replacing them.

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