

Review Article

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Author for correspondence:

Erick Fernando

✉ erick.fernando@umn.ac.id

✉ Faculty of Engineering & Informatics,
Information System Study Program,
Universitas Multimedia Nusantara,
Tangerang, Indonesia



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Exploring the Artificial Intelligence Era in Influencing Self-Paced Learning: Systematic and Bibliometric Review of Literature

Erick Fernando^{id}, Rosilah Hassan^{id}, Dina Fitria Murad^{id},
Zeyad Ghaleb Al-Mekhlafi^{id}

Abstract

Background/purpose. Education continues to evolve along with technological advances, and one of the biggest changes is the application of artificial intelligence (AI) in the learning process. The main problem in this study is the lack of in-depth understanding of the factors that influence the effectiveness of using AI in self-paced learning models. The purpose of this study is to identify key factors that influence the success of AI-based self-paced learning and contribute to the development of more adaptive technology-based education policies.

Materials/methods. This study uses a Systematic Literature Review (SLR) approach with the PRISMA method. SLR to collect and analyze related literature from various academic databases.

Results. The results of the study indicate that factors such as technology and infrastructure that support flexible learning, AI's ability to detect and overcome learning challenges, and personalization of learning that suits students' needs, play a significant role in increasing learning effectiveness.

Conclusion. Ai in self-paced learning the use of chatbots, language support, and assessment automation were also found to contribute significantly to creating a more focused and efficient learning experience.

1. Introduction

The implementation of AI in the educational environment has enabled a new approach that is more responsive to individual needs, both in formal and non-formal education contexts (Baltaci et al., 2024; Englmeier & Contreras, 2024). The use of AI has accelerated the evolution of traditional learning models towards intelligent digital systems that support lifelong learning processes (Yao et al., 2023; Zhao & Liu, 2024). AI has the ability to address important educational difficulties, improve innovative teaching and learning techniques, and ultimately accelerate progress towards the Sustainable Development Goal 4 (SDG 4) (Saharuddin et al., 2025). Various modern learning platforms now use AI not only to facilitate access but also to improve the quality of learning interactions (Brubacher et al., 2025; Sangeethapriya, 2024). In addition, this technology supports data-based decision-making in the management of educational institutions, from the policy level to implementation in the classroom (Aleven et al., 2022; Wu & He, 2023). AI also helps design simulation-based learning scenarios that allow students to experiment with difficult concepts visually and interactively (Chen et al., 2022; Englmeier & Contreras, 2024). On the teacher side, this technology helps in designing materials that are appropriate to the student's level, saving preparation time and enabling automatic learning differentiation (Aleven et al., 2022; Baltaci et al., 2024). As a result, AI has become a major catalyst in the development of more dynamic, future-oriented, and learner-centered learning systems (Brubacher et al., 2025; Yao et al., 2023).

One increasingly popular approach is self-paced learning, where students have the flexibility to learn at their own time, pace, and preferences. In this context, AI plays a vital role in creating a more adaptive, personalized, and effective learning experience (Ellikkal & Rajamohan, 2025; Turan & Tinmaz, 2025; Wu & He, 2023). Several studies have shown that the use of AI in education can increase learning motivation, facilitate content personalization (D. F. Murad et al., 2020), and accelerate the assessment and feedback process (Aleven et al., 2022; Chen et al., 2022; Zhao & Liu, 2024). The presence of features such as chatbots, content recommendation systems, and adaptive learning dashboards strengthens the personalization dimension in self-paced learning (Sangeethapriya, 2024; Wu & He, 2023; Yilmaz & Karaoglan Yilmaz, 2023). AI not only brings efficiency in managing materials, but also enhances a more humane and contextual learning experience (Sukumaran & Khair, 2024; Yao et al., 2023). On the other hand, students gain space for self-reflection and exploration because the AI system is able to recognize their learning patterns and adjust them in real-time (Brubacher et al., 2025; Hardaker & Glenn, 2025; Rufai et al., 2024). AI also facilitates access to materials in various formats and languages, allowing for greater inclusivity in learning (Baltaci et al., 2024; Chen et al., 2022). Thus, AI bridges students' need for flexibility and quality of learning that is on par with face-to-face models (Baltaci et al., 2024; Zhao & Liu, 2024).

The growing interest in this topic has led to a number of studies highlighting the potential and challenges of AI integration in self-paced learning. Many recent studies have shown that AI has a major role to play in supporting flexible learning with more effective personalization systems and automated evaluations that improve learning efficiency (Aleven et al., 2022; Chen et al., 2022; Ellikkal & Rajamohan, 2025). However, most existing studies still focus on the general application of AI in learning, without delving into the specific factors that influence the success of AI integration in the context of self-paced learning in sufficient detail (Wu & He, 2023; Zhao & Liu, 2024). A notable gap in this research is the lack of in-depth analysis on how AI can overcome obstacles that traditional learning methods may not detect. Factors such as material adaptation, automatic detection of learning difficulties, and context-based feedback have not been widely studied separately, even though they play an important role in enhancing the effectiveness of AI-based self-paced learning (Sangeethapriya, 2024; Turan & Tinmaz, 2025). In addition, another significant gap is the lack of studies on the social and psychological role in students' acceptance of AI. In addition, another significant gap is the lack of research on the social and psychological roles in students' acceptance of

AI even though it significantly affects their learning (Panjaitan et al., 2024). Many students may feel isolated in the self-paced learning process and experience anxiety related to the use of technology. This has the potential to affect their engagement in the learning process (Rufai et al., 2024; Yao et al., 2023). Further research is also needed to explore the relationship between individual learning styles and how AI can adapt teaching methods in real-time, to optimize a more inclusive and targeted self-paced learning experience (Brubacher et al., 2025; Zhao & Liu, 2024). Therefore, a more systematic mapping of the key factors that allow AI to contribute significantly to improving the effectiveness of this learning model is essential, especially in terms of personal adaptation, social-psychological challenges, and learning personalization.

With this background, this study aims to identify key factors that influence the success of AI-based self-paced learning and contribute to the development of more adaptive technology-based education policies. The main focus is on identifying technology and pedagogy aspects that determine the success of AI implementation in self-paced learning. The results of this study are expected to be a reference in developing technology-based education policies, compiling digital curricula, and designing learning systems that are more responsive to the needs of self-paced learning (Brubacher et al., 2025; Sukumaran & Khair, 2024). Thus, this study provides a strategic contribution in building an inclusive, sustainable, and future-oriented education ecosystem.

2. Literature Review

Artificial intelligence (AI) is the ability of computers to accomplish tasks normally performed by humans. AI has emerged as one of the most prominent technical advancements of the twenty-first century (Razali & Mahamod, 2025). The development of AI technology has revolutionized various aspects of life, including in the field of education (Agarwal et al., 2024; Păvăloaia & Necula, 2023). AI-learning-based approaches have been created within a universal computing framework for a wide range of services (Fernando et al., 2022, 2023), and they have made substantial progress towards becoming cutting-edge in a variety of technological domains (Razali & Mahamod, 2025). AI not only plays a role in the efficiency of administrative processes, but also becomes a key component in the transformation of learning that is more adaptive, personalized, and data-driven (Titan et al., 2019; Turan & Tinmaz, 2025; Wu & He, 2023). To improve the path and quality of talent training, AI is also actively utilized in educational informatization platforms to combine the benefits of educational models, reform traditional educational ideas, and implement scientific and systematic educational programs (Baratè et al., 2019) to adapt to modern and flexible learning such as online learning (D. Murad, 2025).

The development of AI has opened up new opportunities to support self-paced learning models, especially with the presence of adaptive learning technology and intelligent tutoring systems (Chen et al., 2022; Rufai et al., 2024; Turan & Tinmaz, 2025). In a study conducted by Turan & Tinmaz (2025), it is explained that AI-enhanced technologies have played an important role in personalizing learning and increasing student motivation by providing learning materials tailored to the pace of each individual. This study also highlights how AI-based approaches can improve the effectiveness of self-paced learning through the use of learning analytics, gamification, and data-driven adaptive evaluation systems.

In addition to personalization, another challenge in the context of self-paced learning is the ability of the system to adapt to different domains, an issue described in research on Open-Set Domain Adaptation. According to Hardaker & Glenn (2025), self-paced learning approaches to new domains help improve the generalization of AI models when faced with data or conditions that have never been trained before, which is crucial for creating flexible and scalable learning systems. This finding is reinforced in other studies examining the use of AI in computer-based training systems,

which have successfully improved users' ability to adopt new systems more quickly and efficiently (Bouri & Reponen, 2021; Ellikkal & Rajamohan, 2025; Naidoo & Sibanda, 2024; Wu & He, 2023).

Furthermore, other studies have shown that AI not only supports the technical aspects of learning but also helps improve teachers' experiences in managing students' self-paced learning. For example, the development of an AI-based dashboard that helps teachers monitor students' progress during self-regulated learning has had a positive impact on the effectiveness of academic tutoring (Baltaci et al., 2024; Sukumaran & Khair, 2024; Turan & Tinmaz, 2025; Yilmaz & Karaoglan Yilmaz, 2023). In a broader context, the development of AI research in education is also moving towards the use of advanced techniques such as domain adaptation, federated learning, and intelligent tutoring, which aim to create a more intelligent, adaptive, and human-centered self-learning ecosystem (Aleven et al., 2022; Englmeier & Contreras, 2024; Yao et al., 2023).

3. Methodology

This study uses the Systematic Literature Review (SLR) method by following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PRISMA was chosen because it provides clear stages for selecting and evaluating scientific articles, making the results more transparent and reliable (Haddaway et al., 2022; Page et al., 2021; Xiao & Watson, 2019). The research process using this method is carried out in four main stages, namely the identification stage, screening, feasibility assessment, and data analysis and synthesis.

In the first stage of identification, researchers collected various articles from relevant scientific databases, such as Scopus. The process of searching for this article was carried out using specific keywords, including "AI in education", "self-paced learning", and "personalized learning using AI", to ensure that the scope of the article was in accordance with the research objectives. The results of this initial search produced several scientific articles, which were then selected in the next stage. Next, the second stage is the screening stage, where the articles obtained are re-selected based on several criteria, such as the relevance of the topic to the application of AI in self-paced learning and the methodological quality of the article. At this stage, articles that are less relevant or do not meet the criteria are abandoned to maintain the quality of the study (Page et al., 2021; Xiao & Watson, 2019).

The third stage is the feasibility assessment stage, where researchers thoroughly read the articles that have passed the previous screening stage. Each article is assessed in terms of methodology, content relevance, and contribution to the research objectives. The purpose of this stage is to ensure that the articles analyzed are truly relevant and of high quality, so that the research findings have strong credibility (Haddaway et al., 2022; Xiao & Watson, 2019). The last stage is the data analysis and synthesis stage, which involves identifying the main patterns and factors found from the articles that have been assessed for their feasibility. The analysis was carried out using a thematic analysis approach, where data from various articles were arranged based on the main themes that emerged, such as technology, personalization of learning, and challenges in implementing AI in self-paced education. The research questions found in this study include:

1. Describe comprehensively the development, distribution, and direction of research in this field, namely: Distribution of article types, Number of Publications Per Year, Number of Countries Per Year, Number of Countries Per Year, Author collaboration network, Keyword Frequency from Article Titles
2. Find factors that influence AI-based self-learning. This results in a clearer understanding of the role of AI in self-learning. And it is expected to be an important reference in the development of technology-based education policies in the future.

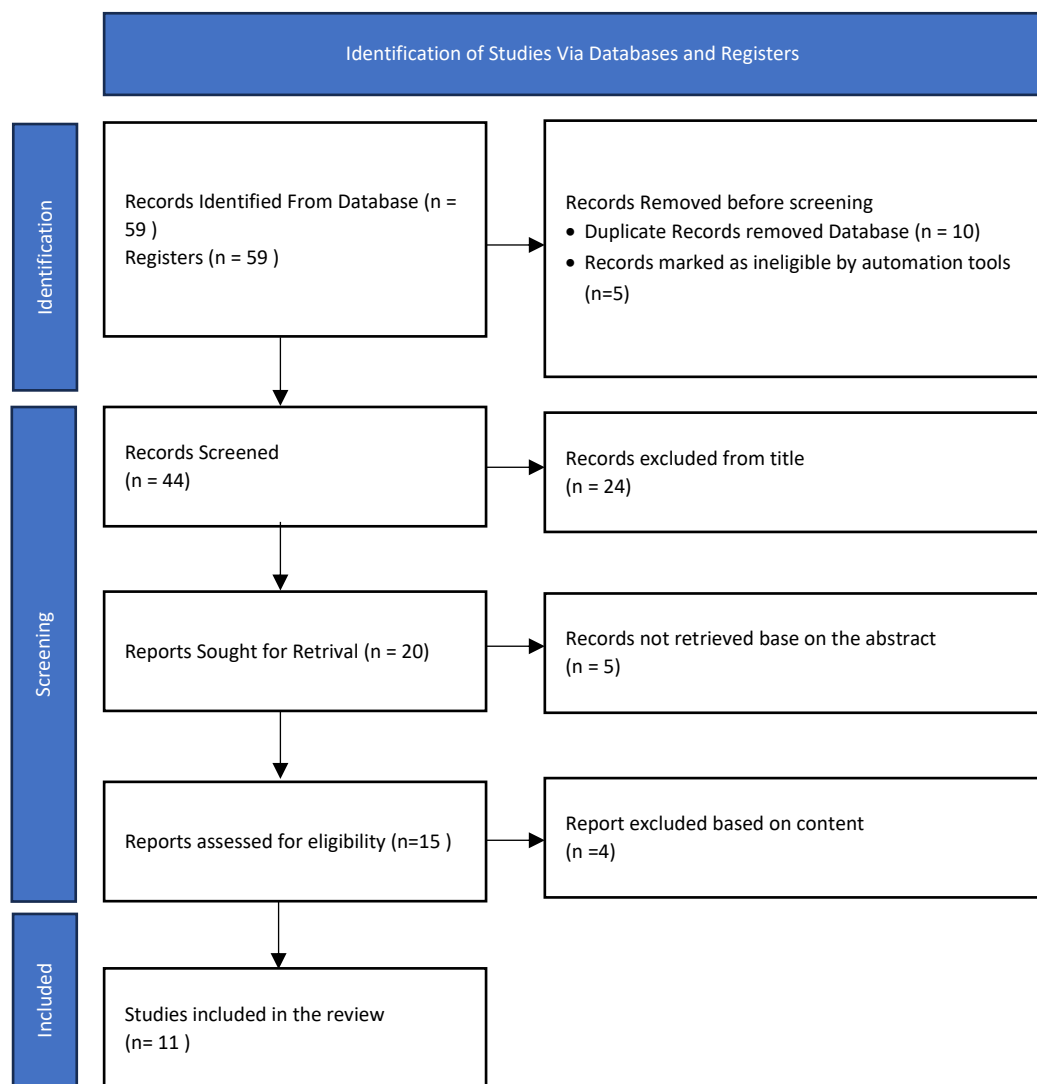


Figure 1. Prisma Steps in SLR (Not Yet Explained in the Text)

The diagram above is a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart describing the study selection and screening process in a systematic review. The process began with the identification of 59 records from databases and registries, which were then reduced by 15 records due to duplication and automatic ineligibility, leaving 44 studies to be examined. From the title-based selection process, 24 studies were eliminated, and 20 proceeded to the abstract search stage, where 5 studies were not retrieved. Fifteen reports were then assessed for eligibility, but 4 of them were excluded due to irrelevant content. Ultimately, a total of 11 studies met the criteria and were included in the systematic review. This process demonstrates a rigorous and transparent selection method to ensure that only relevant studies that meet the criteria are analyzed in the review.

4. Results

In this section, we present several important findings from the analysis of scientific publications discussing the role of artificial intelligence (AI) in supporting independent learning processes. This analysis covers the types of articles published, how the number of publications has evolved over the years, and the extent to which countries have engaged with this topic. We also analyze the keywords that appeared most frequently in article titles to uncover the researchers' main focus. Equally important, we describe key factors that show how AI can truly help create more self-directed and effective learning experiences. These findings are expected to provide a comprehensive picture of the development, distribution, and direction of research in this field.

4.1. Distribution of Article Types

The results of the analysis of article types on datasets relevant to the topic of Artificial Intelligence and Self-Paced Learning show that the majority of articles come from Conference Papers, with a total of 7 articles (63.6%), while the remaining 4 articles (36.4%) are Journal Articles, as shown in Figure 2. The dominance of these conference articles indicates that the discussion of the topic of AI in the context of self-paced learning is widely discussed in academic forums that allow direct interaction and in-depth discussions regarding the latest technology trends.

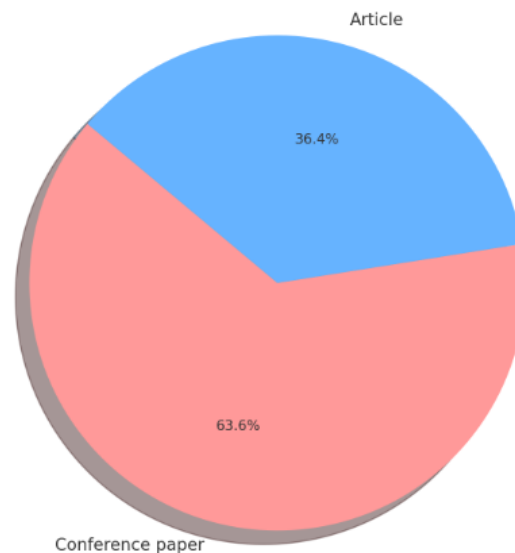


Figure 2. Distribution of Article Types

4.2. Number of Publications Per Year

Publications on AI in self-paced learning have increased significantly in recent years. Referring to Figure 3, there is a high concentration in the period 2020 to 2025, reflecting the growing interest in the integration of AI technologies in education, especially self-paced learning supported by adaptive technologies. Historically, research interest appeared relatively low in previous years, but has grown rapidly since the early 2020s. This trend indicates the increasing importance of AI as an essential enabling technology in modern education and the great potential for further research in developing more effective and personalized learning models.

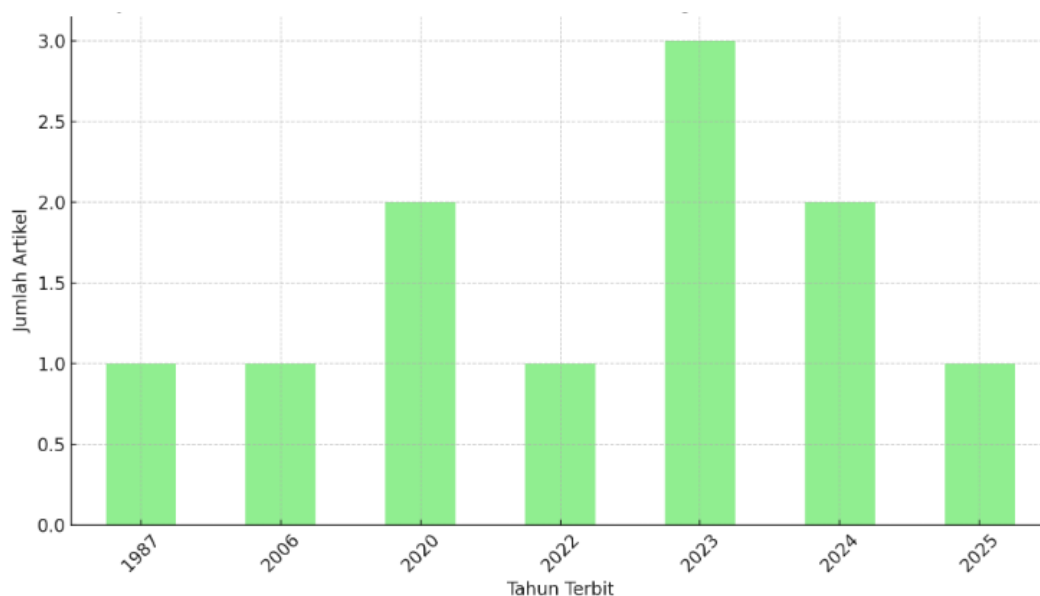


Figure 3. Number of Articles Related to AI and Self-Paced Learning by Year of Publication

4.3. Number of Country Per Year

The results of the analysis of country affiliations show in Figure 4, that the United States (USA) is the country with the largest contribution to research related to AI and Self-Paced Learning, with a total of four articles from various leading sources such as IEEE and ASEE. Germany is in second place with two articles, showing the active role of German institutions in the development of adaptive learning technology. Meanwhile, China, the United Kingdom (UK), Canada, India, and Italy each contributed one article, showing that research on this topic also has global appeal. The dominance of the United States and Germany reflects the strong research and innovation ecosystems in both countries in encouraging the integration of AI to strengthen self-paced learning models.

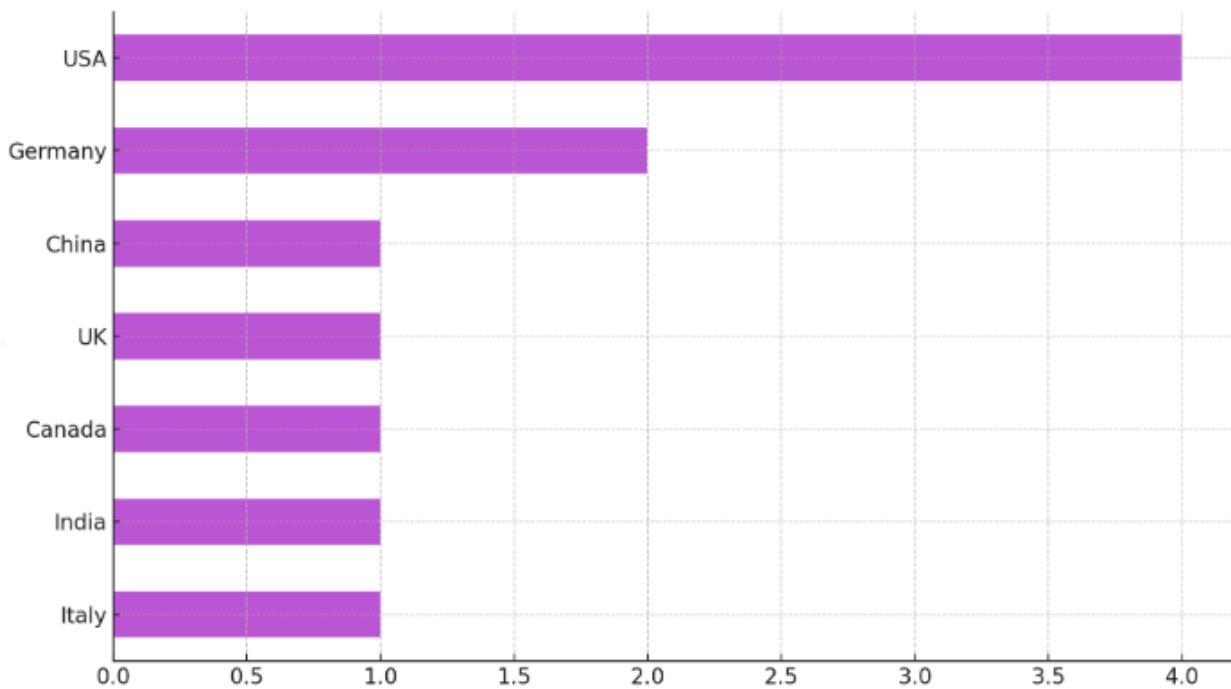


Figure 4. Number of Country Per Year

4.4. Number of Country Per Year

The results of the Text Network Analysis show in Figure 5. This mapping of keyword linkage network clusters shows how research on AI and self-paced learning forms a diverse but closely interconnected landscape. Overall, there are six main clusters, each representing a particular approach to the development of AI-based learning. The largest cluster revolves around digitally enabled collaborative learning, where concepts such as collaborative learning, gamification, and constructivism take center stage to create more dynamic and social learning experiences. On the other hand, there is a cluster that highlights the domains of learning adaptation and transfer, showing how AI is used to adapt learning in different contexts and data. One of the most important clusters relates directly to self-paced learning and intelligent tutoring systems, where AI serves as an intelligent companion to support self-paced learning and assisted programming, such as OpenAI Codex and Copilot. Additionally, clusters focused on personalized learning and formative assessment were also found, which prioritize individual learning experiences and adaptive tracking of student development. No less interesting is a small group discussing the use of advanced machine learning techniques, such as federated learning and adversarial learning, in the context of education, as well as a more specific group on problem-solving practices with the help of AI-based tutoring software. Overall, this map illustrates that research in this area focuses not only on how to make students learn more independently, but also on how AI can make the learning process safer, more collaborative, more personal, and better prepared to face the challenges of the ever-changing digital age.

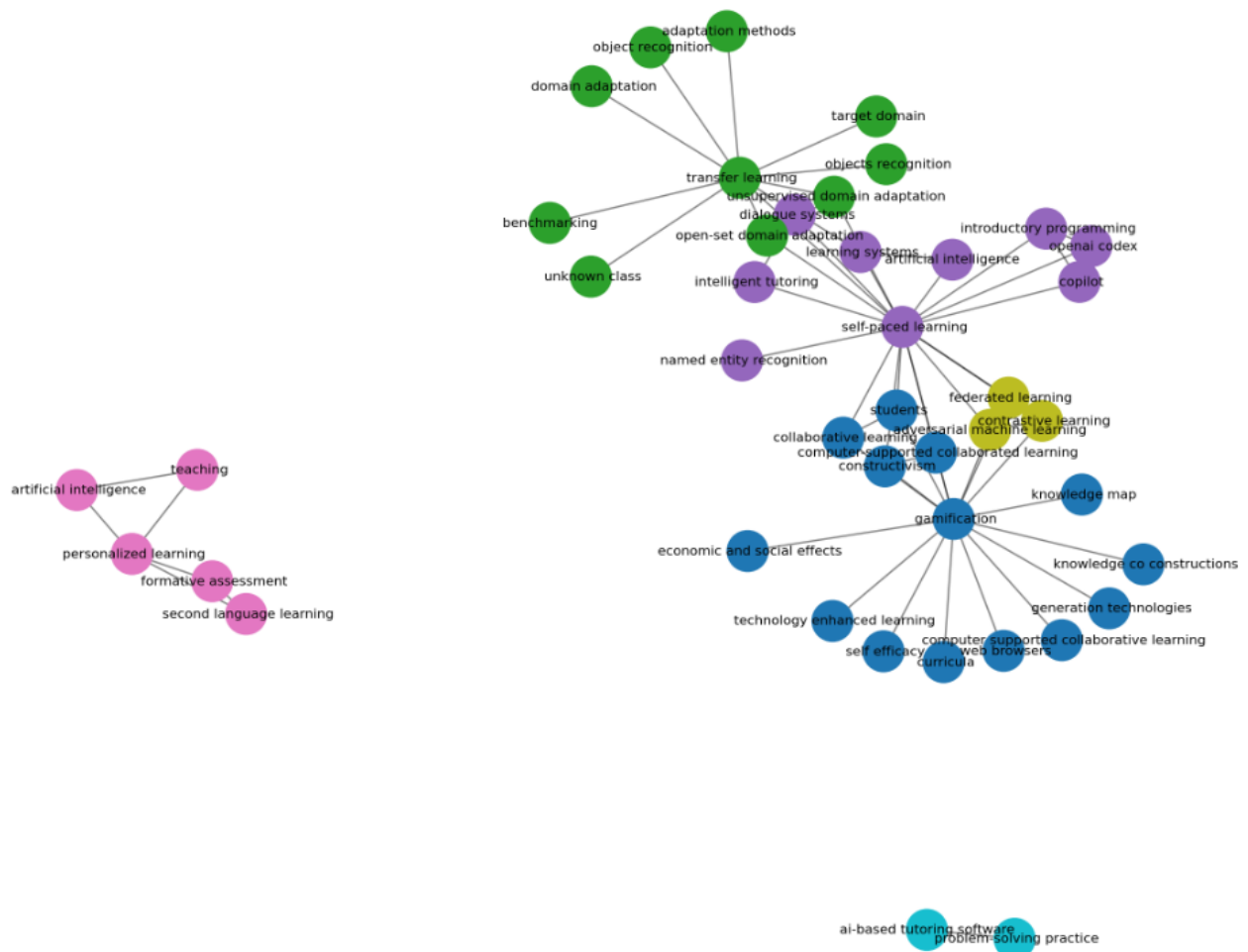


Figure 5. Text Network Analysis

4.5. Author Collaboration Network

The author collaboration network in research on AI that influences Self-Paced Learning shows a fairly organized collaboration structure, where each node represents an author and edges describe the collaborative relationships between authors in one article. From the visualization, it can be seen that most collaborations form small, solid groups, with several authors acting as collaboration centers (hubs) connecting many other colleagues, indicating their importance in research coordination. These authors build a tight network of connections, while some others appear more solitary with limited connections. The network pattern shows that research in this field is collaborative, combining various expertise such as artificial intelligence, educational technology, and instructional design to enrich self-paced learning innovation. This visualization also opens up opportunities to identify key actors in the network, analyze research clusters, and explore new areas for future cross-disciplinary collaboration.

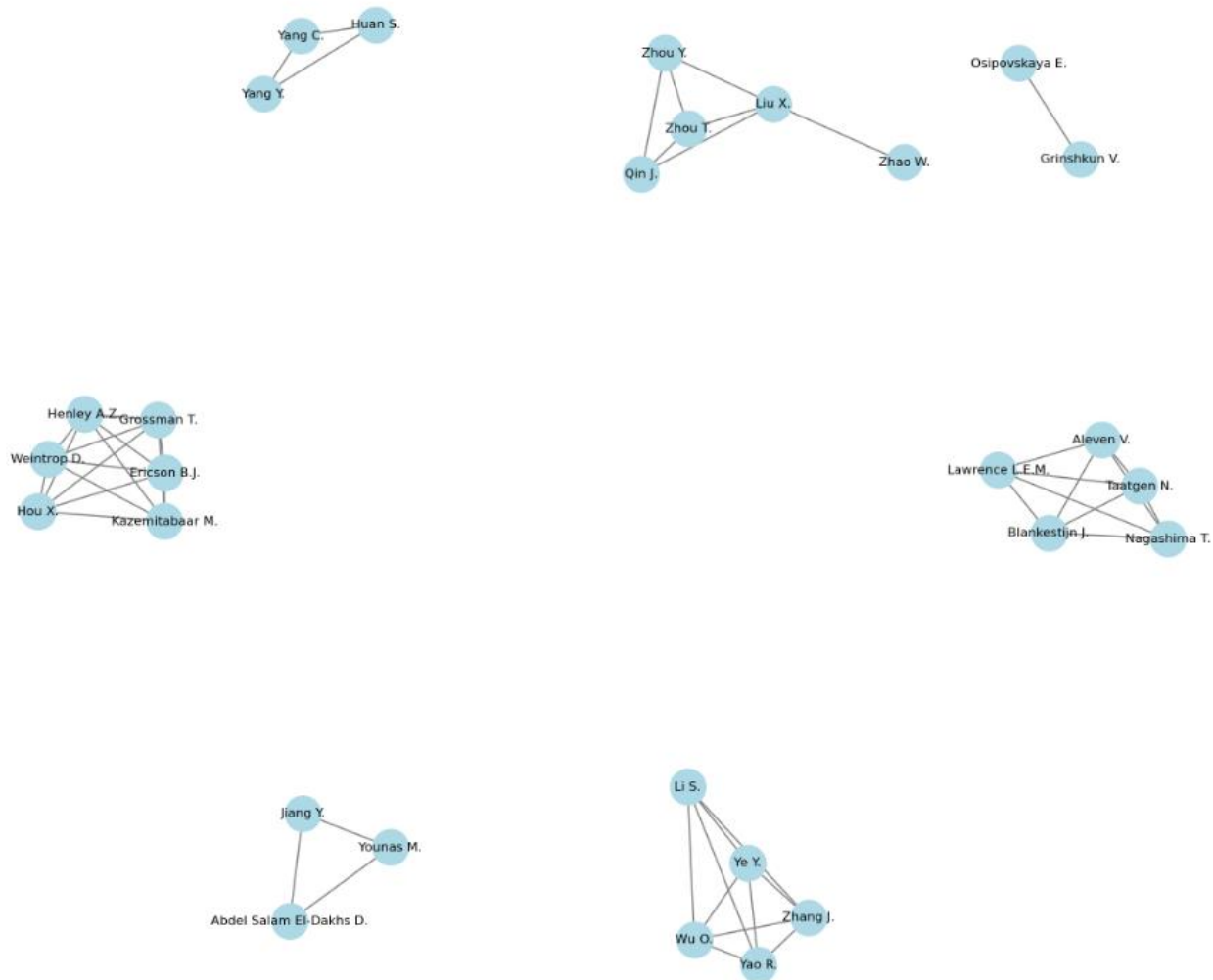


Figure 6. Author Collaboration Network

4.6. Keyword Frequency from Article Titles

The word cloud produced from the titles of articles related to Artificial Intelligence (AI) and Self-Paced Learning shows that the main focus of the research revolves around the themes of "learning", "self-paced", "AI", and "teaching", which appear dominant with larger letter sizes. This allows that the first thing that comes to mind for the authors when they start their research using the keywords AI and self-paced, including how the authors transform these thoughts into their writing and start with these 2 words. Words such as "education", "training", "systematic", and "adaptation" also appear with a fairly high frequency, showing great attention to how AI technology is integrated into a more flexible and independent learning approach. The presence of the terms "review", "self-directed", and "open-set" indicates a tendency to evaluate, adapt, and explore new methods in the context of AI-based education. This word cloud emphasizes that the core of the research is not only focused on the development of technology, but also on the paradigm shift of education that is more personal, adaptive, flexible, and oriented to the needs of learners, in line with the digital transformation that increasingly dominates the academic world and modern learning practices. Figure 7 shows the frequency of keywords from article titles.

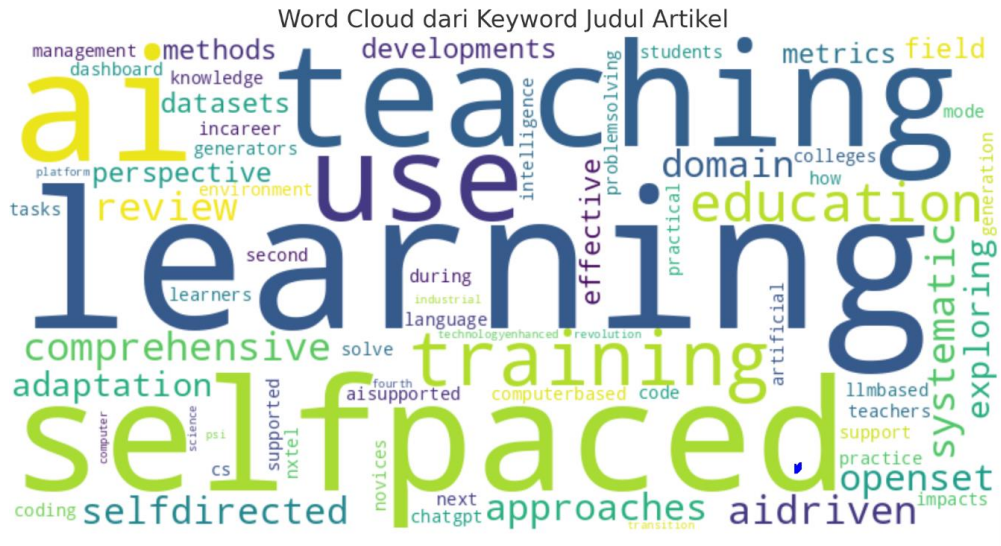


Figure 7. Keyword Frequency from Article Titles

4.7. Comprehensive AI Contribution Factors in Supporting Self-Paced Learning

There are several comprehensive AI contribution factors in supporting self-placed learning, as shown in Figure 8 below:

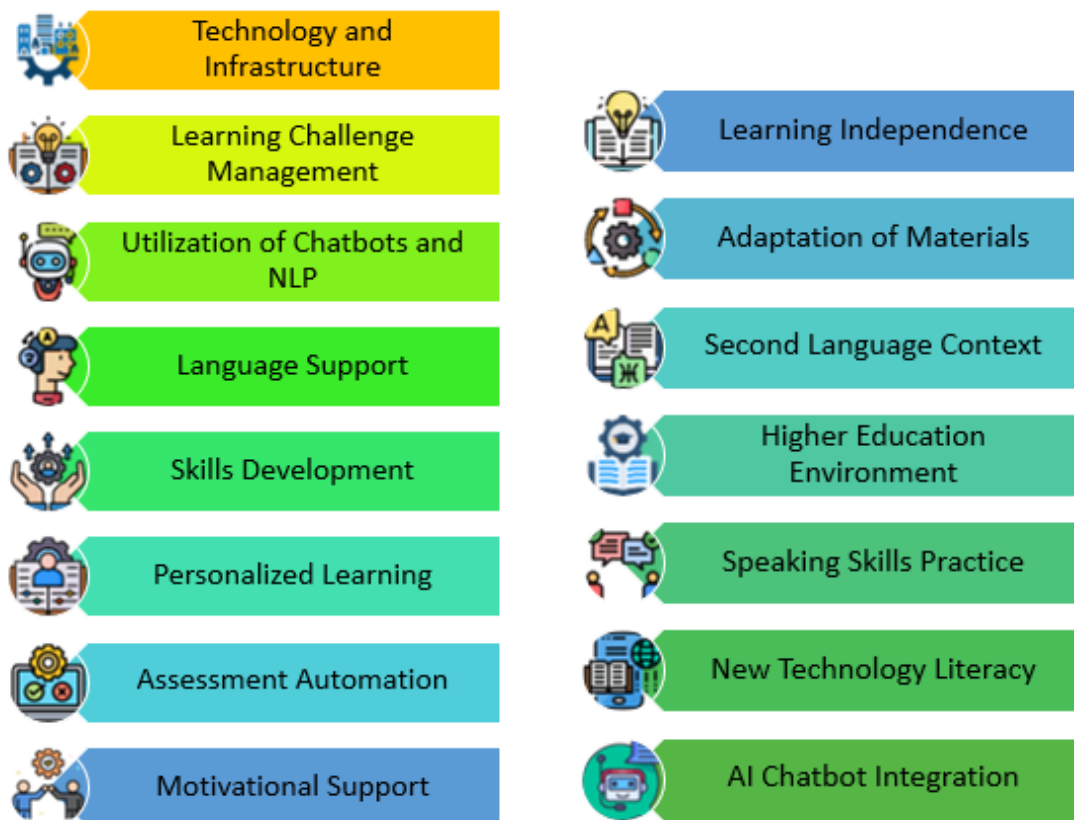


Figure 8. Comprehensive AI Contribution Factors in Supporting Self-Placed Learning

4.7.1 Technology and Infrastructure

Technology is the foundation of AI-based self-paced learning, which enables flexible and efficient delivery of materials (Ellikkal & Rajamohan, 2025; Turan & Tinmaz, 2025; Wu & He, 2023). Automating assessments with BERT (Wijanarko et al., 2023). Digital platforms such as NxTEL are

designed to support dynamic learning experiences, providing robust backend services (Wu & He, 2023; Yao et al., 2023; Zhao & Liu, 2024). This infrastructure also allows students to access materials anytime, anywhere, making learning more inclusive (Baltaci et al., 2024; Yao et al., 2023). Integrated cloud systems play a major role in storing student interaction data and providing real-time progress reports (Bouri & Reponen, 2021; Turan & Tinmaz, 2025; Wu & He, 2023). In addition, this platform makes it easier for institutions to manage distance learning. The existence of AI-based technology also minimizes dependence on manual processes in learning monitoring (Brubacher et al., 2025; Wu & He, 2023). When digital infrastructure is well prepared, students tend to have higher motivation to learn independently (Turan & Tinmaz, 2025; Wu & He, 2023; Yao et al., 2023). Adaptively built learning environments make learning experiences more personal and focused [the success of implementing AI in education begins with the readiness of its technology (Aleven et al., 2022; Baltaci et al., 2024; Turan & Tinmaz, 2025; Yao et al., 2023)].

4.7.2. Learning Challenge Management

AI allows learning systems to automatically detect obstacles experienced by students and provide adaptive solutions (Aleven et al., 2022; Wu & He, 2023). This system is able to recognize performance declines and suggest appropriate remedial materials or learning alternatives (Bouri & Reponen, 2021; Rufai et al., 2024; Zhao & Liu, 2024). This approach supports learning continuity without always having to wait for manual intervention from teachers (Turan & Tinmaz, 2025; Wu & He, 2023). With the help of AI, students receive relevant guidance according to the context of the difficulties they experience (Wu & He, 2023; Zhao & Liu, 2024). Some systems even utilize machine learning to anticipate challenges that may arise based on historical data. This makes the learning system feel more responsive and intelligent in assisting students (Rufai et al., 2024; Wu & He, 2023). With good challenge management, the possibility of students giving up when learning independently can be minimized.

4.7.3. Utilization of Chatbots and NLP

Natural Language Processing (NLP)-based chatbots such as ChatGPT have been widely used to support independent learning (Sangeethapriya, 2024; Wu & He, 2023). This technology provides an interactive learning experience that resembles a dialogue with a personal tutor (Aleven et al., 2022; Bouri & Reponen, 2021; Chen et al., 2022). Chatbots are able to answer questions, explain materials, and direct the learning process according to individual needs (Brubacher et al., 2025; Sangeethapriya, 2024). NLP also enables personalization of communication that helps students understand information in a more natural way (Baltaci et al., 2024; Wu & He, 2023). In addition, chatbots can provide relevant instant feedback, strengthening student engagement and understanding (Chen et al., 2022; Sangeethapriya, 2024). In the context of online education, chatbots minimize the sense of isolation that students often experience when learning independently (Brubacher et al., 2025; Wu & He, 2023). With interactions that take place naturally, students' emotional involvement increases.

4.7.4. Language Support

AI helps students develop second language skills through features such as speech recognition, text correction, and interactive exercises (Chen et al., 2022; Sangeethapriya, 2024). These systems identify pronunciation errors and suggest corrections in appropriate contexts (Aleven et al., 2022; Bouri & Reponen, 2021; Turan & Tinmaz, 2025; Wu & He, 2023). With this technology, students can learn languages independently without fear of being judged. In addition, AI enables inclusive multilingual learning that can be customized for different cultural backgrounds (Baltaci et al., 2024; Chen et al., 2022; Ellikkal & Rajamohan, 2025). Such learning platforms also help students build academic literacy in a foreign language (Sangeethapriya, 2024; Wu & He, 2023). AI provides exercises that can be repeated at any time, allowing for gradual and consistent improvement in competence (Sangeethapriya, 2024; Wu & He, 2023).

4.7.5. Skills Development

AI enables students to practice practical skills through simulation, pattern recognition, and automated feedback (Englmeier & Contreras, 2024; Wu & He, 2023). This technology is used in skills training such as programming, logical reasoning, and oral communication (Aleven et al., 2022; Turan & Tinmaz, 2025). AI-based exercises provide challenges that are tailored to the student's level of understanding and progress (Baltaci et al., 2024; Wu & He, 2023). This makes the learning process more adaptive and less boring (Bouri & Reponen, 2021; Brubacher et al., 2025). AI also encourages students to learn from mistakes without social pressure (Chen et al., 2022; Englmeier & Contreras, 2024). With a data-driven approach, skills development becomes more measurable and results-oriented (Wu & He, 2023; Zhao & Liu, 2024).

4.7.6. Personalized Learning

AI's ability to read learning patterns enables more personalized learning that is tailored to each student's needs (Aleven et al., 2022; Ellikkal & Rajamohan, 2025; Hardaker & Glenn, 2025; Turan & Tinmaz, 2025). This system adjusts the content, methods, and sequence of material delivery based on student performance data. This personalization makes students more motivated because they feel the material being studied is relevant and on target (Bouri & Reponen, 2021; Ellikkal & Rajamohan, 2025; Zhao & Liu, 2024). In addition, AI is able to adjust the pace of learning to the cognitive abilities of each individual (Wu & He, 2023; Yao et al., 2023). This provides space for students to focus on strengthening areas that are still weak without feeling left behind (Turan & Tinmaz, 2025; Zhao & Liu, 2024).

4.7.7. Assessment Automation

AI has made the assessment process easier by providing automatic and instant feedback to students (Rufai et al., 2024; Wu & He, 2023; Zhao & Liu, 2024). This technology analyzes students' answers, assesses the level of understanding, and offers recommendations for further material. With an automated evaluation system, teachers can focus more on pedagogical aspects and personal interventions (Baltaci et al., 2024; Wu & He, 2023). AI-based evaluation also minimizes bias and increases fairness in assessment (Bouri & Reponen, 2021; Chen et al., 2022). In addition, this system is able to store assessment history to monitor student progress in the long term. Automation also helps identify patterns of errors that students often make (Brubacher et al., 2025; Rufai et al., 2024). This allows for a more targeted and effective corrective approach.

4.7.8. Motivational Support

AI contributes greatly to maintaining students' enthusiasm for learning through features such as gamification and positive reinforcement (Baltaci et al., 2024; Sangeethapriya, 2024; Wu & He, 2023). The system designs adaptive challenges and digital rewards to increase student engagement. Providing timely positive feedback can strengthen students' self-confidence (Bouri & Reponen, 2021; Chen et al., 2022). In addition, the element of healthy competition in the AI system triggers enthusiasm for learning and provides a fun learning experience through an approach that is tailored to students' learning styles (Baltaci et al., 2024; Brubacher et al., 2025; Wu & He, 2023). This motivational support is essential in self-directed learning that requires high discipline.

4.7.9. Learning Independence

AI encourages the growth of learning independence by providing tools such as learning planners, progress trackers, and task notifications (Turan & Tinmaz, 2025; Wu & He, 2023). The system also teaches students how to set realistic learning goals and achieve them gradually (Aleven et al., 2022; Baltaci et al., 2024). With better self-monitoring, students become more aware of their strengths and weaknesses (Amedu & Ohene-Botwe, 2024; Bouri & Reponen, 2021; Rufai et al., 2024). The

technology also trains time management and responsibility skills (Amedu & Ohene-Botwe, 2024; Wu & He, 2023; Yao et al., 2023). AI helps transform students from mere recipients of material into active participants in the learning process (Chen et al., 2022; Englmeier & Contreras, 2024; Younas et al., 2025).

4.7.10. Adaptation of Materials

AI can adjust learning content based on students' ability levels and learning styles. This system is able to arrange the sequence of material delivery to suit students' cognitive development (Turan & Tinmaz, 2025; Yao et al., 2023). The material is delivered in a more interactive form, such as videos, simulations, or adaptive quizzes (Aleven et al., 2022; Bouri & Reponen, 2021). AI is also able to reduce boredom by updating the delivery method according to student preferences (Baltaci et al., 2024; Englmeier & Contreras, 2024). This approach helps maintain students' focus and interest in learning.

4.7.11. Second Language Context

In second language learning, AI provides pronunciation practice features and contextual sentence recognition (Chen et al., 2022; Wu & He, 2023). Students can practice speaking with a system that provides immediate feedback on pronunciation errors (Aleven et al., 2022; Sangeethapriya, 2024). This provides an opportunity to learn a language naturally and repeatedly without social pressure (Baltaci et al., 2024; Sangeethapriya, 2024). Voice and text-based systems support simultaneous mastery of listening and speaking skills (Englmeier & Contreras, 2024; Wu & He, 2023). This accelerates the process of students adapting to new language structures.

4.7.12. Higher Education Environment

AI has been widely integrated into higher education institutions, supporting flexibility and efficiency of learning (Wu & He, 2023; Zhao & Liu, 2024). Universities are starting to use AI in academic administration systems, progress tracking, and evaluation systems (Baltaci et al., 2024; Yao et al., 2023). This technology helps lecturers design teaching materials that suit the needs of heterogeneous classes (Brubacher et al., 2025; Turan & Tinmaz, 2025). On the other hand, students gain a more independent and directed learning experience (Aleven et al., 2022; Bouri & Reponen, 2021). This digital campus environment also supports lifelong learning.

4.7.13. Speaking Skills Practice

AI can help students practice speaking skills by recognizing voices and providing responses based on pronunciation quality. The system can compare students' intonation with standard pronunciation models. This allows students to gradually improve their accent and intonation (Aleven et al., 2022; Bouri & Reponen, 2021). With unlimited repetition, AI-based exercises build students' confidence (Englmeier & Contreras, 2024; Wu & He, 2023).

4.7.14. New Technology Literacy

AI serves as a medium to introduce future technologies such as IoT, blockchain, and machine learning (Yao et al., 2023; Yilmaz & Karaoglan Yilmaz, 2023; Zhao & Liu, 2024). Students not only use technology, but also understand it deeply (Aleven et al., 2022; Baltaci et al., 2024; Wu & He, 2023). Learning is done through interactive simulations and problem-based projects (Baltaci et al., 2024; Bouri & Reponen, 2021; Turan & Tinmaz, 2025). This builds critical thinking and students' readiness to face the challenges of digital technology (Englmeier & Contreras, 2024; Yao et al., 2023).

4.7.15. AI Chatbot Integration

Chatbots are currently widely employed in a variety of applications, particularly in systems that provide intelligence support to users. A chatbot is an artificial intelligence software or conversational system capable of mimicking human speech (Azlan et al., 2022). AI chatbots like ChatGPT are used as

digital tutors that are available at all times. They answer students' questions, guide learning, and provide direct feedback (Chen et al., 2022; Sangeethapriya, 2024; Sukumaran & Khair, 2024; Wu & He, 2023). Chatbots also play a role in maintaining learning motivation with a natural communicative approach (Aleven et al., 2022; Brubacher et al., 2025). The presence of chatbot provides the user with great flexibility and makes learning feel more social and interactive, even though it is done online.

5. Discussion

Artificial Intelligence technology has been shown to change the traditional learning paradigm by enabling more personalized, flexible, and adaptive self-paced learning. AI serves as a key driver in automatically providing relevant content, providing real-time feedback, and supporting students' skill development. This encourages students to be more independent in managing their learning process, adjusting the pace, and selecting materials according to their needs. Although AI shows much potential in supporting self-paced learning, existing research is still limited in mapping the factors that directly affect the effectiveness of its implementation. Factors such as material adaptation, automatic detection of learning difficulties, and context-based feedback are still under-explored in the literature, even though these factors have a significant impact on learning outcomes (Sangeethapriya, 2024; Sukumaran & Khair, 2024; Turan & Tinmaz, 2025). Therefore, a more systematic and in-depth mapping of these factors is needed to improve the quality of AI implementation in self-paced learning.

One area that is still rarely researched is the role of social and psychological factors in the acceptance and success of AI in self-paced learning. Students who feel isolated or experience technology anxiety may not fully engage in AI-supported self-paced learning (Rufai et al., 2024; Yao et al., 2023). Further research is needed to examine how AI can support more natural social interactions and reduce the anxiety that may arise from using new technologies. One of the most significant aspects of the application of AI in self-paced learning is its ability to adapt learning to individual preferences. AI is able to identify students' learning patterns and provide the most relevant materials according to their abilities and learning styles. This not only increases learning effectiveness but also supports student motivation, which is often a major challenge in self-paced learning (Sangeethapriya, 2024; Turan & Tinmaz, 2025; Wu & He, 2023).

The success of AI in self-paced learning is highly dependent on the readiness of the technology infrastructure. Although AI offers great potential, its implementation requires support from reliable digital infrastructure and the ability of institutions to manage this technology. Cloud-based platforms, data management, and robust backend systems are key to ensuring that adaptive and flexible learning can run smoothly (Naidoo & Sibanda, 2024; Yao et al., 2023; Zhao & Liu, 2024).

To optimize the potential of AI in self-paced learning, a technology-based education policy is needed that supports the development of adaptive digital learning systems. These policies must be responsive to the diverse needs of students, including individual needs in terms of accessibility, types of learning content, and seamless system integration between technology and pedagogy (Baltaci et al., 2024; Bouri & Reponen, 2021; Turan & Tinmaz, 2025).

One of the main contributions of this study is the importance of developing sustainable digital learning systems. Systems designed with students' needs and technological flexibility in mind will be a strong foundation for creating inclusive, sustainable, and future-oriented learning (Brubacher et al., 2025; Sukumaran & Khair, 2024). Holistic design can provide long-term benefits for various groups of students, not just those who are familiar with technology. The results of this study indicate that the integration of AI in education can influence the design of the curriculum and teaching methods used by educators. Curricula that are responsive to technological developments and student needs will enable more competency-based learning and more relevant outcomes. Thus, educational policies

and curriculum design need to consider the use of AI as a tool in creating more flexible and adaptive learning experiences.

6. Conclusion

This study has successfully identified and mapped the role of AI in supporting self-paced learning, which has been shown to increase the flexibility, personalization, and efficiency of self-paced learning. AI plays a crucial role in creating a more adaptive learning experience by adjusting content, providing real-time feedback, and automating evaluation. Technologies such as chatbots, content recommendation systems, and adaptive learning dashboards allow students to learn at their own pace, enhancing a more personalized and targeted learning experience. Factors such as content adaptation, automatic detection of learning difficulties, and context-based feedback have not been studied in depth, although they are very important in enhancing the effectiveness of this learning model. In addition, many social and psychological challenges have not been widely studied in the literature related to the acceptance of AI by students. Issues such as student engagement, technology anxiety, and student perceptions of the use of AI in self-paced learning need to be further considered, as these affect their learning outcomes. Therefore, to improve the effectiveness of AI implementation in self-paced learning, further research is needed to explore the social, psychological, and pedagogical factors that support the success of this learning model. Overall, this study emphasizes the importance of systematic mapping of key factors that influence the use of AI for self-directed learning. The results of this study are expected to be the basis for developing more inclusive technology-based education policies, as well as designing digital learning systems that are adaptive and responsive to student needs. This study provides a strategic contribution to building a sustainable, inclusive, and future-oriented education ecosystem.

Declarations

Author Contributions.

Erick Fernando: Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization, Data curation, Methodology. **Rosilah Hassan:** Writing – review & editing, Formal analysis, Data curation. **Dina Fitria Murad :** Writing – review & editing, Formal analysis, Data curation. **Zeyad Ghaleb Al-Mekhlafi :** Writing – review & editing, Formal analysis.

Conflicts of Interest.

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Data Availability Statement.

Data can access in Mendeley dataset in link <https://data.mendeley.com/datasets/h93fp9yws6/1>

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References

- Agarwal, P., Swami, S., & Malhotra, S. K. (2024). Artificial Intelligence Adoption in the Post COVID-19 New-Normal and Role of Smart Technologies in Transforming Business: a Review. *Journal of Science and Technology Policy Management*, 15(3), 506–529. <https://doi.org/10.1108/JSTPM-08-2021-0122>
- Aleven, V., Blankestijn, J., Lawrence, L., Nagashima, T., & Taatgen, N. (2022). A Dashboard to Support Teachers During Students' Self-paced AI-Supported Problem-Solving Practice. In *Lecture Notes in Computer Science* (pp. 16–30). https://doi.org/10.1007/978-3-031-16290-9_2

- Amedu, C., & Ohene-Botwe, B. (2024). Harnessing the benefits of ChatGPT for radiography education: A discussion paper. *Radiography*, 30(1), 209–216. <https://doi.org/10.1016/j.radi.2023.11.009>
- Azlan, N. A., Rusli, N. A. F., Mohamad, M., Mohamad Nassir, K., & Mohamed Sharif, N. (2022). A Preliminary Study: Chatbot Development As A Virtual Personal Assistant For Mobile Learning In Diagnostic Imaging Course. *Physics and Technology in Medicine; Vol 3 No 1 (2022): Physics and Technology in Medicine*, 3(1), 14–22. <https://myjms.mohe.gov.my/index.php/ptm/article/view/18050>
- Baltaci, K., Herrmann, M., & Turkmen, A. (2024). Integrating Artificial Intelligence into Electrical Engineering Education: A Paradigm Shift in Teaching and Learning. *2024 ASEE Annual Conference & Exposition Proceedings*. <https://doi.org/10.18260/1-2--47644>
- Baratè, A., Haus, G., Ludovico, L. A., Pagani, E., & Scarabottolo, N. (2019). 5G TECHNOLOGY FOR AUGMENTED AND VIRTUAL REALITY IN EDUCATION. *Journal of Theoretical and Applied Information Technology*, 102(13), 512–516. <https://doi.org/10.36315/2019v1end116>
- Bouri, I., & Reponen, S. (2021). Elements of AI: Busting AI Myths on a Global Scale. *Proceedings of the 21st Koli Calling International Conference on Computing Education Research*, 1–2. <https://doi.org/10.1145/3488042.3490513>
- Brubacher, S. P., Powell, M. B., Johnson, M. S., Cano, M. L., Hassan, S. Z., Riegler, M. A., Halvorsen, P., & Baugerud, G. A. (2025). Experts' Views on Artificial Intelligence-Based Child Chatbots to Train Investigative Interviewing Skills. *Applied Cognitive Psychology*, 39(2). <https://doi.org/10.1002/acp.70048>
- Chen, C., Koong, C., & Liao, C. (2022). Influences of Integrating Dynamic Assessment into a Speech Recognition. *Educational Technology & Society*, 25(1), 1–14. <https://www.jstor.org/stable/48647026>
- Ellikkal, A., & Rajamohan, S. (2025). AI-enabled personalized learning: empowering management students for improving engagement and academic performance. *Vilakshan - XIMB Journal of Management*, 22(1), 28–44. <https://doi.org/10.1108/XJM-02-2024-0023>
- Englmeier, K., & Contreras, P. (2024). How AI can Help Learners to Develop Conceptual Knowledge in Digital Learning Environments. *2024 IEEE 12th International Conference on Intelligent Systems (IS)*, 1–6. <https://doi.org/10.1109/IS61756.2024.10705253>
- Fernando, E., Hidayat, D., Pangaribuan, C. H., Gatc, J., & Stephanie, S. (2022). The Measurement Analysis of University Support, Online Learning Tools, and Technical Support on Online Learning Satisfaction during COVID-19 Pandemic. *Proceedings - 2022 9th International Conference on Information Technology, Computer and Electrical Engineering, ICITACEE 2022*, 107–110. <https://doi.org/10.1109/ICITACEE55701.2022.9924041>
- Fernando, E., Hidayat, D., Pangaribuan, C. H., & Winanti. (2023). The Influence of University Support and Online Learning Tools on Learning Outcomes to Increase Student Satisfaction with Online Learning. In *Smart Learning for A Sustainable Society. ICSLE 2023. Lecture Notes in Educational Technology* (pp. 98–107). Springer Singapore. https://doi.org/10.1007/978-981-99-5961-7_11
- Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020 : An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. *Campbell Systematic Reviews*, 18(2), 1–14. <https://doi.org/10.1002/cl2.1230>

- Hardaker, G., & Glenn, L. E. (2025). Artificial intelligence for personalized learning: a systematic literature review. *The International Journal of Information and Learning Technology*, 42(1), 1–14. <https://doi.org/10.1108/IJILT-07-2024-0160>
- Murad, D. (2025). Multicriteria Feature to Predict Final Score Using a Recommendation System. *Journal of Educators Online*, 22(1). <https://doi.org/10.9743/JEO.2025.22.1.20>
- Murad, D. F., Heryadi, Y., Isa, S. M., & Budiharto, W. (2020). Personalization of study material based on predicted final grades using multi-criteria user-collaborative filtering recommender system. *Education and Information Technologies*, 25(6), 5655–5668. <https://doi.org/10.1007/s10639-020-10238-9>
- Naidoo, P., & Sibanda, M. (2024). Integrating Artificial Intelligence in Electrical Engineering Education: A Framework for the Fourth Industrial Revolution. In *Proceedings of Atlantis Highlights in Social Sciences, Education and Humanities* (pp. 313–327). https://doi.org/10.2991/978-94-6463-630-7_17
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *The BMJ*, 372. <https://doi.org/10.1136/bmj.n71>
- Panjaitan, A. C., Saragih, D., Silitonga, L. C. M., Murad, D. F., & Pradipto, Y. D. (2024). Psychological Impact of Using the Sileb Information System As An Smart Learning Platform In Senior High School. *2024 9th International Conference on Business and Industrial Research (ICBIR)*, 0639–0644. <https://doi.org/10.1109/ICBIR61386.2024.10875882>
- Păvăloaia, V. D., & Necula, S. C. (2023). Artificial Intelligence as a Disruptive Technology—A Systematic Literature Review. *Electronics (Switzerland)*, 12(5). <https://doi.org/10.3390/electronics12051102>
- Razali, F. N., & Mahamod, Z. (2025). The Use of Artificial Intelligence (Ai) among Malay Language Students in Private Higher Education Institutions. *International Journal of Arts and Social Science*, 8(2), 1–16. <https://www.ijassjournal.com/2025/V8I2/41466639997.pdf>
- Rufai, A. A., Hossain Khan, M. S., & Hasan, M. (2024). An exploration of pedagogical approaches in teaching artificial intelligence courses: Experience from undergraduates students of Bangladesh. *Social Sciences & Humanities Open*, 10, 101075. <https://doi.org/10.1016/j.ssaho.2024.101075>
- Saharuddin, M. H., Nasir, M. K. M., & Mahmud, M. S. (2025). Exploring Teachers’ Technological Pedagogical Content Knowledge in Utilising Artificial Intelligence (AI) for Teaching. *International Journal of Learning, Teaching and Educational Research*, 24(1), 136–151. <https://doi.org/10.26803/ijlter.24.1.7>
- Sangeethapriya, S. (2024). AI based ChatGPT impacts on second language learners. *2024 10th International Conference on Communication and Signal Processing (ICCSP)*, 790–794. <https://doi.org/10.1109/ICCSP60870.2024.10543703>
- Sukumaran, S., & Khair, N. S. (2024). Exploring the Role of AI Platforms in Improving English-Speaking Skills in Malaysian Higher Education Institutions. In *Innovative Pedagogical Practices for Higher Education 4.0* (pp. 244–254). CRC Press. <https://doi.org/10.1201/9781003400691-15>

- Titan, T., Fernando, E., Murad, D. F., Warnars, H. L. H. S., & Oktriono, K. (2019). Development Conceptual Model and Validation Instrument for E-Learning Succes Model at Universities in Indonesia: Perspectives influence of Instructor's Activities and Motivation. *2019 International Congress on Applied Information Technology, AIT 2019*, 1–6. <https://doi.org/10.1109/AIT49014.2019.9144754>
- Turan, S. G., & Tinmaz, H. (2025). Generative Artificial Intelligence Applications. In H. Tinmaz & S. Gökçe Turan (Eds.), *Generative Artificial Intelligence Applications: Holistic Reflections From The Educational Landscape*. Peter Lang Verlag. <https://doi.org/10.3726/b22561>
- Wijanarko, B. D., Bachtiar, Hassan, R. B., Murad, D. F., Ihsan, R. B., Heryadi, Y., Kuncoro, E. A., & Julianti, E. (2023). AI-Based Feature Extraction and Cosine Similarity for Automation of Student Learning Assessment. *2023 24th International Arab Conference on Information Technology (ACIT)*, 1–6. <https://doi.org/10.1109/ACIT58888.2023.10453927>
- Wu, B., & He, S. (2023). Self-learning and explainable deep learning network toward the security of artificial intelligence of things. *The Journal of Supercomputing*, 79(4), 4436–4467. <https://doi.org/10.1007/s11227-022-04818-4>
- Xiao, Y., & Watson, M. (2019). Guidance on Conducting a Systematic Literature Review. *Journal of Planning Education and Research*, 39(1), 93–112. <https://doi.org/10.1177/0739456X17723971>
- Yao, R., Ye, Y., Zhang, J., Li, S., & Wu, O. (2023). Exploring developments of the AI field from the perspective of methods, datasets, and metrics. *Information Processing & Management*, 60(2), 103157. <https://doi.org/10.1016/j.ipm.2022.103157>
- Yilmaz, R., & Karaoglan Yilmaz, F. G. (2023). The effect of generative artificial intelligence (AI)-based tool use on students' computational thinking skills, programming self-efficacy and motivation. *Computers and Education: Artificial Intelligence*, 4, 100147. <https://doi.org/10.1016/j.caeai.2023.100147>
- Younas, M., Abdel Salam El-Dakhs, D., & Jiang, Y. (2025). A Comprehensive Systematic Review of AI-Driven Approaches to Self-Directed Learning. *IEEE Access*, 13, 38387–38403. <https://doi.org/10.1109/ACCESS.2025.3546319>
- Zhao, W., & Liu, X. (2024). NxTEL: Next Generation Technology-Enhanced Learning Platform for Computer Science Education. *2024 IEEE Integrated STEM Education Conference (ISEC)*, 1–8. <https://doi.org/10.1109/ISEC61299.2024.10664738>

About the Contributor(s)

Dr. Erick Fernando, Faculty of Engineering & Informatics, Information System Study Program, Universitas Multimedia Nusantara, Tangerang, Indonesia

Email: erick.fernando@umn.ac.id

ORCID: <https://orcid.org/0000-0003-2428-0484>

Prof. Dr. Rosilah Hassan, Centre for Cyber Security, Faculty of Information Sciency and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia.

Email: rosilah@ukm.edu.my

ORCID: <https://orcid.org/0000-0003-1348-5804>

Dr. Dina Fitria Murad, Information Systems Department, Binus Online, Bina Nusantara University, Jakarta, Indonesia

Email: dina.murad@binus.ac.id

ORCID: <https://orcid.org/0000-0001-8724-9105>

Dr. Zeyad Ghaleb Al-Mekhlafi, Department of Information and Computer Science, College of Computer Science and Engineering, University of Ha'il, Ha'il 81481, Saudi Arabia

Email: z.almekhlafi@uoh.edu.sa

ORCID: <https://orcid.org/0000-0001-6367-0309>

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