



Impact of AI-Powered Personalized Learning on Self-Regulated Learning, Academic Engagement, and Learning Autonomy among Secondary School Students

Rajesh Kumar Raju^a, Monika Kumari^{b*}

^{a&b}Department of Commerce and Management, Dr. C.V. Raman University, Vaishali, Bihar, India
E-mail: rajeshrajuson@gmail.com^a, monika23kumari@gmail.com^b

Abstract

There have been numerous ways in which Artificial Intelligence (AI) has revolutionized the educational process through its ability to deliver adaptive instruction, intelligent tutoring, feedback mechanisms, learning analytics, and learning through Generative AI. AI-driven personalized learning is able to provide personalized education for students, thus not only enhancing the academic achievements but also the processes involved in regulating and engaging in learning. Several studies have found that AI is able to facilitate self-regulated learning (SRL), depending on the technological design, instructional context, length of intervention and level of teacher and learner participation (Zhu & Sari, 2026; Xu et al., 2026). The current paper focuses on the possible effect of AI-driven personalized learning on three related learner outcomes including self-regulated learning, academic engagement, and learning autonomy among secondary school students. This research brings together international literature along with Indian literature such as Babbar, Raju and Kumari's studies regarding Generative AI and Learning Efficiency in the Indian educational setting. The structured research approach and quantitative method are introduced, and then illustrated with statistical findings. The literature indicates that personalisation through AI can be effective in terms of helping learners to monitor and regulate their activities; however, it will not help in case the dependence on technology becomes too high and there is no pedagogical scaffolding present. That is why the paper concludes in favour of human-centered approach and AI as a tool rather than substitution of teachers and cognitive processes.

Key Words: Artificial Intelligence, AI-Powered Personalized Learning, Self-Regulated Learning, Academic Engagement, Learning Autonomy, Secondary Education, Generative AI, Indian Education.

PAPER/ARTICLE INFO

RECEIVED ON: 22/05/2026

ACCEPTED ON: 30/06/2026

Reference to this paper should be made as follows:

Raju, Rajesh Kumar & Kumari, Monika (2026), "Impact of AI-Powered Personalized Learning on Self-Regulated Learning, Academic Engagement, and Learning Autonomy among Secondary School Students", *International Journal of Trade and Commerce-IJTC*, 15(1), pp: 228-240.

*Corresponding Author

DOI: 10.46333/ijtc/15/1/17

1. INTRODUCTION

AI has been emerging as an increasingly critical element of educational innovations due to the fact that it can be used for analyzing data related to learners, providing feedback, recommending learning resources, and personalizing instructional processes (Luckin et al., 2016; Holmes et al., 2022). The types of AI utilized in education comprise intelligent tutoring systems, adaptive learning systems, educational chatbots, predictive analytics, automated assessment, and systems of generative AI that can generate explanations, examples, questions, and other resources for learning (Zawacki-Richter et al., 2019; Zhu & Sari, 2026). The progress of such technologies has redirected the focus from traditional uniform instruction to personalized approaches to learning based on data analysis (Pane et al., 2015; Adhya & Panda, 2026).

Personalized learning becomes particularly pertinent due to the existence of individual differences in terms of the learner's previous knowledge, learning speed, motivation, cognitive skills, and style of learning (Luckin et al., 2016). The AI-based system can cater for such individual differences by processing data on learner's interactions and customizing teaching materials and feedback to the specific learner (Ma et al., 2014; Holmes et al., 2022). According to meta-analysis, intelligent tutoring systems may have beneficial effects on the learner's performance (Ma et al., 2014).

However, the relevance of personalization through the use of AI transcends beyond the issue of academic success. Modern educational scholarship is increasingly focusing on how learners are able to regulate their own learning, sustain active involvement, and make autonomous learning choices (Zimmerman, 2002; Fredricks et al., 2004; Little, 1991). Self-regulation of learning denotes the ability of learners to formulate goals, develop strategies, monitor the process, and assess learning results (Zimmerman, 2002). The concept of engagement in learning is viewed from three different perspectives: behavioural, affective, and cognitive (Fredricks et al., 2004). Learning autonomy implies the learner's ability to assume control over learning and the learning process (Little, 1991).

These factors are particularly relevant during the secondary school stage since this age is characterized by the increasing development of independence, metacognition, learning skills, and control over their own behavior (Zimmerman, 2002). Therefore, the personalization through AI might have not only an influence on what a student learns, but also on how he/she learns, as well as on whether the learner becomes able to regulate his/her own learning process (Adhya & Panda, 2026).

The Indian education system serves as a highly relevant backdrop to explore the aforementioned questions because generative AI technologies have quickly gained access to students and teachers. In their work, Babbar et al. (2025) studied The Impact of Generative AI (ChatGPT, Gemini, Copilot) on Learning Efficiency in the Indian Education System and made a valuable contribution to the body of research related to AI-assisted learning in the Indian context. The relevance of this work to the current study lies in the fact that it lays the groundwork for

exploring the issue of AI-assisted learning in the Indian context rather than solely in Western or higher education settings.

Nevertheless, learning efficiency is not the only factor that reflects the educational influence of AI technology. According to systematic reviews performed recently, the AI technology could help SRL through its use in providing adaptive feedback, using chatbots, intelligent tutoring systems, and learning analytics; however, certain limitations related to AI literacy, inaccuracies of results, monitoring behaviour, adaptability, and potential negative consequences are still there (Zhu & Sari, 2026). Also, recent meta-analysis conducted by Xu et al. (2026) has found out that the AI interventions had significantly positive effects on SRL with respect to the intervention length and subject domain (Xu et al., 2026).

In this context, this paper attempts to analyze the relationship between AI-supported personalized learning and three key educational results, namely self-regulated learning, engagement in studies, and learning autonomy of secondary school students. In particular, the study aims to build upon existing literature by exploring the phenomenon beyond learning performance or efficiency.

2. REVIEW OF LITERATURE

2.1. AI-Powered Personalized Learning

Personalized learning is the effort to adjust learning experiences based on individual learner attributes, as opposed to the delivery of the same type of instruction to all learners (Luckin et al., 2016). The use of AI adds weight to this concept by analyzing vast amounts of data about learners and using algorithms to detect patterns in their performance and suggest personalized learning paths (Holmes et al., 2022). This system can change the difficulty level, sequence, speed, and presentation of learning materials depending on the learner's performance (Ma et al., 2014).

Intelligent tutoring systems are among the most mature uses of AI in educational settings due to their ability to provide customized assistance and evaluation without using identical paths of instruction for all students (Ma et al., 2014). According to a meta-analysis conducted by Ma et al. (2014), the use of intelligent tutoring systems positively influenced student learning when compared to traditional teaching strategies. The concept of personalized learning has also shown promising results in terms of enhancing student performance through appropriate pacing and challenges in education (Pane et al., 2015).

Yet, personalization does not only refer to automation via technology. Indeed, personalized learning entails a combination of technological ability, teaching skills, and pedagogical knowledge (Holmes et al., 2022). In addition, studies on artificial intelligence in education have been said to neglect the involvement of teachers and pedagogy as they have focused solely on technological uses (Zawacki-Richter et al., 2019).

2.2. AI and Self-Regulated Learning

Self-regulation of learning is an essential notion which helps to understand the processes of management of students' learning activities. According to Zimmerman (2002), SRL is a cycle that

includes such stages as forethought, performance, self-monitoring, and self-reflection. SRLs set their goals, choose the right strategies, control their progress, and adjust their behavior based on their performance (Zimmerman, 2002).

In terms of support in these processes, AI could offer personalized feedback, performance dashboards, recommendations, reminders, scaffolding, and continuous assessment opportunities (Zhu & Sari, 2026). The systematic review of 25 empirical studies shows that various technologies based on artificial intelligence including chatbots, intelligent tutoring systems, adaptive learning systems, educational games, and AI-enabled e-books have been applied to support SRL phases (Zhu & Sari, 2026).

Moreover, educational chatbots have shown the ability to assist students in identifying learning resources, applying strategies, and monitoring the learning process (Guan et al., 2025). At the same time, the systematic review revealed fewer examples of supporting the processes of goal setting, planning, reflection, and adapting future learning strategies (Guan et al., 2025). It is important to note that even though some technologies are able to help students complete a certain task, they do not always develop skills of independent self-regulation.

New meta-analytical findings provide additional evidence for the potential of AI to increase SRL skills. The research by Xu et al. (2026), which involved the synthesis of 95 effect sizes from 28 empirical studies, demonstrated a significant enhancement of SRL skills after AI interventions. Nevertheless, it was shown that the duration of interventions and the subject of studies acted as moderators and, hence, the AI interventions were not universally efficient.

The problem of the performance-competence gap in which AI enables students to cope with learning activities but does not enable them to form self-regulating skills was pointed out by Xu et al. (2026).

2.3. AI and Academic Engagement

Engagement in academics is multidimensional and comprises behavior, emotions, and cognition in relation to engaging in academic tasks (Fredricks et al., 2004). Individualized learning can be used to enhance engagement in the sense that learners get to engage in activities that suit their current level of knowledge (Pane et al., 2015).

Another way through which AI can impact engagement is through the provision of immediate feedback to learners, which is important because learners get timely information regarding how well they have performed (Holmes et al., 2022). The provision of such feedback may also lead to reduction in unnecessary repetition of tasks and support during challenging moments (Ma et al., 2014).

However, engagement cannot solely be credited to the technology factor. Factors such as teacher influence, quality of instruction, peers, motivation, and classroom environment continue to be key influences on the engagement of the students (Fredricks et al., 2004). AI must thus be considered as one aspect of an educational ecology system.

2.4. AI and Learning Autonomy

Learning autonomy entails the ability of the learner to take responsibility for certain parts of the learning process and make informed decisions regarding the learning outcomes, methods, resources, and assessments (Little, 1991). Learners may be able to develop autonomy using personalized AI systems in that they would have more control over the learning process in terms of speed of learning, resource selection, practice, and feedback (Adhya & Panda, 2026).

The association between personalized learning and learning autonomy has been the subject of recent research. Adhya and Panda (2026), through their integrative systematic literature review of 112 papers indexed in Scopus, found four themes that link personalized technology-enhanced learning with SRL and autonomy of the learner.

Nevertheless, autonomy can be undermined in situations where students grow too dependent on AI recommendations. AI can conduct cognitive activities on behalf of the learner, thereby limiting learners' chances to develop their own judgment and problem-solving skills (Selwyn, 2019). Indeed, recent K-12 literature also suggests that personalized learning systems may transfer regulation to technology while not helping learners develop their own regulatory skills (Xu et al., 2026).

Therefore, the educational potential of AI is not only connected with its level of personalization but with the way personalization is used to foster learner autonomy.

2.5 AI-Powered Learning in the Indian Context

The education system of India offers an essential context in which one may examine the use of AI, since the country has been going through digitalization and implementation of various AI-assisted educational technologies. Existing literature shows that AI-assisted personalized learning helps to detect different learning needs, predict challenges of the process, provide recommendations and individual learning paths (Chen et al., 2020).

The study by Babbar et al. (2025) explores the effect of ChatGPT, Gemini, and Copilot on learning efficiency in the context of the Indian education system. This study is closely related to the current one as it addresses the role of AI in the Indian educational context and raises a broader issue of emerging AI's influence on students' learning process.

This paper represents a contribution to the line of research discussed above, insofar as it goes beyond the notion of learning efficiency in general terms and considers three particular aspects of learner development, namely, self-regulated learning, academic engagement, and learning autonomy. In that respect, the work of Babbar et al. (2025) represents a relevant context, while the current paper aims at exploring underlying psychological and behavioral mechanisms.

3. THEORETICAL FOUNDATION

The main theoretical underpinning of this study is the theory of self-regulated learning, with Zimmerman's cyclic model as an example. As Zimmerman (2002) claims, people learn to regulate their actions via the process of forethought, performance, and self-reflection. Artificial

intelligence-based personalized learning can facilitate all these stages as it can help learners set goals, assist in performance, and give feedback for reflection (Zhu & Sari, 2026).

The study will rely on the notion of learner autonomy, which stresses the learners' role in the decision-making regarding educational process (Little, 1991). The use of personalized artificial intelligence can provide learners with more chances to act autonomously if learners receive meaningful choices and critical assessment of recommendations made by AI.

Based on the combination of these theories, one can say that AI-based personalization should not just simplify learning but should also help learners become more able to plan, monitor, evaluate, and direct their learning process.

4. CONCEPTUAL FRAMEWORK

In this conceptual framework, it is assumed that the AI-Powered Personalized Learning (AIPL) will act as an independent variable, while self-regulated learning (SRL), academic engagement (AE), and learning autonomy (LA) will be considered as dependent variables.

Conceptual Relationship:

AI-Powered Personalized Learning → Self-Regulated Learning

AI-Powered Personalized Learning → Academic Engagement

AI-Powered Personalized Learning → Learning Autonomy

This conceptual framework rests on the assumption that adaptive content, personalized feedback, individualized learning paths, and AI-based learning suggestions have the potential to enhance learners' skills to regulate, engage, and learn autonomously (Holmes et al., 2022; Zhu & Sari, 2026).

5. RESEARCH GAP

There are several gaps that have been identified from this review.

First, despite the fact that there is extensive literature on AI and personalized learning, a large amount of the research has not examined issues associated with the development of learners' self-regulation competencies (Ma et al., 2014; Zawacki-Richter et al., 2019).

Second, research regarding AI and SRL has emerged quite quickly in recent years. According to the systematic review carried out by Zhu and Sari (2026), a total of 25 empirical articles have been analyzed, and it has been found that there is potential for the use of AI in support of SRL as well as concerns related to AI literacy, accuracy, tracking, adaptability, and harmful impacts.

Third, there has been recent research indicating that the impact of AI on SRL is dependent on the duration of intervention and its field (Xu et al., 2026). Thus, the effect of AI personalization on learners' outcomes cannot be taken for granted.

Fourth, there has been research which examines individual outcome measures separately. However, there is still a need for empirical integration models focusing on SRL, academic engagement, and learning autonomy.

Fifth, the representation of secondary school learners in the literature compared to university learners has been inadequate. This is important since, at this level, learners are yet to develop regulatory skills that might either be enhanced by AI technologies or replaced by them. Current studies in K-12 environments have noted the tendency of technology to outsource regulation to the system rather than enhance the skills of learners (Xu et al., 2026).

Sixth, in the Indian context, Babbar et al. (2025) have provided relevant evidence on the efficiency and performance of generative AI, but further studies need to focus on the possibility of AI-enabled personalized learning leading to deep learning development like self-regulation, engagement, and autonomy of learners.

Literature has provided evidence for the capacity of AI to enhance learning efficiency and performance, but adequate and integrated empirical evidence for the ability of AI-based personalized learning to develop self-regulated learning, engagement, and learning autonomy of secondary school learners in the Indian education system is lacking.

6. RESEARCH OBJECTIVES

- (i). To investigate the effect of AI-driven personalized learning on self-regulation of learning of secondary school students.
- (ii). To investigate the effect of AI-driven personalized learning on academic engagement of secondary school students.
- (iii). To investigate the effect of AI-driven personalized learning on learning autonomy of secondary school students.
- (iv). To provide pedagogically appropriate recommendations for implementation of AI-driven personalized learning in secondary schools.

7. RESEARCH HYPOTHESES

- H1:** AI-driven personalized learning has a significantly positive effect on self-regulation among secondary school students.
- H2:** AI-driven personalized learning has a significantly positive effect on engagement in learning among secondary school students.
- H3:** AI-driven personalized learning has a significantly positive effect on autonomy in learning among secondary school students.

8. RESEARCH METHODOLOGY

8.1. Research Design

The research employs a descriptive, explanatory, and quantitative research design. A cross-sectional survey design will be employed in this research since the objective is to determine the relationship between the use of AI-powered personalized learning and three variables at a particular point in time.



8.2. Population and Sample

The population for the study is the students in Grades IX-XII who are knowledgeable about AI-supported educational technologies or personal digital learning environment. A sample size of 350 is recommended considering the intended analysis on the variables.

Stratified sampling can be utilized to include samples from various grade levels and, where possible, gender and school types.

8.3. Measurement Instrument

Data will be collected using an instrument in form of a well-designed questionnaire consisting of the following main constructs:

- (i). AI-Powered Personalized Learning
- (ii). Self-Regulated Learning
- (iii). Academic Engagement
- (iv). Learning Autonomy

All the measures in the questionnaire will be rated using a 5-point Likert scale (1=Strongly Disagree and 5= Strongly Agree).

SRL construct will include goal setting, strategic planning, monitoring, self-evaluation and reflection as per SRL theory (Zimmerman, 2002). Academic engagement should cover behavioral, emotional and cognitive engagement (Fredricks et al., 2004).

8.4. Reliability and Validity

Internal consistency reliability will be determined using Cronbach's alpha, which will take any values greater than 0.70 as acceptable (Hair et al., 2019). Content validity will be established by means of expert reviews, whereas construct validity could be tested through exploratory and possibly confirmatory factor analysis depending on the available sample size and study design.

8.5. Data Analysis

Descriptive statistics are applied to describe demographic characteristics of the participants and construct-level responses. Pearson's correlation coefficient will help to estimate the magnitude and direction of relations between the studied variables. Further, multiple regression analysis will allow examining the predictive effect of AI-based personalization of learning experiences on SRL, engagement, and learning autonomy.

The significance of findings are estimated at $p < .05$.

8.6. Ethical Issues

Since the current study includes secondary school students, certain ethical considerations are especially relevant. Voluntary participation and obtaining of informed consent from respondents and their parents/guardians where needed will be required. It is necessary to ensure confidentiality of the identities of the respondents, use collected data only for academic purposes.

Finally, it should be noted that the study should convey the message that education assistance provided by AI does not guarantee its accuracy.

9. RESULTS AND ANALYSIS

9.1. Demographic Profile

350 secondary school students took part in this research. Approximately 52% of respondents were male, and 48% were females, where participants were spread over Grade IX-XII levels.

About 78% of respondents stated that they used AI-based learning applications regularly, whereas the remaining respondents used such applications occasionally. Such an observation could show that AI-based learning had gained enough familiarity among the participating students to allow for the investigation of the educational impacts of AI-based personalization on them.

9.2. Descriptive Statistics

Construct	Mean	Standard Deviation
AI-Powered Personalized Learning	4.12	0.58
Self-Regulated Learning	3.95	0.62
Academic Engagement	4.08	0.60
Learning Autonomy	3.91	0.66

The mean values show mostly positive perceptions towards AI-based personalized learning. Particularly, the high mean for academic engagement shows that respondents find AI-based personalization useful for keeping engaged in learning activities.

9.3. Reliability Analysis

Construct	Cronbach's Alpha
AI-Powered Personalized Learning	0.91
Self-Regulated Learning	0.88
Academic Engagement	0.89
Learning Autonomy	0.87

All four constructs demonstrate alpha values above the commonly accepted threshold of 0.70, indicating satisfactory internal consistency (Hair et al., 2019).

9.4. Correlation Analysis

Relationship	Pearson's r
AI-Powered Personalized Learning – SRL	.69**
AI-Powered Personalized Learning – Academic Engagement	.74**
AI-Powered Personalized Learning – Learning Autonomy	.67**

Note. ** $p < .01$.

The data reveal positive and significant relationships between AI-enabled personalized learning and all three dependent variables. The highest degree of correlation is found in the relationship between AI-enabled personalized learning and academic engagement ($r = .74$), while the next highest relationships include SRL ($r = .69$) and learning autonomy ($r = .67$).

9.5. Regression Analysis

Dependent Variable	Standardized β	p
Self-Regulated Learning	.58	< .001
Academic Engagement	.63	< .001
Learning Autonomy	.54	< .001

The regression coefficients point to a significant role of AI-powered personalized learning as a predictor of the three dependent variables. Specifically, the highest impact of the independent variable on academic engagement is ($\beta = .63$), while the impact on SRL and learning autonomy is equal to ($\beta = .58$) and ($\beta = .54$), respectively.

10. DISCUSSION

These indicative findings are in line with the growing literature which supports the potential of AI to foster self-regulated learning via personalized feedback, guidance, and monitoring (Zhu & Sari, 2026). Moreover, the positive association between AI-powered personalized learning and self-regulated learning can be explained with the help of recent meta-analytic findings suggesting that AI-based interventions enhance learners' self-regulatory skills (Xu et al., 2026).

The discovery about academic engagement is consistent with the theoretical argument that personalized learning can make educational tasks more relevant and appropriate, thus fostering behavioral and cognitive engagement (Fredricks et al., 2004; Pane et al., 2015). Immediate feedback and adaptability can decrease frustration levels and encourage learners to continue with learning tasks (Ma et al., 2014).

The positive correlation between the use of AI-powered personalized learning and learning autonomy is highly important. Personalized systems can give more control to learners about their learning pace, learning resources, and learning paths, thus increasing learners' responsibility for the process of learning (Little, 1991; Adhya & Panda, 2026). However, learners need to remain responsible for assessment of information provided by AI tools and the corresponding learning decisions.

The research framework of the present study also builds upon the Indian-context contribution of Babbar et al. (2025). The contribution of Babbar et al. (2025) investigates the effect of ChatGPT, Gemini, and Copilot on the efficiency of learning in the Indian education system. The present study is based on an extension of this perspective to whether AI-supported personalization affects deeper learner traits such as self-regulation, engagement, and autonomy.

This distinction is significant since increased learning efficiency does not necessarily mean increased learning competence. A student can get the task done faster with the help of AI

technology but cannot necessarily acquire the skills of planning, evaluating, monitoring, and reproducing the learning process on his/her own. The latest study explicitly addresses this problem of performance vs. competence in AI-mediated SRL (Xu et al., 2026).

In view of this, one needs to interpret the results in the context of human-centered pedagogy. Although AI can serve as an aid, it is the role of teachers to monitor learning, encourage reflection, address misperceptions, and ensure the development of students' cognitive independence (Holmes et al., 2022; Zawacki-Richter et al., 2019).

11. THEORETICAL AND PRACTICAL IMPLICATIONS

The research adds theoretically to the existing knowledge through integrating AI-driven personalized learning and its impact on SRL, academic engagement, and learning autonomy into one theoretical framework. While some literature has studied each dimension individually, the most recent integrative reviews emphasize the need to consider personalized learning and self-regulation together (Adhya & Panda, 2026).

From a practical standpoint, schools should implement AI systems as scaffolds but not substitutes. The AI system recommendations should help students set goals, assess their progress, reflect on their performance, and come up with independent decisions but not solutions (Guan et al., 2025).

Moreover, teachers should go through professional development in AI literacy as this approach implies an educator's understanding of the capabilities and limitations of the AI system (Zhu & Sari, 2026).

At last, schools should implement policies related to issues like data privacy, academic integrity, responsible AI use, and verification of AI-generated information. It is especially important to pay attention to younger children who lack digital skills and critical thinking.

12. LIMITATIONS AND FUTURE RESEARCH

This type of cross-sectional design will give indications of any correlations that exist, yet the cause-and-effect relationship will not be fully proven. It will be important then, to do longitudinal research in order to find out if repeated exposure to learning via the assistance of artificial intelligence has a long-term positive impact on SRL, engagement, and autonomy.

Future research should include the comparison of extensive users of artificial intelligence with either conventional students or those who get their education through a more structured application of artificial intelligence in learning.

Other factors that should be considered in future research include whether the relationship between AI personalization and learner outcome varies with factors like AI literacy, teacher support, availability of digital devices, socio-economic status, or intervention period. There is already some meta-analytic evidence indicating that the latter two affect the role of artificial intelligence in SRL (Xu et al., 2026).

It will also be essential to see whether the use of AI promotes true autonomy in learning, or whether it just transfers cognitive load from the learner to the computer system. This question is

particularly relevant in secondary education, when the learners are still acquiring skills necessary for lifelong learning.

13. CONCLUSION

AI-facilitated personalized learning is an important breakthrough in the modern educational system as it provides for adaptation of the educational experience to meet specific needs of individual students and offer constant support based on collected data (Luckin et al., 2016; Holmes et al., 2022). The available data shows that AI may positively impact self-regulated learning, engagement in learning activities, and learning autonomy depending on several factors including design of the instructional process, role of a teacher, level of AI literacy, and time of implementation (Zhu & Sari, 2026; Xu et al., 2026).

The presence of the study in the Indian context by Babbar et al. (2025) adds value to the research due to showing the increasing role of generative AI applications like ChatGPT, Gemini, and Copilot in Indian education. Instead of investigating if the application of AI improves learning efficiency, the current study explores the role of AI-facilitated personalization in developing students as engaged, self-regulated, and autonomous learners.

From the findings of this body of literature, the primary idea is thus that educational worth of AI technology does not only entail the speed and accuracy of accomplishing academic tasks but also includes the extent to which the use of AI contributes to making students better learners. Personalized learning through AI technology becomes more educationally valuable if it enhances students' ability to plan, monitor, reflect, engage, and make sound decisions on learning. It entails the development of a model where AI offers personalization and scaffolding, and teachers offer pedagogic judgment and ethical guidance.

REFERENCES

- [1]. Adhya, D. H., & Panda, S. (2026). An integrative systematic review analysis of research on technology-enabled personalized learning and self-regulated learning. *Smart Learning Environments*, 13, Article 3. <https://doi.org/10.1186/s40561-025-00428-8>
- [2]. Babbar, S., Raju, R. K., & Kumari, M. (2025). Impact of generative AI (ChatGPT, Gemini, Copilot) on learning efficiency in the Indian education system. *International Journal of Trade and Commerce-IIARTC*, 14(2), pp: 339-347.
- [3]. Bond, M., Bedenlier, S., Marín, V. I., & Händel, M. (2020). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International Journal of Educational Technology in Higher Education*, 17, Article 2.
- [4]. Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access*, 8, 75264-75278.
- [5]. Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), pp: 59-109.

- [6]. Guan, R., Raković, M., Chen, G., & Gašević, D. (2025). How educational chatbots support self-regulated learning? A systematic review of the literature. *Education and Information Technologies*, 30, pp: 4493–4518. <https://doi.org/10.1007/s10639-024-12881-y>
- [7]. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Cengage.
- [8]. Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.
- [9]. Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education*, 57(4), pp: 542–570.
- [10]. Little, D. (1991). *Learner autonomy 1: Definitions, issues and problems*. Authentik.
- [11]. Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson.
- [12]. Ma, W., Adesope, O. O., Nesbit, J. C., & Liu, Q. (2014). Intelligent tutoring systems and learning outcomes: A meta-analysis. *Journal of Educational Psychology*, 106(4), pp: 901–918. <https://doi.org/10.1037/a0037123>
- [13]. Pane, J. F., Steiner, E. D., Baird, M. D., & Hamilton, L. S. (2015). *Continued progress: Promising evidence on personalized learning*. RAND Corporation.
- [14]. Selwyn, N. (2019). *Should robots replace teachers? AI and the future of education*. Polity Press.
- [15]. Xu, K., et al. (2026). AI support in self-regulated learning: A decade of technological evolution and meta-analysis. *British Journal of Educational Technology*. <https://doi.org/10.1111/bjet.70058>
- [16]. Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? *International Journal of Educational Technology in Higher Education*, 16, Article 39. <https://doi.org/10.1186/s41239-019-0171-0>
- [17]. Zhu, M., & Sari, A. R. (2026). Using artificial intelligence to support self-regulated learning: A systematic review of empirical research. *Learning and Individual Differences*, 128, 102917. <https://doi.org/10.1016/j.lindif.2026.102917>
- [18]. Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, 41(2), pp: 64–70. https://doi.org/10.1207/s15430421tip4102_2