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GENERATIVE ARTIFICIAL INTELLIGENCE IN TEACHER-DRIVEN PERSONALIZED LEARNING FOR K-12 EDUCATION: A SYSTEMATIC LITERATURE REVIEW

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Keyword

Generative Artificial Intelligence, Personalized Learning, K-12, Teacher Role, Systematic Literature Review

Abstract

This study is a systematic literature review that aims to analyze the implementation of generative artificial intelligence (GenAI) in teacher-driven personalized learning in the K-12 education context. Three research questions were posed: (1) how is GenAI used to support personalized learning, (2) what are the roles and strategies of teachers in designing, implementing, and evaluating GenAI-based personalized learning, and (3) what supporting and inhibiting factors are reported in its application. The method used followed the PRISMA flow with article sources from the Scopus database in 2025. A total of 20 articles relevant to the K-12 context were analyzed thematically. The results of the study show that GenAI is used to tailor content to students' readiness levels, provide real-time adaptive feedback, detect mistakes step by step, and present contextual material relevant to everyday life. In addition, GenAI also supports creativity and collaboration through interest-based projects, while providing adaptive learning paths for students with special needs and twice-exceptional students. Teachers remain central as designers, facilitators, evaluators, ethical mediators, and learning strategy innovators. Supporting factors for implementation include institutional support, professional development programs, and GenAI features that increase student motivation and engagement, while barriers include infrastructure limitations, lack of training, privacy and bias issues, and the risk of over-automation. This study confirms that GenAI has the potential to be a pedagogical partner in expanding K-12 learning personalization, but its successful implementation is highly dependent on teacher capacity, policy support, and careful ethical and pedagogical integration.

INTRODUCTION

The rapid development of Generative Artificial Intelligence (GenAI) technology capable of producing content in the form of text, images, audio, or video based on deep learning has opened up revolutionary opportunities for more personalized education. Specifically, in the K-12 context, GenAI has been used to create adaptive, interactive, and personalized learning experiences tailored to individual students' needs (Marzano, 2025).

Some concrete applications of GenAI include the creation of personalized lesson materials, enhancing student motivation, strengthening assessment processes, and using tools like ChatGPT as an example of generative AI in an educational setting (Marzano, 2025). Initiatives such as the integration of GenAI into the Canvas platform enable teachers to design interactive, chat-based learning experiences aligned with instructional objectives, while maintaining control over course content and pedagogical direction (Mzwri & Turcsányi-Szabo, 2025).

Furthermore, evaluations of teachers' readiness to adopt GenAI have also begun to be explored. A study in Idaho found that while many teachers felt unprepared, they primarily utilized GenAI for preparatory tasks, such as lesson planning and administration, rather than for direct classroom instruction (Cheah et al., 2025).

More conceptually, some studies also suggest that GenAI can bridge the weaknesses of traditional personalized learning systems particularly in supporting intrinsic motivation, creativity, and collaborative learning in line with the goals of the OECD Learning Compass 2030 (Maity & Deroy, 2024). Other research indicates that GenAI-based tutoring systems have the potential to provide real-time feedback, adaptive learning paths, and personalized interactive dialogue (Manel et al., 2024).

Although early literature shows the potential of GenAI in supporting personalized learning, most studies are conceptual or small-scale, ignoring the role of teachers in the context of GenAI-based learning design and implementation. Some research touches on teacher readiness or technical barriers, but has not delved deeply into the role and strategies of teachers in designing, implementing, and evaluating personalized learning. For example, there is a disparity between the use of GenAI for administrative tasks and its use as a direct learning tool in the classroom.

Additionally, most analyses have not clearly highlighted the enabling and inhibiting factors from the perspectives of teachers, institutions, or policies. Another significant gap is the limited empirical data from the global K-12 context (as well as the disparity in access between advantaged and disadvantaged schools), which may obscure the use of GenAI as a tool for equitable educational empowerment.

Research Questions derived from the above background and gaps

1. RQ1: In the context of K-12 education, how has generative AI been used to support personalized learning?
2. RQ2: What are the roles and strategies of teachers in designing, implementing, and evaluating personalized learning based on generative AI?
3. RQ3: What enabling and inhibiting factors have been reported in the implementation of generative AI for personalized learning in K-12?

METHOD

This study follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to answer the research questions systematically. PRISMA provides a standard framework for conducting systematic reviews, which includes steps such as literature search, screening, data extraction, analysis, and reporting (Page et al., 2021). The specific steps taken in this study were: (1) conducting a comprehensive literature search based on predetermined inclusion and exclusion criteria; (2) conducting two rounds of screening to evaluate the eligibility of identified studies; (3) extracting key information from selected studies and compiling it into structured tables; (4) analyzing the extracted data in detail to answer the research questions; and (5) compiling a research report in accordance with PRISMA standards.

1. Data Sources and Databases

   The articles analyzed in this study were obtained from a leading international academic database, Scopus. This database was chosen to ensure that the sources used were highly credible, well indexed, and relevant to the research topic.

2. Search Strategy

The search strategy was designed using a combination of keywords with Boolean operators (AND, OR) and phrase search. The keywords combine three main aspects that are the focus of the research. First, the Generative AI aspect, which includes the terms "generative artificial intelligence," "generative AI," "large language model," "ChatGPT," and "GPT-4." Second, the Personalized Learning aspect, which includes the terms "personalized learning," "personalized learning," "adaptive learning," "individualized learning," and "differentiated instruction." Third, the K-12 Context & Teacher Role aspect, which includes the terms "K-12," "primary school," "secondary school," and "basic education" combined with the terms "teacher role," "teacher involvement," or "teacher facilitation." The query for searching in Scopus is designed by combining all these keywords into a single structured search statement to maximize the relevance of the results.

3. Inclusion and Exclusion Criteria

The inclusion criteria for this study include articles that discuss the use of Generative Artificial Intelligence (GenAI) in personalized learning in the context of K-12 education, including studies that highlight the role of teachers (teacher-oriented) in the planning, implementation, or evaluation of GenAI-based learning. Included publications are articles in English or Indonesian published between 2025, limited to journal articles and conference proceedings. Meanwhile, exclusion criteria include studies outside the K-12 education context, such as higher education, research that only discusses non-generative AI or is irrelevant to personalized learning, and articles in the form of opinions or popular news that lack a methodological basis.

4. Study Selection Process

The selection process was carried out in several stages. This process used the Rayyan AI application. The application was used to make it easier for researchers to organize, filter, and label each article obtained. The initial stage, identification, involved an initial search of all databases using filters based on year, language, and document type. Next, the initial screening stage was carried out to remove duplicates that were automatically detected in the application. During the screening stage, the abstracts and titles of the articles are examined to ensure their relevance to the research questions and inclusion criteria. Articles that pass are labeled as potentially answering RQ1, RQ2, or RQ3. Articles that pass then undergo a full-text review, which is a comprehensive feasibility evaluation by three independent researchers. If there are differences in assessment, the process continues with discussion. The entire selection process is visualized using the PRISMA 2020 flowchart.

5. Data Extraction

Data from eligible studies were extracted using a prepared form, including bibliographic information (authors, year, title, source), research objectives, research design and methods, educational context (country, level, subject), type and function of GenAI used, teacher roles and strategies, supporting and hindering factors, and key findings relevant to RQ1 to RQ3.

6. Data Analysis

Data analysis was conducted thematically by grouping findings based on research question categories. Findings related to RQ1 were grouped to describe the form of GenAI utilization in personalized learning. Findings on RQ2 focused on teacher roles and strategies, while RQ3 findings identified supporting and hindering factors. Thematic synthesis techniques were used to identify patterns, gaps, and relationships between findings, as outlined by Thomas and Harden (2008).

RESULTS

A literature search of databases for the period 2025 yielded a total of 303 articles. After the PRISMA 2020 screening process, 99 articles met the inclusion criteria, but only 34 articles were accessible in full text, in the end 20 articles fit to analyzed. The selected articles included empirical research, case studies, and conceptual studies from various countries focusing on K-12 education.

Table 1. Synthesis of Reviewed Articles

No.	Author & Years	Title
1.	Al-Karasneh, S.M.; Kanaan, E.M.; Al-Barakat, A.A.; AlAli, R.M.; Zaher, A.M.; Ibrahim, N.A.	Transforming Primary Science Education: Unlocking the Power of Generative AI to Enhance Pupils' Grasp of Scientific Concepts
2.	Evmenova, A.S.; Regan, K.; Mergen, R.; Hrisseh, R. (Evmenova et al., 2025)	Educational Games and the Potential of AI to Transform Writing Across the Curriculum
3.	Farhah, N.S.; Wadood, A.; Alqarni, A.A.; Uddin, M.I.; Aldhyani, T.H.H.	Enhancing Adaptive Learning with Generative AI for Tailored Educational Support for Students with Disabilities
4.	Filiz, O.; Kaya, M.H.; Adiguzel, T.	Teachers and AI: Understanding the factors influencing AI integration in K-12 education
5.	Fragakis, N.; Trichopoulos, G.; Caridakis, G.	Empowering Education with Intelligent Systems: Exploring Large Language Models and the NAO Robot for Information Retrieval
6.	Huynh, L.; McNamara, D.S.	GenAI-Powered Text Personalization: Natural Language Processing Validation of Adaptation Capabilities
7.	Iqbal, M.S.; Rahim, Z.A.; Omerkhel, Q.	Harnessing generative AI for educational innovation: a TRIZ-PLR perspective
8.	Kim, J.	Perceptions and preparedness of K-12 educators in adopting generative AI
9.	Levin, I.; Semenov, A.L.; Gorsky, M.	Smart Learning in the 21st Century: Advancing Constructionism Across Three Digital Epochs
10.	Opanasenko, Y.; Bardone, E.; Pedaste, M.; Siiman, L.A.	Sequence Analysis-Enhanced AI: Transforming Interactive E-Book Data into Educational Insights for Teachers
11.	Ravi, P.; Masla, J.; Kakoti, G.; Lin, G.C.; Anderson, E.; Taylor, M.; Ostrowski, A.K.; Breazeal, C.; Klopfer, E.; Abelson, H.	Co-designing Large Language Model Tools for Project-Based Learning with K12 Educators
12.	Ronksley-Pavia, M.; Ronksley-Pavia, S.; Bigum, C.	Experimenting With Generative AI to Create Personalized Learning Experiences for Twice-Exceptional and Multi-Exceptional Neurodivergent Students
13.	Tasdelen, O.; Bodemer, D.	Generative AI in the Classroom: Effects of Context-Personalized Learning Material and Tasks on Motivation and Performance
14.	Vaccaro, M.; Friday, M.; Zaghi, A.	Multi-Agentic LLMs for Personalizing STEM Texts
15.	Wang, G.; Sun, F.	A review of generative AI in digital education: transforming learning, teaching, and assessment
16.	Yao, X.; Zhong, Y.; Cao, W.	The analysis of generative artificial intelligence technology for innovative thinking and strategies in animation teaching

17.	Ye, X.; Zhang, W.; Zhou, Y.; Li, X.; Zhou, Q.	Improving students' programming performance: an integrated mind mapping and generative AI chatbot learning approach
18.	Żammit, J.	Secondary School Teachers' Experiences with Generative AI in Maltese Language Teaching
19	Zhang, J.; Song, W.; Liu, Y.	Cognitive bias in generative AI influences religious education
20.	Zhang, X.; Xu, S.; Jing, Y.	The Mode and Practice Path of Generative Artificial Intelligence Empowerment Classroom Teaching - Based on Grounded Theory

1. RQ1. The Use of Generative AI to Support Personalized Learning in K-12 Education

A synthesis of the 20 articles analyzed shows that generative AI (GenAI) has been utilized in K-12 education to provide a more adaptive, contextual, and individualized learning experience for students. This application focuses not only on academic differentiation, but also extends to creativity, collaboration, and the development of 21st-century skills.

One of the dominant findings is the adaptation of learning content. GenAI is used to tailor texts, questions, and teaching materials to students' ability levels, so that each individual can learn at a level appropriate to their capacity. This is evident in studies that utilize AI to simplify or enrich reading in the context of STEM (Huynh & McNamara, 2025; Vaccaro et al., 2025) as well as in Arabic and Maltese language learning (Alkaabi & Almaamari, 2025; Żammit, 2025). In addition, many studies emphasize the importance of adaptive feedback-based learning. Systems such as knowledge tracing (X. Wang, 2025; L. Yang et al., 2025) and mistake detection (T. Zhang et al., 2025) enable real-time monitoring of student progress and the provision of individual learning paths. Similar approaches have also proven beneficial for groups of students with special needs, for example in the context of adaptive learning for students with special needs (Farhah et al., 2025) and for twice-exceptional students, i.e., students who are both gifted and have learning disabilities (Ronksley-Pavia et al., 2025).

Another dimension that has emerged is the contextualization of learning. GenAI is used to make teaching materials more relevant to students' daily experiences, such as explaining scientific concepts through personal analogies (Al-Karasneh et al., 2025; Tasdelen & Bodemer, 2025). By presenting content that is relevant to students' lives, motivation and engagement in the learning process increase significantly. Furthermore, a number of studies show that GenAI also supports the strengthening of 21st-century skills, particularly creativity, collaboration, and project-based learning. Teachers and students use GenAI to design projects based on their interests, explore new ideas, and create personalized digital products (Ravi et al., 2025; Yao et al., 2025). This shows that technology not only functions as an academic tool, but also as a medium for innovation and self-expression for students.

Overall, findings across articles indicate that generative AI can expand the scope of personalized learning in K-12. Whereas personalization was previously limited to academic difficulty differentiation, it has now evolved into an adaptive, creative, contextual learning experience that facilitates the development of essential 21st-century skills.

Tabel 2. Results of RQ1

No.	Author & Year	The Use of Generative AI for Personalized Learning
1.	(Al-Karasneh et al., 2025)	GenAI helps explore scientific concepts using personal analogies to make them easier for students to understand.

2.	(Evmenova et al., 2025)	AI in educational games supports automatic feedback and personalized writing practice.
3.	(Farhah et al., 2025)	GenAI supports adaptive learning that adjusts difficulty and provides additional support.
4.	(Filiz et al., 2025)	Teachers report using GenAI to tailor materials and assessments to students' needs.
5.	(Fragakis et al., 2025)	LLM + humanoid robots are used to provide personalized instructions through physical interaction.
6.	(Huynh & McNamara, 2025)	GenAI-based chatbots tailor reading texts to students' skill levels.
7.	(Iqbal et al., 2025)	GenAI is used for personalized learning innovation through problem-based learning.
8.	(Kim, 2025)	Teachers see the potential of GenAI for personalizing lesson plans and formative assessments.
9.	(Levin et al., 2025)	AI helps generate digital artifacts tailored to individual student projects.
10.	(Opanasenko et al., 2025)	GenAI analyzes student interaction data in e-books to create personalized recommendations.
11.	(Ravi et al., 2025)	GenAI generates project ideas based on students' interests for project-based learning.
12.	(Ronksley-Pavia et al., 2025)	GenAI is used to create unique learning paths for gifted students with learning disabilities.
13.	(Tasdelen & Bodemer, 2025)	GenAI generates personalized material based on students' everyday contexts.
14.	(Vaccaro et al., 2025)	Multi-agent LLM is used to simplify or expand text according to the student's level.
15.	(G. Wang & Sun, 2025)	GenAI supports content adaptation, formative assessment, and personalized feedback.
16.	(Yao et al., 2025)	GenAI creates adaptive learning paths and creative feedback.
17.	(Ye et al., 2025)	GenAI is used to facilitate personalized literacy and critical thinking exploration in elementary and middle schools.
18.	(Żammit, 2025)	Teachers use GenAI (ChatGPT) to help differentiate material and provide individual support for students with different ability levels.
19.	(J. Zhang et al., 2025)	GenAI generates customized religious lesson texts, although cognitive bias needs to be taken into account.
20.	(X. Zhang et al., 2025)	GenAI helps personalize lesson plans and classroom-based learning activities.

2. RQ2. Teachers' Roles and Strategies in Generative AI-Based Personalized Learning

The synthesis of various studies shows that the role of teachers remains central even though generative AI has been widely used to support personalized learning in K-12. Teachers have not lost their role; rather, that role has evolved and become more layered in response to new needs in the AI-based classroom ecosystem.

First, teachers act as designers and curators of learning paths. AI is capable of generating adaptive learning path recommendations, but teachers are still responsible for validating, adjusting, and ensuring that these paths are in line with the curriculum and learning objectives. This is important because automated AI results need to be directed to suit the classroom context, student needs, and applicable educational standards (Setyawan Soekamto et al., 2025; X. Wang, 2025; Q. Yang & Liang, 2025). In addition, teachers serve as ethical mediators and quality supervisors. AI has the potential to generate biased or inappropriate content, especially on sensitive topics such as religious education or critical literacy. Therefore, teachers must control, filter, and direct the use of AI so that it continues to support sound educational values and does not mislead (Kim, 2025; J. Zhang et al., 2025).

The next role is that of an adaptive learning facilitator. Teachers use recommendations provided by AI to design specific interventions for certain groups of students, such as students with special needs or gifted students. With the help of AI, teachers can more quickly identify individual difficulties and provide tailored support without sacrificing other students in the class (Farhah et al., 2025; Ronksley-Pavia et al., 2025). Teachers also act as evaluators of personalization outcomes. Although AI is capable of providing feedback and learning recommendations, the final evaluation remains in the hands of the teacher. Teachers assess the extent to which the personalization offered by AI is truly effective and decide which strategies need to be continued or improved. In other words, AI is seen as a professional assistant, not a replacement for the pedagogical role of teachers (Evmenova et al., 2025; Ravi et al., 2025).

Finally, teachers act as innovators in learning strategies. Several studies show that teachers are using AI to create new, more creative learning experiences, such as integrating humanoid robots into the classroom or utilizing AI-based simulations in science projects. Thus, teachers do not only rely on AI for efficiency, but also use it to enrich the learning experience of students (Cooper et al., 2025; Fragakis et al., 2025). Overall, it can be concluded that teachers act as the main controllers who ensure that generative AI-based personalization truly supports students' needs. Teachers keep AI implementation in line with the curriculum, while ensuring its use is ethical, safe, and relevant to the K-12 classroom context.

Tabel 3. Results of RQ2

No.	Author & Years	Teachers' Roles and Strategies
1.	(Al-Karasneh et al., 2025)	Teachers guide the use of GenAI to build personal analogies, helping understanding of abstract concepts.
2.	(Evmenova et al., 2025)	Teachers combine AI feedback with manual instruction to develop students' writing skills.
3.	(Farhah et al., 2025)	Teachers leverage AI recommendations for additional interventions, adjusting the pace of learning to suit students' needs.
4.	(Filiz et al., 2025)	Teachers integrate GenAI to customize materials and assessments, while also managing classroom usage ethics.
5.	(Fragakis et al., 2025)	Teachers set up interaction scenarios between LLM-robots and students to create personalized learning experiences.
6.	(Huynh & McNamara, 2025)	Teachers verify AI-generated text adaptations to suit students' reading levels.
7.	(Iqbal et al., 2025)	Teachers lead the integration of AI in problem-based learning, facilitating innovative strategies.
8.	(Kim, 2025)	Teachers see their role as ethical mediators, guiding students to use AI productively.
9.	(Levin et al., 2025)	Teachers become designers of creative learning environments with AI as a co-creator of students' digital artifacts.
10.	(Ye et al., 2025)	Teachers use GenAI to support students' exploration of critical thinking, while maintaining ethical balance.

11.	(Opanasenko et al., 2025)	Teachers analyze AI recommendations to tailor individual guidance.
12.	(Ravi et al., 2025)	Teachers work with AI to design projects that suit students' interests, then evaluate the results.
13.	(Ronksley-Pavia et al., 2025)	Teachers use AI to create individual strategies, while still conducting qualitative assessments.
14.	(Tasdelen & Bodemer, 2025)	Teachers integrate AI to generate questions/materials that are contextual and relevant to students' lives.
15.	(Vaccaro et al., 2025)	Teachers use GenAI to simplify STEM texts and provide scaffolding based on students' needs.
16.	(G. Wang & Sun, 2025)	Teachers guide the selection of GenAI applications and maintain a balance between automation and pedagogical guidance.
17.	(Yao et al., 2025)	Teachers integrate AI into students' creative assignments, evaluating the originality of the results.
18.	(Żammit, 2025)	Teachers act as facilitators, using GenAI to differentiate material and support students with different needs.
19	(J. Zhang et al., 2025)	Teachers must control AI content due to the potential for cognitive biases that affect the personalization of materials.
20.	(X. Zhang et al., 2025)	Teachers as AI-powered personalized lesson plan redesigners.

3. RQ3. Enabling and Hindering Factors in the Implementation of Generative AI for Personalized Learning

The main supporting factors identified were teacher capacity and institutional support. Kim's (Kim, 2025) study confirmed that clear school policies and targeted professional development programs are essential to facilitate the adoption of GenAI. (Ravi et al., 2025) showed that LLM-based tool designs that include just-in-time teacher training help facilitate use and reduce administrative burdens. (Al-Karasneh et al., 2025) also mention the importance of continuous training and professional networking among teachers to strengthen the integration of GenAI in science teaching practices.

In addition, student engagement and the adaptive nature of GenAI are other driving factors. (Filiz et al., 2025) report that teachers find GenAI to be efficient, interactive, and adaptive in supporting personalization. A study in 7th grade showed that AI chatbots provided immediate feedback to help students debug code, which accelerated individual progress (Ye et al., 2025). In elementary schools, the integration of humanoid robots with LLM increased students' emotional engagement and supported personalized learning adaptation (Fragakis et al., 2025).

However, there are a number of obstacles that need to be overcome. Funding gaps, lack of training, and infrastructure limitations are major issues, especially in rural or resource-poor schools (Filiz et al., 2025; Kim, 2025). Teachers are also concerned about data privacy issues, algorithmic bias, and the additional burden of orchestrating new technologies (Ronksley-Pavia et al., 2025). Other obstacles include resistance to change and the misalignment between AI content and local curricula (Al-Karasneh et al., 2025).

Beyond structural barriers, there are also pedagogical risks. (Ravi et al., 2025) highlight teachers' concerns about over-automation, which can reduce space for spontaneous learning and social skill development. (Ye et al., 2025) warn that instant feedback from AI can encourage superficial understanding if not balanced with adequate scaffolding. (Fragakis et al., 2025) also found technical limitations in humanoid robots, such as failure to recognize emotions due to environmental conditions, which reduces the effectiveness of personalization.

Overall, the implementation of GenAI in personalized learning in K-12 is driven by policy support, teacher professional development, and AI features that provide real-time feedback and motivating learning experiences. However, obstacles such as resource gaps, ethical issues, the risk of over-automation, and technical limitations must be addressed in order for the use of GenAI to truly have a sustainable positive impact on elementary and secondary school students.

Tabel 4. Result of RQ3

No.	Author & Years	Supporting factors (enablers)	Inhibiting factors (barriers)
1.	(Al-Karasneh et al., 2025)	GenAI encourages student-centered learning & inquiry, creativity, and self-paced learning; calling for PD and professional networking among teachers.	ICT access barriers, resistance to change, need for intensive training for meaningful integration.
2.	(Filiz et al., 2025)	Teachers find AI efficient, interactive, and adaptive; tools like ChatGPT/MagicSchool help with personalization and lesson planning.	Technical and hardware challenges, time/workload, curriculum misalignment, language-cultural differences, and ethical/security and output quality concerns.
3.	(Fragakis et al., 2025)	Tangible interaction (NAO) and LLM increase engagement; emotion recognition supports personal learning adaptation.	Technical limitations: noise/lighting interferes with emotion recognition; some students complain the robot "doesn't hear"/want the robot to be "smarter."
4.	(Kim, 2025)	Institutional readiness and ethical and supportive policies are seen as crucial for accelerating adoption.	Lack of funding, professional training (PD), and infrastructure, especially in rural/underfunded schools; as well as concerns about data privacy, bias, and potential student dependency.
5.	(Ravi et al., 2025)	LLM designs that integrate real-time tutoring and PD within the tool can ease administrative burdens and support differentiation.	Concerns about excessive automation reducing spontaneous/soft skills learning opportunities; high context/prompt load; need for clarity on which administrative tasks are safe to automate.
6.	(Ronksley-Pavia et	GenAI-based "pedagogical	Concerns about bias, security,

	al., 2025)	rehearsal" approach helps teachers design individualized support; the teacher remains central/the final judge.	transparency, and alignment of human values; the need for robust teacher training.
7.	(Ye et al., 2025)	GenAI chatbots provide instant feedback/debugging to support individual progress; learning scenarios incorporate mind-mapping (scaffolding) to reduce cognitive load.	Instant feedback risks encouraging surface understanding; teachers need to monitor that students are not simply "generating code."

DISCUSSION

The study results show that the use of Generative Artificial Intelligence (GenAI) in K-12 education to support personalized learning includes various forms of implementation that reinforce learner-centered education principles.

1. RQ1. The Use of Generative AI to Support Personalized Learning in K-12 Education

   Research findings show that generative AI has been utilized in K-12 to provide a more personalized, adaptive, and relevant learning experience tailored to the individual needs of students. The use of GenAI to customize learning content, provide adaptive feedback, and deliver contextual material relevant to students' lives reinforces the idea that personalization can increase both motivation and learning comprehension. This is in line with Vygotsky's constructivism theory, which emphasizes the importance of scaffolding and the zone of proximal development (ZPD). With the help of AI, scaffolding is not only provided by teachers, but also by intelligent systems that can monitor student progress in real-time and provide support according to individual needs (X. Wang, 2025; L. Yang et al., 2025).

   In the K-12 context, the use of GenAI for knowledge tracing and error detection for example, in mathematics or programming shows an important contribution to instructional differentiation. This supports Tomlinson's theory of differentiated learning, which argues that instruction should be tailored to students' readiness, interests, and learning profiles. GenAI enables differentiation to be carried out more efficiently, for example by adapting STEM texts (Vaccaro et al., 2025), providing additional learning paths(Q. Yang & Liang, 2025), or detecting errors step by step in mathematics (T. Zhang et al., 2025) . In this way, AI functions as a cognitive partner that expands teachers' capacity to meet the diverse needs of students in the classroom.

   Furthermore, findings that GenAI can make material more contextual, for example by simplifying scientific analogies according to students' everyday experiences (Al-Karasneh et al., 2025; Tasdelen & Bodemer, 2025), are in line with the contextual constructivist approach. This theory emphasizes that knowledge is easier to understand when it is linked to students' reality. Context-based personalization also demonstrates GenAI's contribution to supporting situated learning, where the learning process is considered meaningful when it is related to students' real environments.

   In addition, findings from several studies show that GenAI not only facilitates academic differentiation, but also encourages creativity and collaboration through projects tailored to students' interests. Ravi et al., (2025) found that LLMs can support teachers in designing interest-based projects, while Yao et al., (2025) showed how AI helps students produce creative products in the field of animation that suit their learning styles. This supports the theory of 21st century skills and project-based learning, which emphasizes the importance of personalization in developing creativity, collaboration, and problem solving.

However, although most findings support constructivism, differentiated learning, and project-based approaches, there are also indications of challenges. For example, if instant feedback is not balanced with scaffolding from teachers, there is a risk that students will only focus on correct answers without understanding the underlying thought process. This can conflict with the principle of constructivism, which emphasizes the importance of active engagement in knowledge building (Huynh & McNamara, 2025). Therefore, the role of teachers remains crucial in ensuring that AI-based personalization does not diminish the quality of meaningful learning processes.

Overall, the results of RQ1 analysis show that the use of GenAI in personalized learning in K-12 generally supports educational theories that emphasize differentiation, scaffolding, and contextualization of learning, while opening up new opportunities in supporting 21st-century skills. However, its successful implementation is greatly influenced by the balance between AI automation and pedagogical control by teachers.

2. RQ2. The Role and Strategies of Teachers in Generative AI-Based Personalized Learning

The synthesis results show that even though generative AI offers the ability to personalize learning paths, teachers still play a central role in designing, implementing, and evaluating personalized learning in K-12. This role has not diminished; rather, it has evolved in line with the integration of new technologies. These findings are consistent with the Technological Pedagogical Content Knowledge (TPACK) theory, which emphasizes the importance of synergy between technological mastery, pedagogy, and content to create meaningful learning (Koehler et al., 2013).

First, teachers act as designers and curators of learning paths. A study by (Setyawan Soekamto et al., 2025) emphasizes that even though the SKYRAG system is capable of generating automatic learning paths, teachers still need to adjust the results to the curriculum and class needs. The same was found by Wang (2025) and Yang & Liang (2025), who showed that teachers use knowledge tracing data and AI recommendation system to design instructional interventions tailored to student progress. This role is in line with Vygotsky's social constructivism, where teachers function as mediators who adjust support according to each student's zone of proximal development (ZPD).

Second, teachers act as ethical mediators and quality supervisors. In the context of religious education, Zhang et al. (2025) warn that AI can reproduce cognitive biases in learning materials, so teachers need to ensure that content remains consistent with educational values. Similar findings were reported by Kim (2025), who showed that K-12 teachers view themselves as guides in ensuring that GenAI use remains productive, safe, and in line with school norms. These findings support the educational ethics theoretical framework that positions teachers as guardians of values and integrity in digital learning (UNESCO, 2023).

Third, teachers act as facilitators of adaptive learning. Farhah et al. (2025) showed that teachers utilize AI recommendations to provide additional support for students with disabilities, while Ronksley-Pavia et al. (2025) found that teachers utilize GenAI to design unique strategies for twice-exceptional students. This role shows how teachers integrate technological recommendations with their pedagogical intuition, ensuring that learning remains humanistic.

Fourth, teachers act as evaluators of personalized outcomes. Although AI can provide automatic feedback, teachers still manually evaluate the quality of student learning outcomes. Evmenova et al. (2025) show that teachers combine automatic feedback from AI with manual instructions to develop students' writing skills. Similarly, Ravi et al. (2025) note that although AI is capable of generating differentiated assessment rubrics, teachers still decide whether the feedback is in line with curriculum standards. This is in line with the principle of assessment for learning, which emphasizes that assessment is not only technical but also requires pedagogical sensitivity.

Finally, teachers also emerge as innovators in learning strategies. Fragakis et al., (2025) show that teachers utilize a combination of LLMs and humanoid robots to create interactive learning experiences in elementary schools. Cooper et al. (2025) demonstrate how science teachers use GenAI to design personalized science experiment simulations. This is in line with constructivist theory, which emphasizes project-based learning, where teachers act as facilitators of innovation and collaboration.

Thus, it can be concluded that teachers are not merely users of technology, but key controllers who ensure that AI-based personalization truly supports student needs, aligns with the curriculum, and is ethically safe. These findings reinforce the TPACK framework and social constructivism theory, which emphasize that technology is only effective when combined with teachers' pedagogical capacity and professional values.

3. RQ3. Supporting and Hindering Factors in the Implementation of Generative AI for Personalized Learning

Analysis of findings from various studies in K-12 shows that the main supporting factors for the implementation of generative AI for personalized learning are closely related to teacher readiness, institutional support, and the pedagogical relevance of technology. Teachers view AI as an efficient, interactive, and adaptive tool in supporting personalized learning, for example in lesson planning, providing feedback, and formative assessment Filiz et al., (2025). This is in line with the Technology Acceptance Model (TAM) (Davis, 1989), in which perceived usefulness and perceived ease of use are important predictors of technology use intentions. Kim (2025) study reinforces this finding by showing that institutional readiness and supportive ethical policies play a major role in increasing teachers' acceptance of AI in schools.

In addition to ease and usefulness, institutional support in the form of policies and professional development (PD) is a significant driver. Ravi et al., (2025) found that when teacher training is integrated directly into LLM tools through a just-in-time professional development approach, teachers feel more prepared to utilize AI in learning and administrative tasks. Meanwhile, Al-Karasneh et al. (2025) highlight the importance of professional networks among teachers for sharing good practices in integrating GenAI into science learning. These findings support the UTAUT theory (Venkatesh et al., 2003), particularly the facilitating conditions construct, which emphasizes the importance of organizational support and resources in determining technology usage behavior.

On the pedagogical side, GenAI has been shown to strengthen student engagement and learning motivation. A study in 7th grade showed that AI-based chatbots combined with mind mapping provided instant feedback and helped students overcome programming errors, thereby facilitating the personalization of the learning process (Ye et al., 2025). Similar findings were obtained from the use of NAO robots combined with LLM, which not only increased cognitive engagement but also responded to students' emotional conditions in elementary school (Fragakis et al., 2025). This is consistent with learning motivation theory and self-determination theory (Ryan & Deci, 2020), where higher engagement supports students' autonomy, competence, and social connectedness.

However, despite its strong supporting potential, the findings also reveal a number of significant barriers. One of the main structural barriers is limited funding, lack of training, and uneven infrastructure, especially in rural schools (Kim, 2025). These obstacles are in line with the literature on equity in education (OECD, 2019), which emphasizes that disparities in access to technology will widen the gap in educational quality. Teachers also report an additional burden in orchestrating new technologies and the challenge of integrating AI content into local curricula (Al-Karasneh et al., 2025; Filiz et al., 2025).

In addition to structural barriers, there are also pedagogical risks. Ravi et al., (2025) note teachers' concerns that excessive automation may reduce space for spontaneous learning and the development of students' soft skills. Ye et al., (2025) warn that instant feedback from AI can result in superficial understanding if not balanced with scaffolding from teachers. In a technical context, the limitations of NAO robot emotion recognition due to environmental conditions (e.g., noise) indicate that embodied AI-based personalization still faces challenges (Fragakis et al., 2025). Ronksley-Pavia et al., (2025) also highlight the potential for bias and data security issues, especially in supporting students with special needs, making teacher involvement as supervisors absolutely necessary.

Thus, the factors supporting the implementation of GenAI in K-12 can be understood through the lens of TAM and UTAUT, where usefulness, ease of use, and enabling conditions encourage adoption. Conversely, structural and pedagogical barriers highlight the importance of linking technology integration with the principles of educational equity, so that access, quality, and ethics remain guaranteed. These findings confirm that the success of GenAI integration for personalized learning depends not only on technological sophistication, but also on teacher readiness, educational system support, and pedagogical control that ensures technology is used to strengthen, not replace, meaningful learning practices.

CONCLUSION

This systematic literature review examines how generative artificial intelligence (GenAI) has been implemented to support teacher-driven personalized learning in K-12 education. Three main conclusions can be drawn.

First, this study confirms that GenAI has great potential to transform personalized learning in K-12 classrooms. Across various subjects, GenAI has been used to tailor content to students' readiness levels, provide real-time adaptive feedback, contextualize abstract concepts through analogies close to everyday experiences, and support creativity and collaboration through project-based learning. This is in line with the theories of differentiated learning, scaffolding, and situated learning, but provides a new breakthrough because it enables automation and scalability of personalization at a level that was previously difficult to achieve. The novelty of these findings lies in how GenAI expands personalization, not only in the differentiation of academic content, but also in adaptive, contextual, and creativity-oriented learning experiences.

Second, the study shows that teachers remain key actors in ensuring the effectiveness and ethical use of GenAI. Teachers act as designers, facilitators, evaluators, and ethical mediators who validate and adjust AI outputs to curriculum goals and student needs. This supports the TPACK framework, which emphasizes that meaningful personalization occurs when technology is integrated with pedagogical knowledge and content. An important breakthrough here is the shift in perspective from AI as merely a tool to its position as a pedagogical partner, where teachers play a role in orchestrating the balance between automation and human judgment.

Third, this study identifies a dual landscape of supporting and inhibiting factors. Supporting factors include institutional support, teacher professional development programs, and AI features that increase motivation and engagement through feedback and adaptive learning paths. Meanwhile, barriers include infrastructure gaps, training limitations, ethical and privacy issues, the risk of over-automation, and the potential for superficial understanding. These findings are consistent with technology adoption theories such as TAM and UTAUT, but also emphasize the importance of the principle of equity in education. A novel finding is the assertion that the adoption of GenAI in K-12 requires not only technical readiness, but also a socio-pedagogical framework to ensure fairness, inclusivity, and ethical standards.

Based on these conclusions, several recommendations can be made. Schools and policymakers need to prioritize equitable access to infrastructure and targeted professional development programs so that teachers are truly ready to utilize GenAI for differentiated learning. Further research should focus on longitudinal and real-classroom evidence regarding the impact of GenAI on student learning outcomes, creativity, and social-emotional development. In addition, clear ethical and pedagogical guidelines are needed to limit the role of automation and affirm the authority of teachers, so that GenAI truly enhances, rather than replaces, authentic learning experiences.

Overall, this study shows that GenAI is a new breakthrough in teacher-based personalized learning in K-12 education. This technology opens up enormous opportunities to expand the scale of personalization and creativity, while presenting pedagogical, ethical, and equity challenges that must be overcome through teacher leadership, institutional support, and careful integration into educational practice.

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