

# A Review of Artificial Intelligence in K-12 Education

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## Abstract

Artificial intelligence (AI) has garnered significant interest within the educational domain over the past decade, promising to revolutionise teaching and learning. This paper provides a comprehensive overview of systematic reviews conducted from 2010 to 2023 on the implementation of AI in K-12 education. By synthesising findings from ten selected systematic reviews, this study explores the multifaceted opportunities and challenges posed by AI in education. The analysis reveals several key findings: AI's potential to personalise learning, enhance student motivation, and improve teaching efficiency are highlighted as major strengths. However, the study also identifies critical concerns, including teacher resistance, high implementation costs, ethical considerations, and the need for extensive teacher training. These findings represent the most significant insights from the analysis, while additional findings further underscore the complexity and scope of AI integration in educational settings. The study employs a SWOT analysis to summarise these insights, identifying key areas for future research and policy development. This review aims to guide educators, policymakers, and researchers in effectively leveraging AI to enhance educational outcomes while addressing its inherent challenges.

## Keywords

AI in Education, Digital Education, Educational Technology, Technology Enhanced Learning, K-12 Education, Systematic Literature Review

## 1. Introduction

The widespread appeal and success of AI technology can be attributed to its interdisciplinary nature, which has had a substantial impact on various sectors, including education [1]. This is evident from the significant increase in publica-

tions on AI in education (AIEd) [2]. Technologies such as intelligent tutoring systems [3], deep learning, and machine learning [4] have greatly advanced the concept of personalized learning [5]. Indeed, AIEd is anticipated to enhance the learning experiences of students [6]. However, the integration of AI in K-12 education faces challenges, including ethical considerations and infrastructure requirements. This umbrella overview aims to provide a thorough synthesis and analysis of various systemic reviews conducted from 2010 to 2023, focusing on the opportunities and challenges of AI in K-12 education (AI4K12). Due to the expansive and dynamic nature of AI, defining it precisely can be challenging. Scholars like Russell and Norvig [7] describe AI as an entity that mimics human cognitive functions such as “learning” and “problem-solving”. Alternatively, Kaplan and Haenlein [8] define AI as a system’s ability to learn from data to accomplish specific goals. In the context of education, AI’s integration is transforming various aspects, including curriculum content, instructional methods, and assessment tools [9]. Despite the potential benefits of AI in education, numerous gaps and issues remain unresolved. Several authors [10]-[12] have pointed out the need for a deeper understanding of both the positive and negative impacts of AI in educational settings.

AI has long been present in education, but it has recently gained significant traction due to major technological advancements [13]. As AI becomes more integrated into educational systems, institutions and policymakers must reassess their current educational policies to accommodate these technological advancements. This study is crucial as it highlights the need for policymakers to devise strategies that capitalize on the opportunities and address the challenges posed by AI in education. It also responds to the academic call for a comprehensive examination of AI’s benefits and challenges, as noted by scholars such as Hrastinski *et al.* [14]. Conducting an umbrella overview study can shed light on existing gaps in the literature and identify areas for future research. Consequently, this study merges various systemic reviews on AI in education from different perspectives, including AI in language teaching, STEM education, inclusive education, and gamification. The aim of this study is to explore the advantages and challenges associated with AI4K12, based on systematic reviews carried out from 2021 to 2023. Therefore, the central research question addressed in this study is: what strengths, weaknesses, opportunities, and threats arise when implementing AI4K12?

## 2. Method

### 2.1. Search Strategy

To determine the search string, systemic reviews from 2021 to 2023 were initially selected and then searched using keywords such as “AIEd”, “AI4K12”, and “Systemic Review”. The article retrieval followed the PRISMA protocol, relying solely on electronic searches. This search included databases such as EBSCO and Science Direct, encompassing both peer-reviewed and non-peer-reviewed arti-

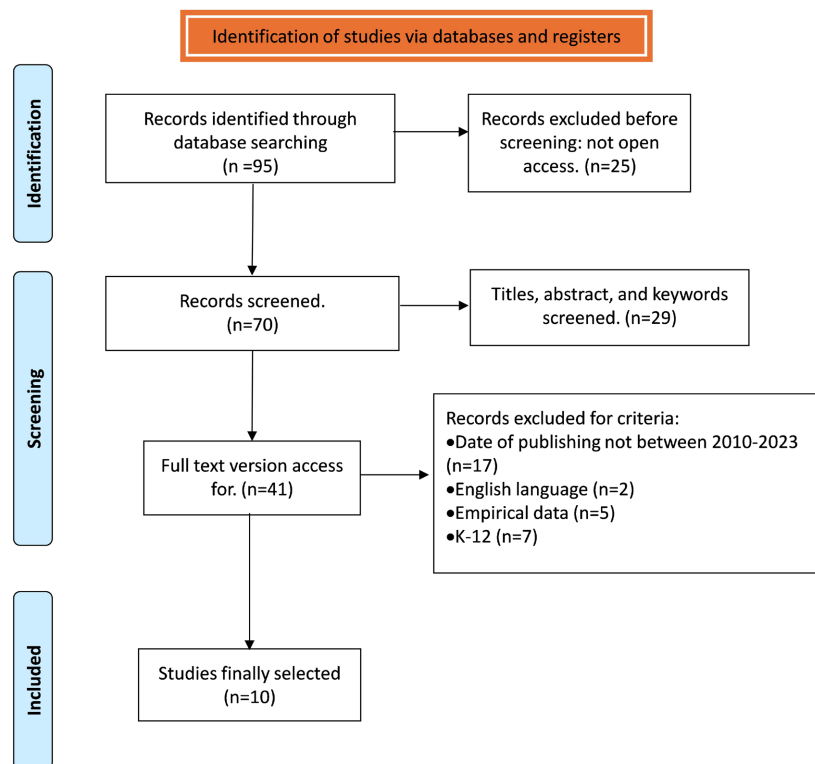
cles to provide a broader and more critical analysis of the scope.

## 2.2. Inclusion and Exclusion Criteria

To address the research questions, the PRISMA methodology was employed, as outlined in **Figure 1**. The inclusion and exclusion criteria detailed in **Table 1** were applied. Initially, 95 papers were identified and assessed based on these criteria. Papers focused on higher education, Master and PhD theses, medical education, and those based on technical AI knowledge were excluded, narrowing the selection to 70. After scanning titles, abstracts, and keywords, 41 papers remained. Further filtering included only papers published from 2010 to 2023, written in English, and presenting systemic reviews, ultimately resulting in a final list of 10 systemic review documents focused on the impact of AI on K-12 students.

**Table 1.** Inclusion vs exclusion criteria.

Inclusion	Exclusion
Published between 2010-2023	Published before 2010
English language	Not in English
Systematic review	Primary data
AI in education	No use of AI
K-12 student	Higher education
	Technical or computing



**Figure 1.** PRISMA flowchart showing the article screening process (source: authors).

### 2.3. Existing Systematic Reviews on AI4K12

To develop an overview on AI4K12, this paper focuses on systematic review articles related to K-12 education. Firstly, Ayotunde *et al.* [15] examined 25 papers on the impact of AI integrated with learning management systems (LMS) on foreign language learning, covering studies from 2011 to 2021. The author observed that AI positively affects teachers by reducing their workload and improve students writing, speaking, reading, and listening skills. Additionally, the author calls for further research to understand students' perceptions of AI tools and their impact on performance.

Salas-Pilco *et al.* [16] analysed 27 papers and found that AI has a promising impact on teaching minority groups and fostering positive social behaviour. The study also highlighted AI's role in enhancing inclusivity for disabled students and its positive impact when used in games related to STEM education. However, two major challenges were identified: the high cost of implementation due to the need for sophisticated facilities and the readiness of the school environment to adopt the technology, and teachers' resistance stemming from concerns about job security and fear of being replaced. The study also emphasised the importance of professional development training for both teachers and students.

Rizvi *et al.* [17] analysed 28 articles to investigate recent empirical studies on AI in education (AIEd) for successful AI4K12 implementation, focusing on two models: the SEAME model and the "five big ideas in AI". The author proposed the gamification of AI-based learning [18]. The findings indicated that students achieved higher scores when they had prior programming knowledge [19] and when they dedicated more time to AI learning tools. However, the author identified several weaknesses in the literature, including a lack of longitudinal and demographic studies. There is also a call for more research on AI's implications for gender and age differences, as existing studies [20] are neither consistent nor sufficient to form a solid foundation. Additionally, more studies are needed to compare AI learning contexts with face-to-face and blended learning environments. The importance of professional development to enhance teachers' skills is also emphasised.

Gonzalez *et al.* [21] examined 22 papers and highlighted AI's significant potential in education. However, the author emphasised the importance of maintaining a human-centred approach in education, particularly when guiding students' future career paths [22]. The study also found that students performed better when taught using AI tools [23]. The author suggested expanding empirical research on AI in education and training students as future professionals, given the increasing role of robots and deep learning machines [24].

Similarly, Martinez *et al.* [25], with a review of 9 papers, highlighted AI's strength in assessment. The author identified four classifications of AI in education: Analytical AI, which identifies patterns in data; Functional AI, which makes decisions based on analysis [26]; Interactive AI, designed to automate communication such as chatbots or voice assistants [27]; and Textual AI, which

detects text and generates content [28]. These techniques are used for data mining and intelligent tutoring systems [29] to understand students' learning processes [30].

Taking a broader perspective, Zafari *et al.* [31] analysed 210 papers and identified four key areas where AI impacts education: student performance (assessment), teaching (content delivery), behaviour (analysing students' actions), and selection (choosing a major at university). The author discussed the use of robots as teaching assistants [32] and emphasised gamification as a means to enhance student engagement in AI learning contexts.

Bhutoria [33], in a review of 353 articles, highlighted AI's role in promoting personalised learning. The author also noted three major AI projects—AI research and development, the new generation AI development plan, and AI for all—led by the USA, China, and India, respectively. While acknowledging the challenges related to infrastructure, the author pointed out that AI enhances student-centred learning. Students with AI companions performed better than those with human companions [34] and experienced a more engaging learning process, reducing the risk of failure or dropout [35].

Casal-Otero *et al.* [36] reviewed 179 papers on integrating AI as a subject. The author mentioned international efforts to include AI in educational curricula worldwide, such as in the USA, China, Germany, Singapore, and Canada. Due to its interdisciplinary nature, the author suggested embedding AI in existing subjects like biology, philosophy, and science. The use of gamification to engage students in the learning process was also supported [37] [38]. Finally, the author called for research on the gender gap and concluded that there is no need to create a separate AI discipline but rather to integrate AI knowledge into existing subjects.

Crompton *et al.* [39] reviewed 169 studies, advocating for the collection of more systematic reviews in the field to strengthen decision-making processes, rather than relying on media myths or hyperbole about AI in education. Her analysis revealed that most published papers in this field come from the USA and China and frequently reported teachers' negative perceptions of AI. She recommended the TPACK framework for professional development to enhance AI teaching skills. Yue *et al.* [40] reviewed 32 papers discussing various aspects of AI literacy for K-12, including machine learning and visual tools. The authors claimed that most research on AI and education has focused on student motivation rather than academic achievement. They also argued that the majority of instruments used in the selected papers were qualitative. The study found that most AI applications were in face-to-face learning environments and called for more research on the impact of AI in asynchronous contexts. **Table 2** breaks down all the systematic reviews in terms of objectives, findings, and recommendations.

This synthesis of multiple systematic reviews aimed to explore various aspects of AI in K-12 education (AIK12), addressing objectives, findings, and recom-

mendations for future research. Several themes and patterns emerged through this review, highlighting the current advancements and challenges of AI4K12.

**Table 2.** Summary of systematic review articles selected on AI4K12.

Author(s)	Objective	Findings	Recommendation
Ayotunde <i>et al.</i> , (2023) 25 papers From 2011-2021	To study the impact of AI on foreign language teaching when using LMS (Moodle, Edmodo).	Develop students' four language skills (writing, reading, speaking, listening) and improvement their motivation. AI provides a personalized learning; thus, the learning experience of teachers & students is improved.	Teachers must decide which AI tools fit best in their context. More studies to investigate teachers' perception on AI as assistant tools. Call for more research on AI in underdeveloped countries.
Casal-Otero <i>et al.</i> , (2023) 179 papers From 2021-2023	To discuss the implementation of AI literacy into K-12 curriculum.	For a successful implementation, teachers and students have to be involved. Training on AI must include both technical & ethical aspects.	Better to embed AI literacy with already existing disciplines, rather than teach it alone as a separate. Need a framework and a training program on how to prepare teachers for AI4K12. More research to address the gender gap.
Bhutoria (2022) 353 papers From 2019-2021	To describe the personalized learning experience in USA, China, and India.	AI augments educational content customizes it according to students' needs, and anticipated learning difficulties. Personalized learning help including marginalized learners and boost their teaching and learning productivity (Yonezawa <i>et al.</i> , 2012).	None.
Rizvi <i>et al.</i> , (2023) 28 papers From 2019-2022	Investigate recent empirical studies on AI4K12.	Students with programming knowledge "prerequisite" scored higher. Students participated in AI learning improved cognitive & affective perception.	AI should be implemented in K-12 curriculum. More research on minorities. Need longitudinal studies on AI4k12. Particularly assessment. Need for more demographic studies (age, gender).
Gonzalez-Calatayud <i>et al.</i> , (2021) 22 papers From 2010-2020	To analyse the use of AI for students' assessment.	AI has the capability to facilitate and improve education. AI technology in education need to be humanized, do not exclude human from decision-making. AI facilitates face 2 face and blended learning.	Specific training for teachers & students. Create collaboration channels between AI and educational experts. Need more studies on demographic aspects because findings are not consistent with age groups and gender.
Martinez-Comesana <i>et al.</i> , (2023) 9 papers From 2010-2023	To analyse the contribution of AI in student assessment for primary/secondary level.	Assist students acquiring the 21st century skills. Importance of data mining in designing and generating personalize assessments; but consider limitations such as creating a bias for not considering family, health condition of student.	None.
Salas-Pilco <i>et al.</i> , (2022) 27 papers From 2017-2021	To study the impact of AI on education.	AIEd is promising when teaching minorities, it provides equitable opportunities, and enhance STEM education. Challenges: High cost, negative physical outcome, resistance from teachers, need for training (students & teachers).	Provide a culturally sensitive curriculum. PD for teachers and students.

**Continued**

Zafari <i>et al.</i> , (2022) 210 papers 2011-2021	To investigating the role and the impact of AI on K-12 education.	High school have been the most investigated, followed by middle school & elementary. VR - Games - AR are significant in learning. Incorporating AI in curricula may not be obvious.	Need for longitudinal research.
Crompton <i>et al.</i> (2022) 169 papers From 2011-2021	To investigating the positive and negatives sides of AI on K-12 education.	None.	Need more studies on teachers' perception. PD on "TPACK" for teachers.
Yue <i>et al.</i> (2022) included 32 papers	To identify the pedagogical characteristics of AIEd.	None.	Need more longitudinal studies. Empirical studies on students' knowledge rather than motivation.

### 2.4. Use of a SWOT Analysis in This Study

SWOT analysis is a strategic planning tool used to identify and analyse the Strengths, Weaknesses, Opportunities, and Threats related to a particular project or in a business context. The primary objective of a SWOT analysis is to support organisations in developing a full awareness of all the factors involved in making a decision. The acronym SWOT stands for 1) Strengths: Internal factors that are advantageous to achieving the objectives; 2) Weaknesses: Internal factors that might hinder achieving the objectives; 3) Opportunities: External factors that could be leveraged for success; 4) Threats: External factors that could cause trouble or pose risks to achieving the objectives.

The application of SWOT analysis in this study is particularly relevant as it provides a structured framework to comprehensively evaluate the multifaceted impact of AI in K-12 education. By categorising the findings from various systematic reviews into strengths, weaknesses, opportunities, and threats, the analysis offers a holistic view of the current state and future prospects of AI integration in educational settings. This approach not only highlights the positive aspects and potential areas for growth but also brings attention to existing challenges and risks, enabling stakeholders to make informed decisions.

Using SWOT analysis allows the study to 1) synthesise diverse perspectives and findings from multiple sources into a coherent framework. 2) Identify key areas where AI has shown significant benefits (strengths) and where there are notable gaps or issues (weaknesses). 3) Highlight external opportunities that can be harnessed to enhance AI integration and mitigate potential threats that need to be addressed. 4) Provide actionable insights and recommendations for educators, policymakers, and researchers, facilitating strategic planning and policy development. In summary, the SWOT analysis serves as an effective tool to summarise and interpret the extensive data collected from systematic reviews, offering a clear and organised perspective on the implementation of AI in K-12 education. To better organise the most frequently mentioned statements on AI in education, **Table 2** could be presented as a SWOT analysis (see **Table 3**).

**Table 3.** SWOT analysis.

Strength	AI provide a personalized learning; thus the learning experience of teachers & students is improved (6 times). Personalized learning help including marginalized learners and boost their teaching and learning productivity (Yonezawa <i>et al.</i> , 2012) (3 times). Students with prior knowledge on AI perform better in exams (2 times). AI facilitates face 2 face and blended learning. Enhance STEM education. Reduce teachers' workload (2 times).
Opportunities	Develop students' four language skills (writing, reading, speaking, listening) (2 times). Improvement students' motivation (2 times). Teachers and students' perceptions on AI4K12 plays a pivotal role on the success of such project (2 times). Better to embed AI literacy with already existing disciplines. AI should be implemented in AI4K12 curriculum (2 times). Most AI4K12 articles interested in students' assessment. Create collaboration channels between AI and educational experts. Assist students acquiring the 21st century skills (2 times). AI Enhance Global collaboration.
Weaknesses	More studies to investigate teachers' perception on AI as assistant tools (3 times). More research on AI is needed in underdeveloped countries. Need for a framework and a training program on how to prepare teachers/students for AI4K12 (6 times). More research to address the gender gap (3 times). Challenges to personalized learning: tech-heavy, require training for agents, data privacy concerns. More research on minority groups. Need longitudinal studies on AI4K12 (3 times). Research is needed to clarify whether online or blended AI learning interventions are as effective as face-to-face activities. More studies to understand teachers' role. Majority of AIED research focus of higher education. High cost of adopting AI tools (2 times). Teacher resistance (4 times). The AI algorithm may not include minority culture characteristics (2 times).
Threats	Teachers must decide which AI tools fit best in their context. Training on AI have to include both technical & ethical aspects. Young age develops over-reliance habits on AI. AI technologies in education need to be humanized, don't exclude human from decision-making (2 times). Negative physical outcome (headache, visual problems).

### 3. Discussion of Findings

By assessing the strengths, weaknesses, opportunities, and challenges, key insights have emerged. This analysis was conducted to address the research questions regarding the opportunities and challenges of AI4K12, based on different systemic reviews of AI4K12 from the past three years.

#### 3.1. Strengths

AI's most significant strength lies in its ability to provide personalised learning experiences for both teachers and students. This was explicitly mentioned in six of the selected systemic reviews. Additionally, two articles highlighted AI-enabled tools' capacity to reduce teachers' workload. Other, less frequently mentioned strengths include AI tools' ability to accurately assess students, enhance both face-to-face and blended learning environments, and improve STEM education.

#### 3.2. Opportunities

Regarding opportunities, two articles emphasized AI's role in language acquisition, increasing student motivation and engagement, and helping students acquire 21st-century skills. Similarly, two articles underscored the importance of integrating AI into educational curricula and examining teachers' and students' perceptions of AI for a successful learning experience. Additionally, the potential of AI to enhance global collaboration was discussed. Finally, it was noted that most papers on AI4K12 focus on student assessments.

### 3.3. Weaknesses

Despite its potential, several weaknesses are evident. Firstly, most AI research has focused on higher education rather than K-12. Secondly, AI has a limited impact on underdeveloped countries and minority groups due to existing algorithms not being culturally sensitive to their conditions. The need for longitudinal research and a training framework to prepare teachers was a prominent point in more than six studies. Additionally, teachers' resistance to implementing AI tools and the high cost of such implementations were noted. Lastly, there is a call for more empirical research comparing face-to-face or blended learning environments with AI-enhanced learning settings.

### 3.4. Threats

AI-generated outputs have consistently faced criticism for not being verified by experts, underscoring the need to humanise this technology and deem it unreliable for determining students' learning paths. Another concern is the potential for young users to develop an over-reliance on AI, which can lead to health issues. Additionally, data privacy, content copyright, and ethical concerns pose significant threats to the implementation of AI4K12.

## 4. Conclusions

This study provides a comprehensive synthesis of systematic reviews conducted from 2010 to 2023 on the implementation of AI in K-12 education (AI4K12). The analysis revealed numerous strengths, opportunities, weaknesses, and threats associated with AI in the educational landscape. In terms of strengths, AI significantly enhances personalised learning experiences for both teachers and students. AI tools can reduce teachers' workload and improve student engagement and motivation. AI has the potential to enhance both face-to-face and blended learning environments, as well as improve STEM education. Regarding opportunities, AI can aid in language acquisition and help students acquire 21st-century skills. It is also known that integrating AI into educational curricula and understanding perceptions of AI among teachers and students can enhance learning experiences. Lastly, AI offers opportunities for global collaboration and innovation in student assessments.

On the other hand, most AI research focuses on higher education rather than K-12. Existing AI algorithms may not be culturally sensitive, limiting their impact on underdeveloped countries and minority groups. There is a need for longitudinal research training frameworks to prepare teachers. High implementation costs and teacher resistance are significant barriers. Furthermore, AI-generated outputs are often critiqued for not being verified by experts, leading to reliability issues in determining students' learning paths. Over-reliance on AI can lead to health issues among young users. Data privacy, content copyright, and ethical concerns pose significant challenges to AI4K12 implementation.

Future research should incorporate longitudinal studies to gain a comprehen-

sive understanding of the long-term impacts of AI on K-12 education. Additionally, demographic studies focusing on gender, age, and cultural differences are essential for creating more inclusive and effective AI tools. Developing comprehensive training programs and frameworks for teachers is crucial. Professional development initiatives should focus on equipping teachers with the necessary skills to effectively integrate AI into their teaching practices and to address potential resistance to adopting these technologies. There is a need for more empirical research comparing the effectiveness of AI-enhanced learning environments with traditional face-to-face and blended learning settings. Such studies will help identify best practices for AI implementation in various educational contexts. Addressing ethical concerns, data privacy, and content copyright issues is vital. Research should explore strategies to humanise AI technology, ensuring it complements rather than replaces human decision-making in education. Targeted research on the implementation of AI in underdeveloped countries and among minority groups is necessary. This research will aid in developing culturally sensitive AI tools that can be effectively utilised in diverse educational settings. Investigating the role of gamification and other interactive AI technologies can provide valuable insights into enhancing student engagement and motivation. These approaches have the potential to make learning more enjoyable and effective, thereby improving educational outcomes. By leveraging the strengths, addressing the weaknesses, capitalising on opportunities, and mitigating the threats, educators, policymakers, and researchers can maximise the potential of AI to enhance educational outcomes in K-12 settings. This synthesis serves as a foundational guide for future research and policy development in the rapidly evolving field of AI in education.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

### References

- [1] Charles, T. and Hill, C. (2023) Remaining Steadfast in the Face of Overwhelming Change. In: Lamie, J. and Hill, C., Eds., *The Evolving Nature of Universities*, Routledge, 89-98. <https://doi.org/10.4324/9781003389361-7>
- [2] Luckin, R., Holmes, W., Griffiths, M. and Forcier, L.B. (2016) Intelligence Unleashed: An argument for AI in Education.
- [3] Beaulac, C. and Rosenthal, J.S. (2019) Predicting University Students' Academic Success and Major Using Random Forests. *Research in Higher Education*, **60**, 1048-1064. <https://doi.org/10.1007/s11162-019-09546-y>
- [4] Benotti, L., Martinez, M.C. and Schapachnik, F. (2018) A Tool for Introducing Computer Science with Automatic Formative Assessment. *IEEE Transactions on Learning Technologies*, **11**, 179-192. <https://doi.org/10.1109/tlt.2017.2682084>
- [5] Chen, X., Zou, D., Xie, H., Cheng, G. and Liu, C. (2022) Two Decades of Artificial Intelligence in Education. *Educational Technology & Society*, **25**, 28-47.

- <https://www.jstor.org/stable/48647028>
- [6] Alam, A. (2021). Possibilities and Apprehensions in the Landscape of Artificial Intelligence in Education. 2021 *International Conference on Computational Intelligence and Computing Applications*, Las Vegas, 26-27 November 2021, 1-8. <https://doi.org/10.1109/iccica52458.2021.9697272>
- [7] Russell, S.J. and Norvig, P. (2016) *Artificial Intelligence: A Modern Approach*. Pearson.
- [8] Kaplan, A. and Haenlein, M. (2019) Siri, Siri, in My Hand: Who's the Fairest in the Land? on the Interpretations, Illustrations, and Implications of Artificial Intelligence. *Business Horizons*, **62**, 15-25. <https://doi.org/10.1016/j.bushor.2018.08.004>
- [9] McArthur, D., Lewis, M. and Bishary, M. (2005) The Roles of Artificial Intelligence in Education: Current Progress and Future Prospects. *Journal of Educational Technology*, **1**, 42-80. <https://doi.org/10.26634/jet.1.4.972>
- [10] Chen, L., Chen, P. and Lin, Z. (2020) Artificial Intelligence in Education: A Review. *IEEE Access*, **8**, 75264-75278. <https://doi.org/10.1109/access.2020.2988510>
- [11] Holmes, W., Bialik, M. and Fadel, C. (2023) *Artificial Intelligence in Education*. Globethics Publications, 621-653. <https://doi.org/10.58863/20.500.12424/4276068>
- [12] Hwang, G., Xie, H., Wah, B.W. and Gašević, D. (2020) Vision, Challenges, Roles and Research Issues of Artificial Intelligence in Education. *Computers and Education: Artificial Intelligence*, **1**, Article 100001. <https://doi.org/10.1016/j.caeai.2020.100001>
- [13] Charles, T. (2021) The Past, Present and Future of Assessments in the Higher Education Sector. In: Hill, C., Lamie, J. and Gore, T., Eds., *The Evolution of Transnational Education*, Routledge, 126-136. <https://doi.org/10.4324/9781003225386-13>
- [14] Hrastinski, S., Olofsson, A.D., Arkenback, C., Ekström, S., Ericsson, E., Fransson, G., et al. (2019) Critical Imaginaries and Reflections on Artificial Intelligence and Robots in Postdigital K-12 Education. *Postdigital Science and Education*, **1**, 427-445. <https://doi.org/10.1007/s42438-019-00046-x>
- [15] Oluwafemi Ayotunde, O., Jamil, D.I. and Cavus, N. (2023) The Impact of Artificial Intelligence in Foreign Language Learning Using Learning Management Systems: A Systematic Literature Review. *Information Technologies and Learning Tools*, **95**, 215-228. <https://doi.org/10.33407/itlt.v95i3.5233>
- [16] Salas-Pilco, S.Z., Xiao, K. and Oshima, J. (2022) Artificial Intelligence and New Technologies in Inclusive Education for Minority Students: A Systematic Review. *Sustainability*, **14**, Article 13572. <https://doi.org/10.3390/su142013572>
- [17] Rizvi, S., Waite, J. and Sentance, S. (2023) Artificial Intelligence Teaching and Learning in K-12 from 2019 to 2022: A Systematic Literature Review. *Computers and Education: Artificial Intelligence*, **4**, Article 100145. <https://doi.org/10.1016/j.caeai.2023.100145>
- [18] Priya, S., Bhadra, S., Chimalakonda, S. and Venigalla, A.S.M. (2022) A Game for Introducing Machine Learning Concepts to K-12 Students. *Interactive Learning Environments*, **32**, 229-244. <https://doi.org/10.1080/10494820.2022.2084115>
- [19] Norouzi, N., Chaturvedi, S. and Rutledge, M. (2020) Lessons Learned from Teaching Machine Learning and Natural Language Processing to High School Students. *Proceedings of the AAAI Conference on Artificial Intelligence*, **34**, 13397-13403. <https://doi.org/10.1609/aaai.v34i09.7063>
- [20] Williams, R., Park, H.W. and Breazeal, C. (2019). A Is for Artificial Intelligence. *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*,

- Glasgow, 4-9 May 2019, 1-11. <https://doi.org/10.1145/3290605.3300677>
- [21] González-Calatayud, V., Prendes-Espinosa, P., & Roig-Vila, R. (2021). Artificial Intelligence for Student Assessment: A Systematic Review. *Applied Sciences*, **11**, Article 5467. <https://doi.org/10.3390/app11125467>
- [22] Ulum, Ö.G. (2020) A Critical Deconstruction of Computer-Based Test Application in Turkish State University. *Education and Information Technologies*, **25**, 4883-4896. <https://doi.org/10.1007/s10639-020-10199-z>
- [23] Goel, A.K. and Joyner, D.A. (2017). Using AI to teach AI: Lessons from an Online AI class. *Ai Magazine*, **38**, 48-59. <https://doi.org/10.1609/aimag.v38i2.2732>
- [24] Roig-Vila, R. and Moreno-Isac, V. (2020) Computational Thinking in Education. Bibliometric and Thematic Analysis. *Distance Education Magazine*, **20**, 1-24. <https://doi.org/10.6018/red.402621>
- [25] Martínez-Comesaña, M., Rigueira-Díaz, X., Larranaga-Janeiro, A., Martínez-Torres, J., Ocarranza-Prado, I. and Kreibel, D. (2023) Impact of Artificial Intelligence on Assessment Methods in Primary and Secondary Education: Systematic Literature Review. *Revista de Psicodidáctica*, **28**, 93-103. <https://doi.org/10.1016/j.psicoe.2023.06.002>
- [26] Aslam, N., Khan, I., Alamri, L. and Almuslim, R. (2021) An Improved Early Student's Academic Performance Prediction Using Deep Learning. *International Journal of Emerging Technologies in Learning*, **16**, 108-122. <https://www.learntechlib.org/p/220061/>
- [27] Pivetti, M., Di Battista, S., Agatolio, F., Simaku, B., Moro, M. and Menegatti, E. (2020) Educational Robotics for Children with Neurodevelopmental Disorders: A Systematic Review. *Heliyon*, **6**, e05160. <https://doi.org/10.1016/j.heliyon.2020.e05160>
- [28] Caratozzolo, P., Rodriguez-Ruiz, J. and Alvarez-Delgado, A. (2022). Natural Language Processing for Learning Assessment in Stem. 2022 *IEEE Global Engineering Education Conference (EDUCON)*, Tunisia, 28-31 March 2022, 1549-1554. <https://doi.org/10.1109/educon52537.2022.9766717>
- [29] Ventura, M.D. (2016) Creating Inspiring Learning Environments by Means of Digital Technologies: A Case Study of the Effectiveness of Whatsapp in Music Education. In: Vincenti, G., Bucciero, A., Helfert, M. and Glowatz, M., Eds., *E-Learning, E-Education, and Online Training*, Springer International Publishing, 36-45. [https://doi.org/10.1007/978-3-319-49625-2\\_5](https://doi.org/10.1007/978-3-319-49625-2_5)
- [30] Baepler, P. and Murdoch, C. (2010) Academic Analytics and Data Mining in Higher Education. *International Journal for the Scholarship of Teaching and Learning*, **4**, Article 17. <https://doi.org/10.20429/ijsotl.2010.040217>
- [31] Zafari, M., Bazargani, J.S., Sadeghi-Niaraki, A. and Choi, S. (2022) Artificial Intelligence Applications in K-12 Education: A Systematic Literature Review. *IEEE Access*, **10**, 61905-61921. <https://doi.org/10.1109/access.2022.3179356>
- [32] Mubin, O., Stevens, C.J., Shahid, S., Mahmud, A.A. and Dong, J. (2013) A Review of the Applicability of Robots in Education. *Technology for Education and Learning*, **1**, 5. <https://doi.org/10.2316/journal.209.2013.1.209-0015>
- [33] Bhutoria, A. (2022) Personalized Education and Artificial Intelligence in the United States, China, and India: A Systematic Review Using a Human-in-The-Loop Model. *Computers and Education: Artificial Intelligence*, **3**, Article 100068. <https://doi.org/10.1016/j.caeai.2022.100068>
- [34] Fryer, L.K., Ainley, M., Thompson, A., Gibson, A. and Sherlock, Z. (2017) Stimu-

- lating and Sustaining Interest in a Language Course: An Experimental Comparison of Chatbot and Human Task Partners. *Computers in Human Behavior*, **75**, 461-468. <https://doi.org/10.1016/j.chb.2017.05.045>
- [35] Hadwer, A.A., Gillis, D. and Rezania, D. (2019). Big Data Analytics for Higher Education in the Cloud Era. 2019 *IEEE 4th International Conference on Big Data Analytics (ICBDA)*, Suzhou, 15-18 March 2019, 203-207. <https://doi.org/10.1109/icbda.2019.8713257>
- [36] Casal-Otero, L., Catala, A., Fernández-Morante, C., Taboada, M., Cebreiro, B. and Barro, S. (2023) AI Literacy in K-12: A Systematic Literature Review. *International Journal of STEM Education*, **10**, Article No. 29. <https://doi.org/10.1186/s40594-023-00418-7>
- [37] Reyes, A.A., Elkin, C., Niyaz, Q., Yang, X., Paheding, S. and Devabhaktuni, V.K. (2020). A Preliminary Work on Visualization-Based Education Tool for High School Machine Learning Education. 2020 *IEEE Integrated STEM Education Conference (ISEC)*, Princeton, 1 August 2020, 1-5. <https://doi.org/10.1109/isec49744.2020.9280629>
- [38] Alshehhi, N., Alzouebi, K. and Charles, T. (2024) Perspectives on Game-Based Learning within the Higher Education Sector. *Education Administration: Theory and Practice*, **30**, 3229-3233. <https://doi.org/10.53555/kuvey.v30i5.2153>
- [39] Crompton, H., Jones, M.V. and Burke, D. (2022) Affordances and Challenges of Artificial Intelligence in K-12 Education: A Systematic Review. *Journal of Research on Technology in Education*, **56**, 248-268. <https://doi.org/10.1080/15391523.2022.2121344>
- [40] Yue, M., Jong, M.S. and Dai, Y. (2022) Pedagogical Design of K-12 Artificial Intelligence Education: A Systematic Review. *Sustainability*, **14**, Article 15620. <https://doi.org/10.3390/su142315620>