Dual Impact of AI on Education: Boosting Personalization, Hindering Computational Thinking

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Abstract. The introduction and influence of artificial intelligence into our lives were not the same as any other technological progress, it questioned the fundamental rules of every field it fused and caused a radical change. Various aspects of education field were affected by this trend. In particular, the sharp impact of artificial intelligence on students' approach to assignments, topics, and learning methodology has caused concern in the academic field. In addition to accepting the presence of substantial positive effects, educators are worried about the irreversible negative impact of this integration. The foremost of these is the student's critical thinking ability. Such a dual effect of AI in the education sector, on the one hand, aims to provide easy access to information and personalized assistance, on the other hand, the possibility of hindering their ability to think critically is a profound. Our study aims to address this, to reveal its possible negative effects, lay groundwork for further research, and suggest solutions.

Keywords: Artificial Intelligence, Education, AI Impact on Education, Computational Thinking

1. Introduction

1.1. What is AI?

The term "Artificial Intelligence" (AI) was first mentioned by John McCarthy at the Dartmouth Artificial Intelligence Conference in 1956. Leading researchers from different disciplines converged to develop the concept around "thinking machines". The most common discussion was not about whether computers could mimic human intelligence, but rather about how and when it would happen. Nowadays, Artificial Intelligence is developing and extending over every part of the world at an alarming rate. [1], [2]

1.2. AI in Education

The introduction of AI into educational contexts may be traced to the 1970s. At that time, researchers were interested in seeing how computers might substitute for one-to-one human tutoring, which is considered to be the most efficacious approach to teaching but is inaccessible to most people. [3] Since those beginnings, the application of AI in education has expanded in multiple directions from student-facing AI (tools designed to support learning and assessment) to also include teacher-facing AI (designed to support teaching) and system-facing AI (designed to support

the management of educational institutions). [4] 'Intelligent', 'adaptive', and 'personalized' learning systems are increasingly being developed by the private sector for deployment in schools and universities around the world, creating a market expected to be worth 6 billion dollar in 2024 according to UNESCO Education Sector. [5] During this study we will focus on student support tools and its impacts on their Computational Thinking (CT) ability.

1.3. Computational Thinking (CT)

Since Jeanette Wing brought the term computational thinking to the forefront of the educational research field, there has been a dramatic expansion in studies examining the0 concept of computational thinking. [6] Wing outlined the basic definition of CT as a way of "solving problems, designing systems, and understanding human behavior by drawing on the concepts of computer science". On the other hand, according to the International Society for Technology in Education (ISTE) and Computer Science Teacher Association (CSTA), [7] CT is a problem-solving process that includes (but is not limited to) the following characteristics:

- Logically organizing and analyzing data
- Representing data through abstractions
- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources
- Generalizing and transferring this problem-solving process to a wide variety of problems

1.4. CT: A Critical Competency for Success in the Modern World

The report "Charting a Course for Success: America's Strategy for STEM Education", released by the White House in December 2018, included CT when laying out the vision for the United States to succeed in STEM education. [8] This recognition extends beyond America. "The Digital Competence Framework for Citizens" report by the European Commission's science and knowledge service has identified CT Competency as crucial and necessary in the modern era, especially in the context of Media literacy skills. [9]

With the key concepts of AI, its role in education, and critical thinking established, we will explore how AI specifically impacts educational practices. The upcoming section will review existing research on this topic, laying the groundwork for a more in-depth analysis of how AI tools influence students' behavior. The primary goal of this study is to provide insights to support future research and promote effective use of AI in education, while also preserving and enhancing students' Computational Thinking abilities.

2. Methodology

The authors operated cautiously to investigate how AI contributes to education. We pursued a structured procedure proposed by the well-known review methodology called Preferred Reporting Items for Systematic Reviews and Meta-Analyses. [10] The review process in the current study consisted of multiple stages. The following sections detail how each step was conducted for this study.

We utilized a combination of key terms including "AI," "Generative AI," "ChatGPT," and "intelligent systems," combined with "education" and "science." This search strategy was formulated to discover and evaluate a wide variety of relevant works centered on AI in teaching and education.

2.1. Search Strategy

We focused on prestigious digital repositories for relevant literature, particularly IEEE Xplore, Springer, ERIC (U.S. Dept. of Education), and the European Commission's science and knowledge service. In addition, we conducted searches on Google Scholar and Google for the most current surveys or studies.

2.2. Eligibility Criteria

Defining explicit eligibility standards helps specify the boundaries of the review. Inclusion of studies meeting essential prerequisites and exclusion of those not aligning with research goals are vital.

- The study must have utilized empirical methods (quantitative, qualitative, data collection, and analysis.
- A crucial requirement is the incorporation of artificial intelligence in the research.
- Studies that did not explicitly mention AI are not accepted.
- Excluding studies are only available in abstract form.

3. Findings

In this comprehensive literature review, we carefully analyzed 38 empirical studies focusing on the integration of AI in education and listed **Table 1**. Various research methodologies were followed within these studies. More than 10 papers in the year 2024 demonstrated an increasing interest in the topic of "AI in education".

Author(s)	Year	Country	Topic
Aldabe & Maritxalar [11]	2014	Spain	Teacher assistance
Blikstein et al. [12]	2014	USA	Patterns in learning
Figueiredo et al. [13]	2015	Portugal	Teaching-Learning Sequence
Zhu X [14]	2015	USA	ML approach toward optimal education
Satabdi Basu et al. [15]	2016	USA	CT in middle school
Avelino et al. [16]	2017	USA	ChatGPT usage in Physics
Balakrishnan [17]	2018	Malaysia	Personalized learning environment
García-Gorrostieta [18]	2018	Mexico	Automatic assessment

Rokade A et al. [19]	2018	India	Automated grading system using Na
Hossain et al.[20]	2019	USA	Students attitude towards sustainable learning
Lee et al. [21]	2019	USA	Automated scoring
Azcona et al. [22]	2019	Ireland	Automated evaluation
Jalil N et al. [23]	2019	Malaysia	Machines learning trends in education sector
Koć-Januchta et al. [24]	2020	Sweden	Students' interaction with AI
Yannier [25]	2020	USA	AI in education
VanLehn [26]	2020	USA	Tutoring systems
Perrotta [27]	2020	Australia	AI in education
J Kim [28]	2020	USA	Students' perspective on AI
Ferrarelli & Iocchi [29]	2021	Italy	AI usage in Physics
Deveci Topal [30]	2021	Turkey	Chatbot application
Maestrales [31]	2021	USA	Automatic assessment
Ngadiran N et al. [32]	2021	Malaysia	Self-Directed Language Learning
Lee et al. [33]	2022	Taiwan	Impact of AI tools
N Selwyn [34]	2022	Australia	Impact of AI
Dirin A et al.[35]	2022	Finland	ML to predict students' path
Cooper [36]	2023	Australia	ChatGPT usage in education
Elkhodr et al.[37]	2023	Australia	Students' perspective on AI
Bitzenbauer [38]	2023	Germany	ChatGPT in physics
Kieser et al. [39]	2023	Germany	ChatGPT in physics
Nasution [40]	2023	Indonesia	AI in biology class
Daher et al. [41]	2023	Israel	AI in chemistry class

Nja et al. [42]	2023	Nigeria	AI in science class
Cochran et al. [43]	2023	Switzerland	Automated evaluation
Nguyen [44]	2023	Vietnam	AI in biology class
Chiu et al. [45]	2023	USA	Future of AI in education
Chan [46]	2023	China	AI policy for university
Marzuki et al. [47]	2023	Indonesia	The impact of AI writing tools on the content
Ward B et al. [48]	2024	USA	Analyzing the Impact of AI Tools on Student Study Habits

Table 1: Articles included in the comprehensive review

3.1. AI Adoption

The results revealed that AI has been integrated into various subject areas in the field of education, including the physical and natural sciences. The Figure 1 provides a clear visualization of the distribution of research topics, highlighting the prevalence of AI applications across different educational contexts.

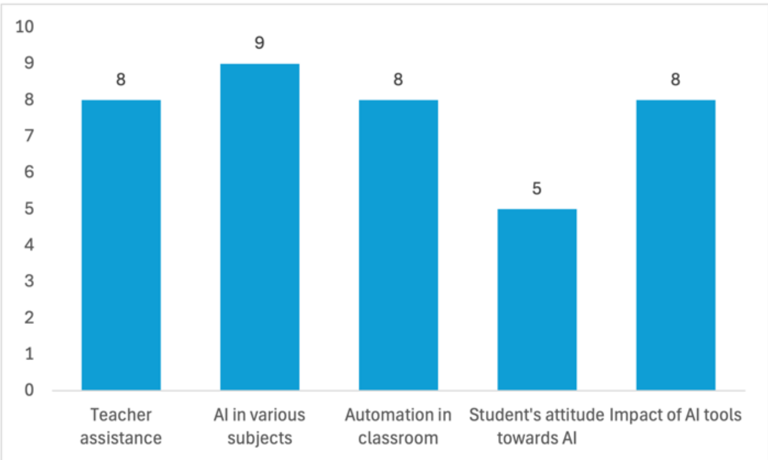

Figure 1: Distribution of topics across 38 reviewed papers, grouped into broader categories. Each bar represents the number of papers addressing a specific category

Some notable Machine Learning (ML) applications include:

- Automated Grading and Feedback Tools – mainly using supervised learning methodologies [18],[21],[31]. There is also study [19] that relies on Natural Language Processing (NLP). Utilization of ML has shown positive increase on straightforwardness and responsibilities in evaluation process.

- Tutoring tools - The human exertion of teachers focuses on organizing exercises, creating rich learning conditions and, above all, building a profound relation with each understudy. Based on these objectives, ML Tutors need to develop in tutoring algorithms [14].
- Prediction of student path - Several organizations have developed programs to predict student success in educational initiatives and reduce the likelihood of dropping out [35]. Based on the understudy dull activities, the projects perceive their shortcomings and inspect whether they can lead to expulsion.
- Matching students and teachers – These ML processing-based platforms (Skooli, TutorMe, Brainly Tutor) matches students with certified teachers based on subject, learning style, and availability. There are also self-directed learning models [32]. System learns from labeled data and predicts the best match.

3.2. Students' attitude towards learning and AI

AI-based tools were shown to have a positive impact on student learning outcomes in certain courses. The experimental group that was exposed to AI integration in their learning environments demonstrated significantly higher scores on their academic tests.[11], [12], [31] Besides, [13] and [29] illustrated how AI helps facilitate improved subject understanding.

Study from Indonesia [47] where research was constructed within a case study design has highlighted AI writing tools such as (Grammarly, QuillBot, Wordtune, and Jenni) have been found to significantly improve students' writing skills.

Another worth to highlight results were derived from lately publicized research by Kent State University [48], research focuses on how AI tools can support personalized learnings where results and analyzes were constructed based on diverse group of 71 university students' detailed feedback.

Figure 2 demonstrates students' perceived academic improvement since they began using AI tools. As we can see from the chart, study [48] reveals a strongly positive trend in the perceived academic impact of AI tools, a substantial majority 48% (34 students) reported some level of academic improvement. This distribution indicates that AI tools are generally having a positive impact on academic performance for most students who use them.

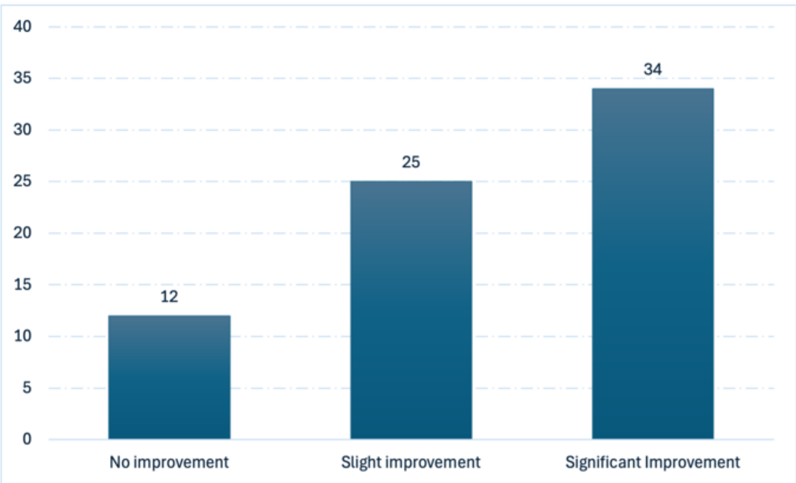

Figure 2: Perceived Academic improvement chart

Even though the study emphasizes AI's promising role in enhancing educational tools, with feedback from students showing substantial support, students also noted the need for flexibility and transparency to ensure AI complements traditional teaching methods.

Other studies supporting there is missing room in state of art approach, Daher [41] and Cooper [36] argued that AI tools require strong evaluation by educators on behalf of their effectiveness in aiding student learning. In addition, Lee [33] contends that AI-based tools, such as chatbots, can facilitate increased cognitive activity among students during the learning process. Correspondingly, Azcona [22] highlights that AI-facilitated personalized learning can reduce the gap between lower and higher-performing students.

Concerns about the impact of AI tools on students' behavior, and cognitive activity extend beyond these studies. A survey conducted by Forbes Advisor in 2023 with 500 practicing educators from around the U.S. revealed further details on how artificial intelligence is affecting education.

3.3. The Most Common AI Tools Used in the Classroom

Teachers use AI-powered educational games more frequently than any other AI tools, but adaptive learning platforms and automated grading and feedback systems [21], [31] are also widely used. The survey results depicted in Figure 3 provide a clear distribution of the types of AI-based tools educators have encountered or interacted with. The results indicate that while AI-powered educational games (51) and adaptive learning platforms (43) are among the most frequently encountered tools, intelligent tutoring systems (29) remain underutilized. This emphasizes the need for increased awareness and targeted training for educators to understand better and incorporate these tools.

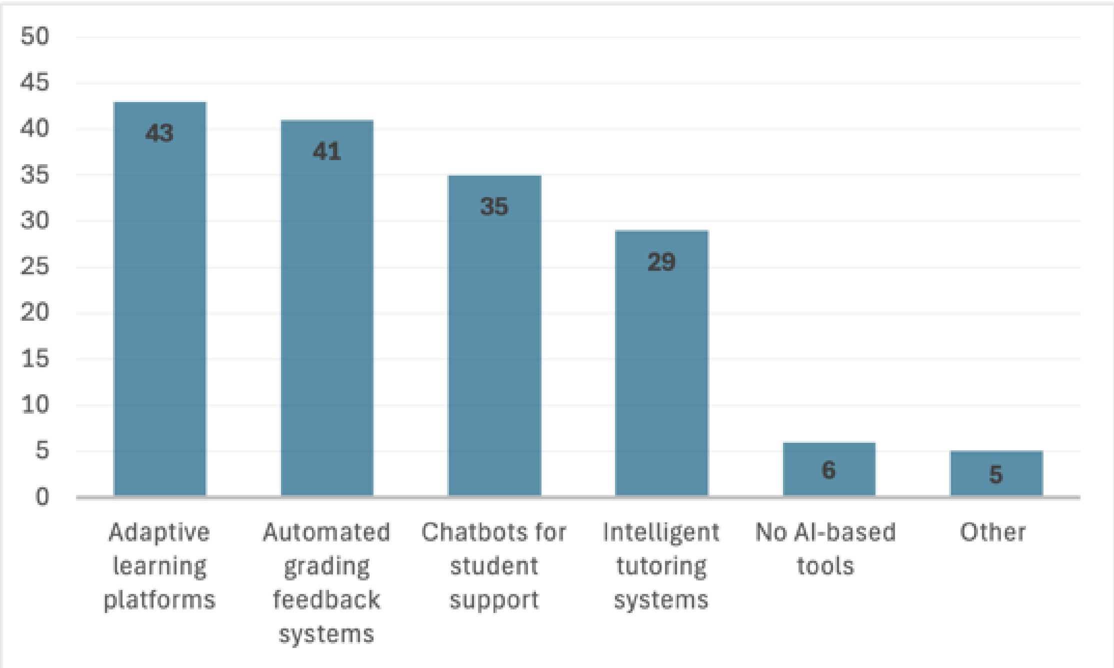

Figure 3: Distribution of AI-based tools or applications encountered in educational settings, based on a survey with US educators

Based on Figure 3 it is obvious that certain tools have gained popularity and are getting wider use. The most common AI tools encountered by educators are outlined in **Table 2**, underlining their functionalities.

AI Tool	Functionality
ChatGPT (OpenAI)	assistant chatbot with NLP that allows you to have human-like conversations to complete various tasks.
Quillbot	provides wide range of advanced, AI-powered writing tools (grammar checker, paraphraser, citation generator, translator)
Grammarly	suggests edits in real time for spelling, grammar, and writing style. It also suggests edits based on types of writing
Magic School AI	provides platform designed specifically for educators, aiming to alleviate burnout and enhance classroom efficiency by offers over 70 AI tools to assist with lesson planning, differentiation, assessment creation
Curipod	allows teachers to develop engaging lessons with interactive elements such as polls, word clouds, and drawing activities, enhancing student participation.
Eduaide.AI	provides AI-driven lesson plan generation, customizable templates, and adaptable lesson plans for unique needs
Khanmigo	provides personalized and interactive tutoring with real-time feedback with a wide range of subjects, and integrations with Khan Academy's curriculum
Gradescope	delivers grading and feedback with student performance analytics, and integrates with learning management systems
PowerPoint Speaker Coach	assists educators in refining their presentation skills. It offers real-time feedback on pacing, use of filler words, and even suggests improvements in tone and clarity.
Brisk Teaching	offers an AI-powered extension for educators that can help when creating curriculum, giving feedback, assessing student writing, adjusting reading levels and translating texts.

Table 2: Overview of the most common AI-based tools used in educational settings, their core functionalities

3.4. Concerns of Educators

AI adoption in the classroom poses a challenge for students, teachers, and schools as they must learn to use these technologies responsibly. As can be seen in Figure 4 which lists down the concerns raised by US educators regarding AI integration into the classroom, survey demonstrates that educators worry about cheating the most. Only four educators said, "no concerns in particular," implying that the majority view AI integration with some level of skepticism or critical awareness.

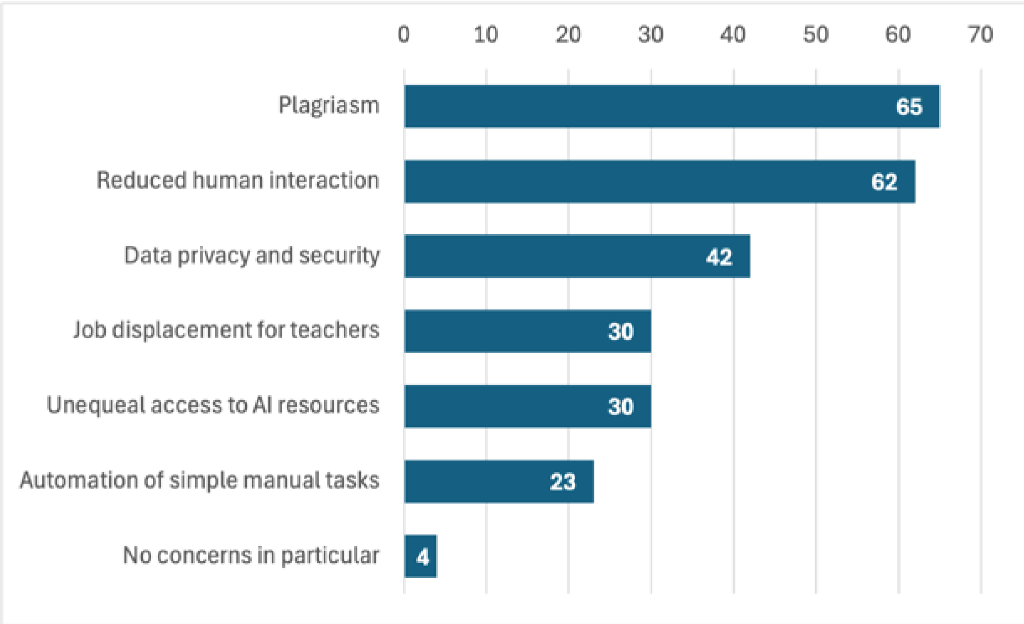

Figure 4: Distribution of concerns about the use of AI in education. based on a survey with US educators

4. Discussion

As highlighted by peers, integration of AI in the learning environment brings numerous benefits, like personalized learning and improved understanding of subjects, but it also raises valid concerns about its impact on the CT Competencies of the learners. Within this section, the authors would like to discuss the potential impacts of integrating AI into education on the core characteristics of students' CT competencies.

4.1. Abstraction

Due to its strong nature AI tools can effortlessly break down a problem into simpler steps or provide a direct solution, students may miss out on the opportunity to practice extracting key concepts and focusing on relevant details. **High dependency on AI** might lead students to become less proficient at identifying and managing abstract concepts independently.

4.2. Pattern Recognition

While AI can promote learning, the sheer volume and presentation of information may cause **Cognitive overload**, potentially hindering students' ability to recognize patterns and underlying trends in tasks and problems.

4.3. Algorithmic Thinking

One of the key drivers for developing algorithmic thinking is when learners are faced with challenging tasks that require a solid foundation in abstract knowledge and the ability to recognize patterns within the problem. However, with **Easy Access to Answers** provided by AI tools, learners may miss out on the opportunity to develop this competency altogether.

4.4. Generalization

AI tool adapts content to a given task automatically which doesn't encourage the application of learned principles to varied contexts, students may not develop the ability to transfer their knowledge to different scenarios. This could cause **Cognitive rigidity** within learners.

5. Conclusion

The anticipation that somewhere around 100 million people will work in the field of artificial intelligence by 2025 and a 50 percent growth in the field of education, and dozens of similar statistical indicators are an indicator that artificial intelligence has caused a revolution and will continue to do so. However, in the current situation, the deadlock has come to a point in the field of education, because many educators and educational institutions do not know how to behave in this matter, due to a lack of expertise, it has led to banning and blocking the use of artificial intelligence among students and taking measures against it.

As we mentioned in the discussion section, the excessive use of artificial intelligence can have a significant impact on their ability to criticize, think analytically, understand the basic factors of a problem, how to behave when faced with similar challenges, and how to solve it when the task becomes more complex.

While our research highlights the transformative potential and challenges associated with artificial intelligence in education, it is essential to acknowledge certain limitations in the scope of our review. Firstly, the rapid evolution of AI technologies and their diverse applications make it difficult to capture the full spectrum of their impact comprehensively.

We see the cause for this in the students' use of AI tools and platforms as a problem solver, an answer device, instead of a database, source of information and assistance, which leads to the side effects mentioned above. It is our view that the best way is to show the capabilities, limitations, and possible impacts of AI and to what level it can be used if it is used correctly. One of the possible paths in the noted topic is the design of an instructive, interactive, innovative curriculum in which various aspects and fields of use of artificial intelligence are discussed and mentioned in this topic and its training in educational institutions. We hope that our research and the results we have revealed will leave a motivating force and influence to look deeply into this topic and work on it in the next research in this field.

Bibliography

1. E. Yudkowsky and others, "Artificial intelligence as a positive and negative factor in global risk," *Global catastrophic risks*, vol. 1, no. 303, p. 184, 2008. https://doi.org/10.1093/oso/9780198570509.003.0021
2. F. Tahiru, "AI in education: A systematic literature review," *Journal of Cases on Information Technology (JCIT)*, vol. 23, no. 1, pp. 1–20, 2021. https://doi.org/10.4018/JCIT.2021010101
3. B. S. Bloom, "The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring," *Educational researcher*, vol. 13, no. 6, pp. 4–16, 1984. https://doi.org/10.3102/0013189X013006004
4. T. Baker, L. Smith, and N. Anissa, "Exploring the future of artificial intelligence in schools and colleges," 2019, *Retrieved from Nesta Foundation website* .
5. F. Miao, W. Holmes, R. Huang, H. Zhang, and others, *AI and education: A guidance for policymakers*. Unesco Publishing, 2021.
6. J. M. Wing, "Computational thinking," *Commun ACM*, vol. 49, no. 3, pp. 33–35, 2006. https://doi.org/10.1145/1118178.1118215
7. C. S. T. Association and others, "Operational definition of computational thinking," *Report*, p. 1, 2011.
8. WHITE HOUSE OFFICE OF SCIENCE AND TECHNOLOGY POLICY, "2023 PROGRESS REPORT ON THE IMPLEMENTATION OF THE FEDERAL SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) EDUCATION STRATEGIC PLAN," https://www.whitehouse.gov/wp-content/uploads/2024/04/2023-CoSTEM-Progress-Report.pdf.
9. V. Riina, K. Stefano, and P. Yves, "DigComp 2.2: The Digital Competence Framework for Citizens-With new examples of knowledge, skills and attitudes," 2022.
10. M. J. Page *et al.*, "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews," *bmj*, vol. 372, 2021.
11. I. Aldabe and M. Maritxalar, "Semantic similarity measures for the generation of science tests in basque," *IEEE transactions on Learning Technologies*, vol. 7, no. 4, pp. 375–387, 2014. https://doi.org/10.1109/TLT.2014.2355831
12. P. Blikstein, M. Worsley, C. Piech, M. Sahami, S. Cooper, and D. Koller, "Programming pluralism: Using learning analytics to detect patterns in the learning of computer programming," *Journal of the Learning Sciences*, vol. 23, no. 4, pp. 561–599, 2014. https://doi.org/10.1080/10508406.2014.954750
13. M. Figueiredo and F. Paixão, "O papel da observação na compreensão da natureza do conhecimento cient\'\ifico: uma proposta didática baseada nas reaç\~oes de combustão," *Proceedings do Encontro Nacional de Educação em Ciências–ENEC*, pp. 205–209, 2015.
14. X. Zhu, "Machine teaching: An inverse problem to machine learning and an approach toward optimal education," in *Proceedings of the AAAI conference on artificial intelligence*, 2015. https://doi.org/10.1609/aaai.v29i1.9761
15. S. Basu, G. Biswas, P. Sengupta, A. Dickes, J. S. Kinnebrew, and D. Clark, "Identifying middle school students' challenges in computational thinking-based science learning," *Res Pract Technol Enhanc Learn*, vol. 11, pp. 1–35, 2016. https://doi.org/10.1186/s41039-016-0036-2

16. F. Avelino, J. M. Wittmayer, R. Kemp, and A. Haxeltine, "Game-changers and transformative social innovation," *Ecology and Society*, vol. 22, no. 4, 2017. https://doi.org/10.5751/ES-09897-220441
17. B. Balakrishnan, "Motivating engineering students learning via monitoring in personalized learning environment with tagging system," *Computer Applications in Engineering Education*, vol. 26, no. 3, pp. 700–710, 2018. https://doi.org/10.1002/cae.21924
18. J. M. Garc\'\ia-Gorrostieta, A. López-López, and S. González-López, "Automatic argument assessment of final project reports of computer engineering students," *Computer Applications in Engineering Education*, vol. 26, no. 5, pp. 1217–1226, 2018. https://doi.org/10.1002/cae.21996
19. A. Rokade, B. Patil, S. Rajani, S. Revandkar, and R. Shedge, "Automated grading system using natural language processing," in *2018 Second international conference on inventive communication and computational technologies (ICICCT)*, 2018, pp. 1123–1127. https://doi.org/10.1109/ICICCT.2018.8473170
20. S. F. A. Hossain, X. Shan, and M. Nurunnabi, "Is M-learning a challenge?: Students attitudes toward the sustainable learning and performance," *International Journal of e-Collaboration (IJeC)*, vol. 15, no. 1, pp. 21–37, 2019. https://doi.org/10.4018/IJeC.2019010102
21. H.-S. Lee, A. Pallant, S. Pryputniewicz, T. Lord, M. Mulholland, and O. L. Liu, "Automated text scoring and real-time adjustable feedback: Supporting revision of scientific arguments involving uncertainty," *Sci Educ*, vol. 103, no. 3, pp. 590–622, 2019. https://doi.org/10.1002/sce.21504
22. D. Azcona, I.-H. Hsiao, and A. F. Smeaton, "Detecting students-at-risk in computer programming classes with learning analytics from students' digital footprints," *User Model User-adapt Interact*, vol. 29, pp. 759–788, 2019. https://doi.org/10.1007/s11257-019-09234-7
23. N. A. Jalil, H. J. Hwang, and N. M. Dawi, "Machines learning trends, perspectives and prospects in education sector," in *Proceedings of the 3rd International Conference on Education and Multimedia Technology*, 2019, pp. 201–205. https://doi.org/10.1145/3345120.3345147
24. M. M. Koć-Januchta, K. J. Schönborn, L. A. E. Tibell, V. K. Chaudhri, and H. C. Heller, "Engaging with biology by asking questions: Investigating students' interaction and learning with an artificial intelligence-enriched textbook," *Journal of Educational Computing Research*, vol. 58, no. 6, pp. 1190–1224, 2020. https://doi.org/10.1177/0735633120921581
25. N. Yannier, S. E. Hudson, and K. R. Koedinger, "Active learning is about more than hands-on: A mixed-reality AI system to support STEM education," *Int J Artif Intell Educ*, vol. 30, pp. 74–96, 2020. https://doi.org/10.1007/s40593-020-00194-3
26. K. VanLehn, C. Banerjee, F. Milner, and J. Wetzel, "Teaching Algebraic model construction: a tutoring system, lessons learned and an evaluation," *Int J Artif Intell Educ*, vol. 30, no. 3, pp. 459–480, 2020. https://doi.org/10.1007/s40593-020-00205-3
27. C. Perrotta and N. Selwyn, "Deep learning goes to school: Toward a relational understanding of AI in education," *Learn Media Technol*, vol. 45, no. 3, pp. 251–269, 2020. https://doi.org/10.1080/17439884.2020.1686017
28. J. Kim, K. Merrill, K. Xu, and D. D. Sellnow, "My teacher is a machine: Understanding students' perceptions of AI teaching assistants in online education,"

Int J Hum Comput Interact, vol. 36, no. 20, pp. 1902–1911, 2020. https://doi.org/10.1080/10447318.2020.1801227

29. P. Ferrarelli and L. Iocchi, "Learning Newtonian physics through programming robot experiments," *Technology, Knowledge and Learning*, vol. 26, no. 4, pp. 789–824, 2021. https://doi.org/10.1007/s10758-021-09508-3
30. A. Deveci Topal, C. Dilek Eren, and A. Kolburan Geçer, "Chatbot application in a 5th grade science course," *Educ Inf Technol (Dordr)*, vol. 26, no. 5, pp. 6241–6265, 2021. https://doi.org/10.1007/s10639-021-10627-8
31. S. Maestrales, X. Zhai, I. Touitou, Q. Baker, B. Schneider, and J. Krajcik, "Using machine learning to score multi-dimensional assessments of chemistry and physics," *J Sci Educ Technol*, vol. 30, pp. 239–254, 2021. https://doi.org/10.1007/s10956-020-09895-9
32. N. M. Ngadiran, N. A. Alias, and N. Anuar, "M-Learning Module for Self-Directed Language Learning; a Study of Students' Needs Analysis," *Development in Language Studies*, vol. 1, no. 1, pp. 1–11, 2021.
33. Y.-F. Lee, G.-J. Hwang, and P.-Y. Chen, "Impacts of an AI-based cha bot on college students' after-class review, academic performance, self-efficacy, learning attitude, and motivation," *Educational technology research and development*, vol. 70, no. 5, pp. 1843–1865, 2022. https://doi.org/10.1007/s11423-022-10142-8
34. N. Selwyn, "The future of AI and education: Some cautionary notes," *Eur J Educ*, vol. 57, no. 4, pp. 620–631, 2022. https://doi.org/10.1111/ejed.12532
35. A. Dirin and C. A. Saballe, "Machine learning models to predict students' study path selection," *iJIM*, vol. 16, no. 01, p. 159, 2022. https://doi.org/10.3991/ijim.v16i01.20121
36. G. Cooper, "Examining science education in ChatGPT: An exploratory study of generative artificial intelligence," *J Sci Educ Technol*, vol. 32, no. 3, pp. 444–452, 2023. https://doi.org/10.1007/s10956-023-10039-y
37. M. Elkhodr, E. Gide, R. Wu, and O. Darwish, "ICT students' perceptions towards ChatGPT: An experimental reflective lab analysis," *STEM Education*, vol. 3, no. 2, pp. 70–88, 2023. https://doi.org/10.3934/steme.2023006
38. P. Bitzenbauer, "ChatGPT in physics education: A pilot study on easy-to-implement activities," *Contemp Educ Technol*, vol. 15, no. 3, p. ep430, 2023. https://doi.org/10.30935/cedtech/13176
39. F. Kieser, P. Wulff, J. Kuhn, and S. Küchemann, "Educational data augmentation in physics education research using ChatGPT," *Phys Rev Phys Educ Res*, vol. 19, no. 2, p. 20150, 2023. https://doi.org/10.1103/PhysRevPhysEducRes.19.020150
40. N. E. A. Nasution, "Using artificial intelligence to create biology multiple choice questions for higher education," *Agricultural and Environmental Education*, vol. 2, no. 1, pp. 4–8, 2023. https://doi.org/10.29333/agrenvedu/13071
41. W. Daher, H. Diab, and A. Rayan, "Artificial intelligence generative tools and conceptual knowledge in problem solving in chemistry," *Information*, vol. 14, no. 7, p. 409, 2023. https://doi.org/10.3390/info14070409
42. C. O. Nja *et al.*, "Adoption of artificial intelligence in science teaching: From the vantage point of the African science teachers," *Smart Learning Environments*, vol. 10, no. 1, p. 42, 2023. https://doi.org/10.1186/s40561-023-00261-x
43. K. Cochran, C. Cohn, J. F. Rouet, and P. Hastings, "Improving automated evaluation of student text responses using gpt-3.5 for text data augmentation," in

International Conference on Artificial Intelligence in Education, 2023, pp. 217–228. https://doi.org/10.1007/978-3-031-36272-9_18

44. T. Hana, P. X. Nguyen, P. D. H. Nguyen, L. C. T. Cao, P. Bruneau, and J. Wang, “Evaluation of Google Bard on Vietna mese High School Biology Examination,” *ScienceOpen Preprints*, 2023.
45. T. K. F. Chiu, Q. Xia, X. Zhou, C. S. Chai, and M. Cheng, “Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education,” *Computers and Education: Artificial Intelligence*, vol. 4, p. 100118, 2023. https://doi.org/10.1016/j.caeai.2022.100118
46. C. K. Y. Chan, “A comprehensive AI policy education framework for university teaching and learning,” *International journal of educational technology in higher education*, vol. 20, no. 1, p. 38, 2023. https://doi.org/10.1186/s41239-023-00408-3
47. Marzuki, U. Widiati, D. Rusdin, Darwin, and I. Indrawati, “The impact of AI writing tools on the content and organization of students’ writing: EFL teachers’ perspective,” *Cogent Education*, vol. 10, no. 2, p. 2236469, 2023. https://doi.org/10.1080/2331186X.2023.2236469
48. B. Ward, D. Bhati, F. Neha, and A. Guercio, “Analyzing the Impact of AI Tools on Student Study Habits and Academic Performance,” *arXiv preprint arXiv:2412.02166*, 2024.

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