

AI Tools Facilitating Personalized Education for Children with Special Needs in the Era of Education 5.0

Sagar Srivatsa

Shrewsbury High School, United States of America

Abstract

In the context of Education 5.0, this study discusses the critical role that artificial intelligence plays in enabling individualized education for students with special needs. The main goal is to investigate how AI-powered educational technologies affect learning pathway customization and encourage active participation from students with special needs, particularly in peer-to-peer learning settings. The research uses a qualitative case study analysis and is based on a thorough evaluation from the major meta-databases such as IEEE Xplore, Web of Science (WOS), and Scopus. The results highlight how AI-enabled platforms, such as assistive technology and adaptive learning systems, allow for data-driven instructional modifications and real-time tailoring, catering to a variety of cognitive and socioemotional profiles. Furthermore, by removing obstacles to participation, the incorporation of augmented intelligence through AI-driven peer collaboration promotes inclusivity and emotional well-being in addition to improving academic results. Namely, the study highlights a research gap for statistically sound information as well as more thorough on-site assessments of AI-assisted peer-to-peer learning models. The ramifications highlight how important it is for educators, tech-developers, and legislators to work together in the 21st century to create and thoroughly evaluate AI systems that support equitable, connected, and interesting learning opportunities for students with special needs.

Keywords: AI in Education, Special Needs Education, Personalized Learning, Peer-to-Peer Collaboration, Adaptive Learning Platforms

I. Introduction

To understand the entire evolution of education, there needs to be a thorough understanding of its earliest and primitive stages, all the way up to modern stages, where resources are becoming more digitalized and accessible to everyone. In Education 1.0, students were taught in the same way, with the same method. Known as rote learning, students often memorize information through repetition, negatively evaluating all students with the same techniques and negating their different learning attitudes (Cristaine Espinoza et. al. 2024). This one-size-fits-all model laid the groundwork for a much-needed transformation in the way education is delivered. However, as we have progressed from primitive to inclusive, in an era of 5.0, education has bigger implications for young students. Therefore, education has revolutionized from its primary to current stages in the past few decades. In fact, from 1940 to 2000, the United States observed its biggest advancement in educational technology (Diego_Restucca, et. al, 2015). Primarily, technology has become increasingly integrated, transitioning from a blackboard to an iPad and computer setting. This transition marks the critical shift from traditional instruction to dynamic and interactive learning environments.

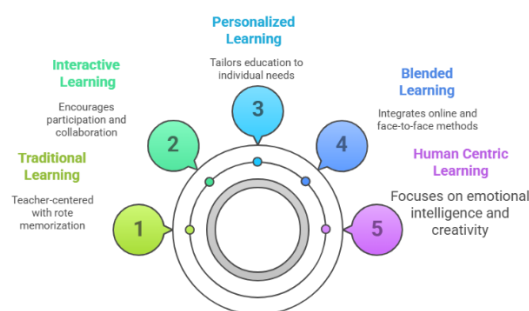


Fig. 1: Evolution of Education 1.0 to Education 5.0

Fig 1. above shows the evolution of education throughout its five eras. In the earlier areas, less creativity and more rote learning was involved, inhibiting introspective learning. However, as decades progressed and new eras of education were reached, artificial intelligence and technology were seamlessly integrated to enhance student-learning and consider various aspects that contribute to learning such as emotions and engagement through personalized content.

Regarding special needs children, certain tools have been made use of to make education more inclusive as the eras progressed. In Education 1.0, however, there has been a lack of technology as education back then was a one-size-fits-all, so there was no prominent use of technology to disseminate teachings (Ahmad et al., 2023). However, heading into Education 2.0, there were first instances of resources apart from physical textbooks utilized to enhance learning. Specifically, digital resources such as videos and websites added on to the traditional learning methods. Most importantly, it removed certain socio-economic barriers significantly to make it more accessible to all. (Ahmad et al., 2023). Moving on to Education 3.0, there was a revamp based on the shortcomings of Education 2.0. The idea of a “flipped classroom” was introduced, allowing students to engage in critical thinking and implement creativity, as they were required to complete more work at home, thereby freeing up time for open discussions and active learning in class. Furthermore, the notion of identifying learning gaps emerged, with teachers using data and analytics paired with each student to analyze their work (Ahmad et al., 2023). Transitioning to Education 4.0, technologies were invented specifically to emphasize the personalized aspect of learning, with breakthroughs in artificial intelligence (AI) and machine learning (ML) integration in education. Similarly, virtual and augmented reality (VR/AR) and the internet of things (IoT) made their debut in the educational space, fully immersing students in the learning experience. Also, gamification was introduced, the idea of adding game elements to learning to make it appealing to students (Ahmad et al., 2023). However, Education 4.0 is not the be-all and end-all, as its next era – Education 5.0 – seeks to improve upon some of the older achievements becoming obsolete. As students use personalized technology more often, collaboration and connectedness are often inhibited, so teachers aim to intertwine technology and student-to-student interaction to maximize learning. Moreover, as technology is becoming prominent, people who don’t have access to specific technology are getting left far behind. So, people are using resources like cloud computing, which breaks internet barriers and gives access to students at any location from any time (Ahmad et al., 2023). As so much is focused on learning itself, people often overlook the emotional aspect behind the learning process. Therefore, human-centric technology is being developed, with metrics such as satisfaction surveys and engagement metrics to gauge the student’s learning as a whole.

Table I. Special Needs Education Era and Associated Pedagogy and Tools Used

Education	Pedagogy	Suitable Tools Used For Special Needs
Education 1.0	Rote learning & memorization	N/A; Very little to no tools used
Education 2.0	Student-centered, interactive learning	Computers and the Internet
Education 3.0	Personalized, technology-driven learning	Revamped technology, “flipped classroom” approach
Education 4.0	Self-directed, lifelong, global learning	AI/ML, VR/AR, IoT, Gamification
Education 5.0	Human-centric, emotional and ethical focus, hyperpersonalization	AI, VR, ML, IoT, Cloud Computing, Big Data and Analytics

Table 1.0 refers to the pedagogies of the education eras evolving to become more supportive of learners, bolstered by the improvement in suitable tools used to assist various styles of education. Moreover, in the pandemic era, technology revolutionized. This is because teachers needed to find different ways to teach, effectively rethinking their entire teaching process (Chrysi Rapanta et. al, 2021). This marked a significant step toward Education 3.0, where learners and teachers began to co-create the educational experience. Previous research shows that teachers found they can teach online, and the focus of education shifted. Both education managers and students changed their ways of providing education and adjusting to education (Chrysi Rapanta et. al, 2021). Naturally, global e-learning markets have grown as a result of the pandemic. The top companies in online education, such as Udemy and Coursera, have seen growth over the years, with more users around the world creating accounts to access content for self-improvement. There was a gradual increase in market capitalization by 2022, with an expected 13.16% compounded growth of 2022-2027 equating to 830 billion in revenue, validating the CAGR (compounded annual growth rate) (Bagdi et al., 2023). Clearly, this surge in digital learning platforms illustrates how education is evolving to become more decentralized and learner-driven, as shown in Table I.

The resolution and success of pandemic education represent just one facet of Education 5.0. Specifically, education 5.0 eliminates barriers by improving learning methods and the well-being of the students through technology (Hernandez-De-Menendez & Morales-Menendez, 2019b). This evolution builds upon the foundations of Education 3.0, which emphasized

participatory learning and teacher-student collaboration. (Make a mention of 3.0) For example, the inclusion ICT (information and communications technology) has proven to be substantially useful for students. For instance, in universities, professors are teaching students with a strong relationship between information and communicative technology. Termed as ICTs, they bolster students' experience as well as academic performance as seen in higher education (Hernandez-De-Menendez & Morales-Menendez, 2019). Personalized learning is an approach that adapts to the unique needs and learning styles of the student. Previous research has shown that technological resources and opportunities provide key gateways to personalized learning (Chrysi Rapanta et. al, 2021). Technology such as AI and ML (Machine Learning) adjusts student learning by actively creating personalized learning plans. While AI can certainly benefit college students, they heavily rely on its credibility as well, since "85 percent of undergraduate university students said that they would feel more comfortable using AI tools if they were developed and vetted by trusted academic sources" (Statista). Therefore, a need for double-checking progress and reducing AI-hallucinations could significantly benefit undergraduate students. Regarding such technology, however, certain metrics such as student engagement, achievement, and motivation could be used (Ahmad et al., 2023). These innovations ensure that educational pathways are no longer static but instead continuously adapt to the learner's evolving needs. Personalized education plays a more significant role in education for the especially abled. Children with special needs often require tailored educational plans that address their unique cognitive, emotional, and physical requirements. AI-driven tools can help create customized learning experiences that enhance their academic outcomes and overall well-being. Students with special needs need diverse learning, and TSPL (Technology Supported Personalized Learning) does just that. In a study on TSPL 5.0 in Pakistan, where major improvement on learning methods is still needed, researchers found that TSPL was strongly correlated with increased cognitive assistance and better class management. This demonstrates the global relevance and applicability of personalized learning solutions, even in developing educational environments.

AI has a significant role in education. Studies from McKinsey show that personalized learning can improve academic performance by up to 30% for students with special needs (Echeverry & Echeverry, 2024). Gamification, the application of game elements, especially in learning apps like Duolingo, boosts learning up to 60% (Echeverry & Echeverry, 2024). This will be especially useful, since the society for younger generations revolves around fads and trends, one of them being gaming. Furthermore, AI takes on a third dimension of predicting outcomes in academics and identifying areas needing improvement. ensuring no child gets left behind. The International Society for Technology in Education highlights that these predictive analytics improve retention rates by 10-20% (Echeverry & Echeverry, 2024). As we move deeper into Education 5.0, AI emerges not just as a supplement to instruction but as a transformative force shaping the future of inclusive learning. Of course, implementing AI for children undergoing special education will be challenging. For example, a COVID-19 case study reveals that technologies are only consistent with improvement in appropriate scenarios at home and school, not anywhere and anytime (Bah & Artaria, 2020). Furthermore, the study also highlights how teacher intervention is needed at times, as AI is automated and could steer away from children's learning paths by error (Bah & Artaria, 2020). Thus, while AI offers immense promise, its deployment must be carefully balanced with human oversight to ensure ethical and effective learning experiences. The primary objective of this research is to critically analyse the effectiveness of AI tools in delivering personalized educational experiences for children with special needs, while identifying the opportunities and challenges associated with integrating such technologies within the inclusive and human-centric framework of Education 5.0.

The organization of the rest of the paper is as follows: Section 2 delves into current and previous research and studies relevant to the advancement of special needs children's education through artificial intelligence. Section 3 focuses on 4 case studies, each regarding artificial intelligence and their assistance towards different aspects related to education. Section 4 addresses the unresolved research questions and provides insights into potential future research trajectories.

II. Literature Review

In the realm of AI, personalized learning tools are crucial to adapting to one's learning style. BESPECIAL, a modern AI, aimed to help dyslexic students with learning, as they struggled with concentration and had short-term memory tools (Zingoni, A., et. al 2021). A preliminary study found that BESPECIAL's supporting tools, such as highlighted keywords and concept maps, helped dyslexic students over general digital tools (Zingoni, A., et. al, 2021). Conversely, audio tools were found to be useless to dyslexic students as their rankings fell much lower than the proper tools. Furthermore, Intelligent Tutoring Systems are another by-product of AI applications in education. An Intelligent Tutoring System (ITS) plays a vital role in education by offering individualized teaching support to students, helping them learn problem-solving

skills through tailored guidance and timely feedback (AlShaikh, et. al. 2021). Without intervention from teachers, they help students get specific knowledge through different technologies (AlShaikh, et. al. 2021). Also, they have come to be inclusive education tools. For example, Speech-to-Text (STT) and Text-to-Speech (TTS) systems have come a long way, transforming industries by converting speech into text and generating speech that sounds natural. With improved accuracy and efficiency, they have transitioned from traditional methods to deep learning techniques like CNNs, RNNs, and transformers (Reddy, V. M., et. al, 2023).

Augmented reality (AR) and artificial intelligence (AI) are applied to develop new learning tools for sign language, enhancing interactivity and accessibility for hearing-impaired individuals. These technologies have already been applied to sign language learning in various languages, including English, Indonesian, and Peruvian, while AI-based applications allow the hearing and hearing-impaired to communicate with one another (Hwang, K.-F. et. al, 2025). Despite technological advancements in learning, systemic integration and scalability are crucial for implementing these technologies with effect. Software such as Learning Management Systems (LMS). They are especially useful as teachers don't have to be in the same location as their students, and education can be kick-started online according to the student's convenience (Cavus, N., 2010). Automated grading tools are also a huge component of LMS. GRAD-AI, for example, helps teachers overcome traditional grading methods by assisting in unbiased grading. Furthermore, the mix in teacher and AI-grading streamlines grading processes by providing personalized and adaptive learning (Gambo, I. et. al., 2024). Similarly, teacher empowerment is necessary as it leads to engaged staff and fosters innovative teaching processes. Information communication technologies (ICTs) achieve this goal, as they are vital for developmental education. A study highlights how crucial it is for children with special educational needs (SEN) to use the same digital tools both at home and in school. Equally important is the continued guidance and assistance families receive from qualified professionals, including teachers, therapists, support staff, tutors, and experts in assistive technology. Additionally, when parents show a supportive outlook on their children's use of technology and actively encourage communication and connection within the household, it significantly enhances the overall impact (Nussbaumer, D, et. al, 2024). ICTs are essential to teacher empowerment, but early development can be detected with the inclusion of AI. For example, Dyslexic children often suffer from low self-esteem and frustration, and this highlights the importance of early identification and intervention. The methods used for detection include reading tests, eye tracking, facial image processing, and brain imaging methods like MRI and EEG (Priyasri, G. R. et. al., 2025). One of the greatest challenges for dyslexia detection is small and imbalanced datasets, which limit model generalizability and performance. Deep learning with advanced data augmentation can improve learning from small datasets, enhancing diagnostic accuracy and robustness. ML and DL techniques for automating dyslexia detection to improve accuracy and accessibility. It comprises ML models like decision trees and SVMs, and DL models like CNNs and RNNs on text, speech, and eye-tracking (Priyasri, G. R. et. al., 2025). With these AIs in mind, we should consider their ethicality and equity. AI has significantly developed with the potential to revolutionize many industries, but a major source of limitation is bias. Bias is inherently bad, as it provides inaccurate information from poorly trained models, creating repeated mistakes if left unchecked. Therefore, it is crucial to monitor AI to mitigate bias (Ferrara, E. 2023).

Figure 2.0 is a radial conceptual map positioning assistive technologies that support children with special needs at the centre, with six surrounding domains—Intelligent Tutoring Systems (ITS), Learning Management Systems (LMS), Machine Learning/Deep Learning (ML/DL), Text-to-Speech (TTS), Augmented/Virtual Reality (AR/VR), and Information and Communication Technologies (ICTs)—representing the technological ecosystems within which these tools are developed and deployed.

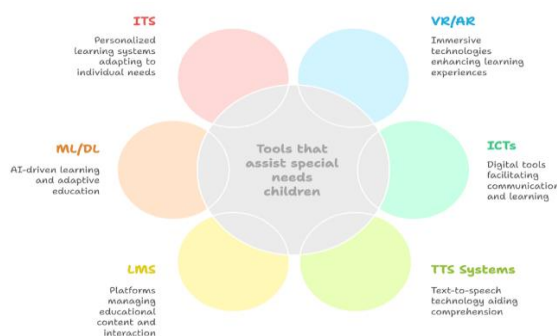


Fig. 2: Major tools that assist special needs education

Table II: Literature Review Table for Special Needs Children

References	AI Tools Used	Purpose in Education/ Special Needs	Research Gap	Outcome
1	Open AI	Identify the knowledge gaps and provide personalised learning	Apps for teachers in the classroom	Helps express emotions more clearly
2	BESPECIAL	Personalized support for dyslexic students	Lack of tailored tools and strategies	AI-based predictor and support platform
3	Chatbot	Language training using AI chatbots	Effectiveness and limitations of chatbot novelty and design	Identified chatbot types & pros & cons in chatbot learning
4	AutoGrad	Automated grading for coding assignments	Lack of scalable grading tools for mobile coding education	Reduced grading time using static and dynamic analysis
5	Virtual Mentor(BlackBoard)	Personalized feedback and mentorship for students, including ELLs	Limited exploration of AI's role in mimicking teacher mentorship and guiding learning paths	Blackboard effectively supports learning through interactive AI-driven feedback and resource suggestions
6	Grammarly	Enhanced writing proficiency, automated feedback, and minimization of grammatical errors	Impact on elementary education, and insufficient statistics	Enhanced writing proficiency, automated feedback, and minimization of grammatical errors
7	Canva	Enables collaborative learning, promotes extensive networking, and bolsters student innovation	Lower-level education, proper experimental methods	Contribution to the academic sphere and digitalization of campus initiatives
8	Magic School AI	Reduce workload, personalize learning, and build AI literacy skills	Lack of technological training for teachers, inactionable and indirect plans provided by AI	Simplification of lesson plans, improved scaffolding, and support

Following an extensive review of relevant literature, a comprehensive literature review table was constructed as shown in Table II to synthesize existing work on various tools that have assisted children with special needs. This synthesis enabled the identification of key gaps, including the limited integration of collaborative-based approaches, smaller student populations, and a paucity of research on middle-school-aged children. Building upon these insights, the subsequent stage of this study focuses on formulating a rigorous research methodology designed to address the stated research questions and hypotheses. The proposed methodology encompasses a comprehensive set of 4 case studies. By aligning the methodological framework directly with the gaps revealed in the literature, this approach ensures that the analysis is both targeted and capable of generating reproducible, evidence-based conclusions suitable for real-world application.

Research Question:

RQ1: How do AI-powered educational tools influence the personalization of learning pathways and active engagement for students with special needs in peer-to-peer learning environments?

RQ2: What are the effects of integrating augmented intelligence via AI-driven peer collaboration on the academic and socio-emotional outcomes of children with specialized needs?

Hypothesis

H1: Integrating AI-powered adaptive learning platforms with structured peer-to-peer learning significantly enhances active engagement and learning outcomes for students with special needs compared to traditional individualized instruction.

H2: The use of AI tools to facilitate augmented intelligence in peer-supported learning environments leads to greater inclusivity and reduces barriers to participation for students with specialized educational needs.

III. Research Framework

While AI tools are increasingly used to personalize learning for students with special needs, there is limited research on how these tools can be leveraged to foster *augmented intelligence*—the synergistic combination of human and artificial intelligence—through peer-to-peer learning, thereby creating truly inclusive and active learning environments. Leveraging a qualitative case-study approach, the research synthesizes metadata from Scopus, Web of Science, and IEEE databases, enriched by statistical insights from McKinsey, Deloitte, Statista, Tractica, and Business Today.

Case 1: Adaptive Learning Platform in an Inclusive School

This 2022 article by Liu examines "precision education" (PE) within the application of the Taiwan Adaptive Learning Platform (TALP). The TALP platform is designed to determine individual students' learning deficiencies, provide adaptive material, and provide real-time feedback. The research was implemented with three fifth-grade classes of 76 students and two teachers at one Taiwanese elementary school. Quantitative data were obtained using pre-tests, post-tests, and repeated measurements, handled with nonparametric tests (Kruskal–Wallis and Median tests), revealing no statistically significant improvements. To support this, qualitative insight was extracted from teacher observation and interviews. Whereas quantitative results lacked statistical significance, teachers testified that TALP clearly identified the students' learning gaps and supported personalized instruction. This qualitative evidence shows PE tools like TALP hold promise for differentiation in the classroom and timely intervention. For future research, the author recommends carrying out longitudinal studies, expanding the variety of PE implementations, and gathering direct student feedback through interviews and observations to gather richer evidence of learning progress.

Case 2: AI-Supported Social Skills Training

Chan and Li (2023) provide an exemplary case study of how to develop a large-language-model-based (LGPT, i.e., GPT-3, Yuan 1.0) chatbot to facilitate social work education in a Chinese context. Moving away from classical decision-tree chatbots that have rigid and artificial conversational exchanges, the LGPT chatbot aims to develop more conversational and context-aware dialogue. The research method included early development and system testing geared towards whether LGPT-driven bots can improve training in counselling, needs assessment, and narrative interviewing situations, although the article fails to provide user results or mass deployment. The authors point out that LGPT models significantly enhance the quality of conversations using fewer resources, opening up sophisticated chatbot technology to more users. The research shows possible advantages such as increased engagement from trainees and more naturalistic dialogue simulation. But it also points to limitations: this application remains pre-natal and situation-specific, with minimal evidence of effectiveness. Subsequent studies will have to rigorously test learning outcomes, expand the range of social work environments, consider cultural and ethical concerns, and attempt scalability, especially in diverse populations

Case 3: Multimodal AI Tools in a Mainstream Classroom

Some recent research has emphasized the value of integrating DMC into L2 Chinese learning and teaching (e.g., [Wang & Li, 2022, 2023](#)). In one study that focused on L2 Chinese DMC teaching, [Wang and Li \(2022\)](#) explored a teacher's year-long experience of applying multimodal pedagogies and multiliteracies instruction with students from diverse cultural backgrounds at an international school in Hong Kong. The same authors subsequently developed three DMC interventions – "Concrete Poetry", "Emoji Retelling", and "Video Essay" – and deployed them in a similar research setting ([D. Wang & Li, 2023](#)). However, the technology employed in those previous studies was limited to audio and video. The emergence of generative AI has introduced new possibilities for fostering students' multimodal literacy ([Kang & Yi, 2023](#)). In a recent two-week qualitative study of L2 English students' cognitive processes during generative AI-assisted DMC, ([Liu et al. 2024](#)) found considerable intergroup differences in patterns of text generation. That is, students who used PowerPoint to generate multimodal writing tended to construct more bridge texts and examples and were more likely to use the summarized text generated by a generative AI chatbot without modification. While this and other studies have begun

exploring the intersection of generative AI and DMC, there remains a need for empirical research examining how students utilize these tools in various cultural and linguistic contexts, particularly in multicultural L2 settings.

Case 4: Gamifying Learning with AI: A Pathway to 21st-Century Skills

The study, published in 2024 in the Journal of Research in Childhood Education, investigates how gamification and AI technology applied in schools can promote key 21st-century skills—creativity, collaboration, communication, and critical thinking—among learners. Following PRISMA guidelines, authors conducted systematic review and bibliometric analysis using VOS viewer. Their search for literature yielded 175 salient studies, which were submitted to qualitative content analysis to map thematic trends and associations in the developing field. The review identifies several findings of note: gamification interventions—through elements like points, leaderboards, and storytelling—radically enhance students' motivation, engagement, and acquisition of target skills. Meanwhile, AI assists in tailoring learning pathways, adjusting gamified content in real-time, and offering targeted feedback. The incorporation of social interaction in virtual gamified environments further encourages the development of collaborative and communicative competence. The authors argue these dual technologies revolutionize traditional pedagogy by marrying motivation-based gameplay with adaptive, data-driven learning cycles. In the future, they propose further in-depth empirical research on long-term effects, evaluating AI-led game development in inclusive education, and considering ethical and technical challenges in AI-supported gamification to enable scalability and equal access.

IV. Results & Discussion

In Chan and Li's study of chatbot Yuan 1.0 usage to bolster social skills training in the Chinese sociocultural context, their simulated chat sessions with real humans revealed that the bot could be used anytime and anywhere, humans could curate the chatbot's personality, and the bot could naturalize the flow of conversations, making it feel humane (Chan & Li, 2023). In the realm of special needs education, this could be directly applied as it helps build essential communication skills for children, something that is needed for peer-to-peer learning. Moreover, Wang & Li found that the use of multimodal education – the expression of education in various formats – in multicultural contexts helps promote student creativity and engagement with other students (Wang & Li, 2022). This could be specifically helpful considering the fact that special needs children in a single classroom setting can come from varying backgrounds, and AI tools that help fill in those gaps and connect students, facilitate and speed up the teaching process. These studies highlight the fact that special education has the potential to reach new limits, especially with the advent of AI-powered technologies. In the case study synthesis, AI tools ranging from intelligent tutoring systems all the way to speech generating devices are active contributors to unprecedented levels of personalization. These technologies adapt to suit individual needs, connecting gaps that are left untouched by traditional pedagogies. With tools such as text-to-speech, visual support, and adaptive feedback loops, these tools notably help support children with diverse disabilities.

A significant finding is the shift in the previous era's sometimes isolating, individualized instruction to a more connected and collaboration-based AI-facilitated peer learning. Studies reveal that AI, as a medium for peer-to-peer learning, enhances both cognitive and emotional outcomes. For learners with attention difficulties and problems with communication, AI can cultivate greater engagement, motivation, and social participation. In combination with human support along with AI guidance, inclusiveness and deep-connectedness are fostered, challenging long-held notions of approaching education in an individualized manner. However, as there are benefits described in the AI-driven peer learning approach, challenges also arise – namely, the ethical considerations of data implementation, accessibility, as well as detailed on-site and factually objective methodologies to assess the impacts of AI on peer collaboration. While preliminary qualitative evidence seems to be promising, there remains a paucity of large-scale, evidence-based studies that address the sustainability and efficiency of AI-driven models in real education settings. Therefore, the research urges an approach towards more rigorous, data-driven evaluations, especially focusing on participatory, on-site methodologies for future projects.

V. Conclusion & Future Scope

This study provides evidence that AI tools hold promises for furthering personalized and inclusive education for children with special needs, especially in the era of Education 5.0. Utilizing adaptive and assistive technologies, educators can combine learning experiences alongside the integration of AI in peer-learning contexts to amplify student engagement, which in turn nurtures socio-emotional growth. Nevertheless, movement of research into practical application requires continued refinement of objective, scalable assessment frameworks and sustained cross-disciplinary team effort to ensure

fair, just, and effective application in diversified learning environments. Subsequent research must obtain quantitative verification and longitudinal on-site studies to further ground AI-assisted peer learning's transformative value for all pupils.

Regarding the future, there are key improvements that are needed for future studies to more fully assess special needs education. First off, existing literature emphasizes focus on low- and high-level education, but not much is emphasized in the middle, when students are just starting to approach high school level. This is a crucial time where distinctive mindsets start to develop, and they need to be monitored to help predict special needs students' behavior in the future. Next, a wider student population from different countries can help strongly generalize claims to students in general, not specific to a sociocultural context within a country. Finally, extended AI optimal functionality is vital to making grounded claims, as the reviewed literature contained certain aspects of AI tools that degraded over time, such as grammar and on-topic engagement.

References

1. Restuccia, D., & Vandenbroucke, G. (2013). THE EVOLUTION OF EDUCATION: A MACROECONOMIC ANALYSIS. *International Economic Review*, 54(3), 915–936. <http://www.jstor.org/stable/24517070>
2. Bass, I., Espinoza, C., Bonawitz, E., & Ullman, T. D. (2024). Teaching Without Thinking: Negative Evaluations of Rote Pedagogy. *Cognitive science*, 48(6), e13470. <https://doi.org/10.1111/cogs.13470>
3. Hernandez-De-Menendez, M., & Morales-Menendez, R. (2019). Technological innovations and practices in engineering education: a review. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 13(2), 713–728. <https://doi.org/10.1007/s12008-019-00550-1>
4. Rapanta, C., Botturi, L., Goodyear, P. et al. Balancing Technology, Pedagogy and the New Normal: Post-pandemic Challenges for Higher Education. *Postdigit Sci Educ* 3, 715–742 (2021). <https://doi.org/10.1007/s42438-021-00249-1>
5. Bagdi, Himanshu & Pothabathula, Seshu & Sharma, Latika & Bulsara, Hemantkumar. (2023). The global market upsurge in web traffic and revenues during the epidemic: an exploratory research of e-learning companies. *International Journal of Development Issues*. 22. 10.1108/IJDI-06-2023-0147.
6. Education 5.0: Requirements, Enabling Technologies, and Future Directions, Shabhir Ahmad et. al, (2023)
7. Impact of technology-supported personalized learning 5.0 on instructional quality: insights from the higher education institutions of Pakistan, Muhammad Mujtaba Asad (2025)
8. Echeverry, C., & Echeverry, C. (2024, July 16). Personalized Learning with AI: Innovations in Education. Intersog. <https://intersog.com/blog/strategy/personalized-learning-with-ai/>
9. Corona virus (COVID- 19) and education for all achievement: artificial intelligence and special education needs- achievements and challenges, Yahya Muhammed Bah, 2020
10. Khang, A., Muthmainnah, M., Seraj, P. M. I., Al Yakin, A., & Obaid, A. J. (2023). AI-Aided teaching model in education 5.0. In *Handbook of Research on AI-Based Technologies and Applications in the Era of the Metaverse* (pp. 83-104). IGI Global. DOI: 10.4018/978-1-6684-8851-5.ch004
11. Zingoni, A., Taborri, J., Panetti, V., Bonechi, S., Aparicio-Martínez, P., Pinzi, S., & Calabrò, G. (2021). Investigating issues and needs of dyslexic students at university: Proof of concept of an artificial intelligence and virtual reality-based supporting platform and preliminary results. *Applied Sciences*, 11(10), 4624.
12. AlShaikh, Fatema, and Nabil Hewahi. "Ai and machine learning techniques in the development of Intelligent Tutoring System: A review." *2021 International Conference on innovation and Intelligence for informatics, computing, and technologies (3ICT)*. IEEE, 2021.
13. Reddy, V. M., Vaishnavi, T., & Kumar, K. P. (2023, July). Speech-to-text and text-to-speech recognition using deep learning. In *2023 2nd international conference on edge computing and applications (ICECAA)* (pp. 657-666). IEEE.

14. Hwang, K.-F., Wang, Y.-H., Tsao, T.-Y., Chou, S.-H., Chueh, S.-Y., Wu, C.-C., & Ho, K.-Y. (2025). Adopting Artificial Intelligence and Artificial Reality in an Interactive Sign Language Learning System: Acceptance of Interactive Technology. *Engineering Proceedings*, 89(1), 14. <https://doi.org/10.3390/engproc2025089014>
15. Cavus, N. (2010). The evaluation of Learning Management Systems using an artificial intelligence fuzzy logic algorithm. *Advances in Engineering Software*, 41(2), 248-254.
16. Gambo, I., Abegunde, F. J., Gambo, O., Ogundokun, R. O., Babatunde, A. N., & Lee, C. C. (2024). GRAD-AI: An automated grading tool for code assessment and feedback in programming course. *Education and Information Technologies*, 1-41.
17. Nussbaumer, D., & Deuss, C. (2024, June). ICT Usage at the Family-School Interface: A Systematic Review on the Situation of Children with Special Educational Needs. In *International Conference on Human-Computer Interaction* (pp. 144-158). Cham: Springer Nature Switzerland.
18. Priyasri, G. R., & Devi, M. U. (2025, February). Leveraging AI for Dyslexia Detection: Exploring Multimodal Approaches with Machine Learning and Deep Learning. In *2025 4th International Conference on Sentiment Analysis and Deep Learning (ICSADL)* (pp. 797-804). IEEE.
19. Ferrara, E. (2023). Fairness and bias in artificial intelligence: A brief survey of sources, impacts, and mitigation strategies. *Sci*, 6(1), 3.
20. Fitria, T. N. (2021, December). Artificial intelligence (AI) in education: Using AI tools for teaching and learning process. In *Prosiding Seminar Nasional & Call for Paper STIE AAS* (pp. 134-147).
21. Liu TC. A Case Study of the Adaptive Learning Platform in a Taiwanese Elementary School: Precision Education from Teachers' Perspectives. *Educ Inf Technol (Dordr)*. 2022;27(5):6295-6316. doi: 10.1007/s10639-021-10851-2. Epub 2022 Jan 6. PMID: 35013667; PMCID: PMC8731679.
22. Chan, C., & Li, F. (2023). Developing a natural language-based AI-chatbot for social work training: an illustrative case study. *China Journal of Social Work*, 16(2), 121–136. <https://doi.org/10.1080/17525098.2023.2176901>
23. Lin, Chin-Hsi & Zhou, Keyi & Li, Lanqing & Sun, Lanfang. (2024). Integrating Generative AI into Digital Multimodal Composition: A Study of Multicultural Second-language Classrooms. *Computers and Composition*. 10.1016/j.compcom.2024.102895.
24. Gómez Niño, J. R., Árias Delgado, L. P., Chiappe, A., & Ortega González, E. (2024). Gamifying Learning with AI: A Pathway to 21st-Century Skills. *Journal of Research in Childhood Education*, 1–16. <https://doi.org/10.1080/02568543.2024.2421974>
25. Alsahli, M., Alanezi, F., Basri, W. S., Attar, R. W., Alghamdi, A., Alyahya, N. M., Albagmi, S., Almutairi, S. A., Alsedrah, I. T., Arif, W. M., Alsadhan, A. A., AlShammari, M. H., Bakhshwain, A. M., Almuhanha, A. F., Alnaim, N., & Alhazmi, A. H. (2025). Effectiveness of ChatGPT in facilitating learning for students with special educational needs: An empirical study in Saudi Arabia. *Nutrition and Health*. <https://doi.org/10.1177/02601060241307770>
26. Arisandi, N. V., & Sudarajat, N. A. (2023). REVISITING “GRAMMARLY” IN HIGHER EDUCATION (A LITERATURE REVIEW). *Journal of Innovation Research and Knowledge*, 2(8), 3351–3356. <https://doi.org/10.53625/jirk.v2i8.5461>
27. Alfiana, M., Aditya, B. R., Hernawati, E., Wijayanto, P. W., & Gunawan, T. (2023, November). Usability testing of the Canva application as a student collaboration design media. In *2023 8th International Conference on Information Technology and Digital Applications (ICITDA)* (pp. 1-5). IEEE.
28. Li, X., Li, B., Li, J., & Cho, S. J. (2025). Technology Review of Magic School AI: An Intelligent Way for Education Inclusivity and Teacher Workload Reduction. *Education Sciences*, 15(8), 963.