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Artificial Intelligence and Neuroeducation: Enhancing Education for Students or Patients with Albinism

Ana-Maria Danila

Department of Biology, Faculty of Biology, Alexandru Ioan Cuza University of Iasi, Bd. Carol I nr. 20A, 700505 Iasi, Romania.
danilamariuca@yahoo.com
<https://orcid.org/0000-0003-0056-428X>

Irina-Luciana Gurzu

Faculty of Medicine, University of Medicine and Pharmacy Grigore T. Popa, 700115 Iasi, Romania.
ilgurzu@gmail.com
<https://orcid.org/0000-0003-3095-3497>

Bogdan Novac *

Faculty of Medicine, University of Medicine and Pharmacy Grigore T. Popa, 700115 Iasi, Romania.
bogdannvc@gmail.com
<https://orcid.org/0000-0003-4501-1718>

Otilia Novac

Faculty of Medicine, University of Medicine and Pharmacy Grigore T. Popa, 700115 Iasi, Romania.
otilia76@gmail.com
<https://orcid.org/0000-0002-4708-3603>

Antoneta Dacia Petroaie

Faculty of Medicine, University of Medicine and Pharmacy Grigore T. Popa, 700115 Iasi, Romania.
pantoneta@yahoo.com
<https://orcid.org/0000-0002-1239-8058>

Alin Ciobica

Ioan Haulica Institute, Apollonia University, Pacurari Street 11, 700511 Iași, Romania.
Department of Biology, Faculty of Biology, Alexandru Ioan Cuza University of Iași, Carol I Avenue, No. 20A, 700505 Iași, Romania.
Academy of Romanian Scientists, 3 Ilfov, 050044, Bucharest, Romania.
Center of Biomedical Research, Romanian Academy, Iasi, B-dul Carol I, Romania.
alin.ciobica@uaic.ro
<https://orcid.org/0000-0001-7293-859X>

Ioana Vata *

Apollonia University, Pacurari Street 11, 700511 Iași, Romania.
ioanamacovei@yahoo.com

Gabriel Dăscălescu

Ioan Haulica Institute, Apollonia University, Pacurari Street 11, 700511 Iași, Romania.
Department of Biology, Faculty of Biology, Alexandru Ioan Cuza University of Iași, Carol I Avenue, No. 20A, 700505 Iași, Romania.
gabidascalescu2001@gmail.com, <https://orcid.org/0009-0001-1962-7861>

Bogdan Gurzu

Faculty of Medicine, University of Medicine and Pharmacy Grigore T. Popa, 700115 Iasi, Romania. bgurzu@yahoo.com
<https://orcid.org/0000-0002-1834-9142>

* Corresponding authors

Abstract: This article investigates how artificial intelligence can support the inclusive education of students and patients with albinism, a genetic condition that manifests itself in visual deficits and cognitive challenges. Starting from a systematic synthesis of specialist studies and a case study of some AI platforms already in use, we aim to identify technologies capable of personalising teaching materials and adjust digital interfaces according to the visual and mental needs of the beneficiaries. The analysis reveals that while these tools can provide adaptive content and real-time feedback, their effectiveness depends on fine-tuning the parameters for the particularities associated with albinism. Furthermore, we argue that integrating neuroscientific perspectives, particularly those on neural plasticity and attentional processes, in the design of AI solutions can lead to truly personalised educational strategies. We conclude that the responsible adoption of artificial intelligence in inclusive environments requires careful reflection on the ethical and neuro-educational implications to guarantee an equitable and effective learning experience.

Keywords: neuroscience; artificial intelligence; albinism; inclusive education.

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1. Introduction

In recent years, inclusive education has become increasingly important in schools around the world, focusing on creating an environment where all students, regardless of abilities or special needs, can learn. This type of education adapts learning to meet the specific needs of students with disabilities or cognitive and developmental challenges. Furthermore, recent discoveries in neuroscience and technologies based on artificial intelligence (AI) offer new possibilities to enhance the educational process, making learning more accessible and efficient (Bastian, Liza, & Efastri, 2023). A relevant example of students who could benefit from personalised education is those with albinism, a genetic condition that presents visual and cognitive characteristics requiring a carefully adapted educational approach (Liu et al., 2021).

Albinism is a hereditary genetic condition caused by mutations that affect the enzymes involved in the formation of melanin, leading to insufficient or absent production of this pigment responsible for the color of the skin, hair, and eyes. It manifests as a partial or total lack of melanin, and the types of albinism are classified based on the affected genes, such as oculocutaneous albinism, ocular albinism, and cutaneous albinism. This condition affects approximately 1 in 17,000 to 20,000 individuals worldwide (Kirkwood, 2009; Ramos, Ramos, & Fernandes, 2021). From a long-term perspective, individuals with albinism are more prone to sunburn, skin cancer, and other dermatological conditions due to the lack of natural protection against ultraviolet rays. Additionally, ocular risks are significant, including vision problems such as strabismus and myopia, which can severely affect the ability to perceive visual details (Marçon et al., 2020; Maia et al., 2015).

From a social and educational perspective, albinism can create significant barriers for affected individuals. Social stigma and misconceptions related to the physical condition can lead to social isolation and difficulties in integrating into schools or the community (Brilliant, 2015). Education thus becomes a major challenge, as visual difficulties are not always recognised or responsibly managed within traditional educational settings (The Lancet Child & Adolescent Health, 2019; Kromberg, 1992). Albinism has a significant impact on visual perception, affecting the visual information processing and, consequently, the cognitive processes involved in learning. Individuals with albinism face increased sensitivity to light (photophobia) and reduced visual acuity, which makes essential activities such as reading and interpreting visual materials more difficult in a traditional educational setting (Creel, 2015; Karlén, Milestad, & Pansell, 2019). These visual impairments can lead to a distorted perception of information, affecting learning efficiency and cognitive development (Thomas, Zippin, & Brooks, 2023).

Although there are studies dedicated to adapting educational materials for people with visual impairments, research aimed at applying modern technologies, especially assistive technologies based on AI, remains limited (Zhang et al., 2022; Wu et al., 2020). These innovative solutions can provide adaptive support, increasing the accessibility and efficiency of the learning process and thus contributing to the development of an optimal and inclusive educational framework. In parallel, a relevant question persists: how does the brain manage to compensate for these visual deficiencies to support learning in the case of people with albinism? The answers come from neuroscience, which highlights neural plasticity, the ability of the nervous system to reorganise itself as a result of new stimuli, providing an essential mechanism for students with reduced visual acuity and photophobia (Carruthers, 2018; Huurneman, Boonstra, & Goossens, 2016). Thus, they can develop cognitive alternatives by capitalising on auditory and tactile information, training their brains to process non-visual sensory data, and underpinning multisensory educational strategies.

In addition, neuroscientific perspectives can guide the design of assistive technologies, from optimising contrast and enlarging fonts to integrating voice recognition, to facilitate access to information and school integration for students with albinism (Wu et al., 2020; Crossland, Silva, & Macedo, 2014; Jaiswal et al., 2019). Understanding the cognitive processes affected by vision impairment also allows for the design of personalised pedagogical methods that effectively integrate visual, auditory, and tactile materials. These practices not only respond to the specific needs of people with albinism but also promote an inclusive education model that enables them to perform to

their full potential. Therefore, neuroscience becomes a particularly valuable ally in improving educational access and social integration of these individuals by implementing solutions based on brain adaptability and advanced technologies, for a truly efficient and equitable learning environment (Vantieghem, 2023; Heilmann, Bertone, & Wojtyna, 2024).

Although neuroeducation holds significant potential, progress has been slow due to neuro-scientific myths, confusion between the fields of neuroscience and education, and an excessive focus on pedagogy rather than pedagogical support (Jolles & Jolles, 2021; Torrijos-Muelas, González-Víllora, & Bodoque-Osma, 2021). At the same time, technology, especially artificial intelligence (AI), plays an increasingly important role in inclusive education. AI can completely transform the way educational materials are designed, adapting them to meet the needs of students with albinism. For example, AI-based educational platforms can automatically adjust text size, contrast, or brightness of visual materials, facilitating access to necessary information. Additionally, AI can provide interactive solutions that promote active learning and help students develop cognitive skills in a personalised manner, based on their visual and learning needs. Thus, the use of AI in education can support students with albinism by personalising the educational experience, providing a more inclusive environment that allows them to learn in a way tailored to their characteristics (Pagliara et al., 2024). The use of adaptable AI technologies and research from neuroeducation can contribute to the development of personalised educational strategies that effectively address the students' individual needs, promoting a more inclusive educational system. These strategies can improve access and learning outcomes for all students, regardless of their health or learning conditions. However, despite the potential that AI offers in education, there are both advantages and challenges (Dave & Patel, 2023).

2. Methodological Approach

Literature Selection and Analysis Process

Studies that integrate artificial intelligence and neuroscience in the educational field for students and patients with albinism are still limited and under-researched. There is an ongoing debate regarding the use of AI technologies for personalised learning. Some argue that AI could replace traditional teaching methods, while others express concerns about their efficiency and accessibility. Major challenges include data security, resistance to AI adoption, and ethical issues. Additionally, there are ongoing concerns about the accessibility of technological resources, especially in educational institutions with limited budgets (Silva, 2024).

This article reviews existing research on how AI and neuroeducation are being used to support the education of students and patients with albinism. Studies that explore the impact of visually and cognitively adapted technologies on learning will be analysed, including the use of AI to personalise educational materials.

Interest in the interaction between AI and education has grown considerably over the past decade, as seen in the analysis of the number of articles published between 2015 and 2025 on PubMed, in *Figure 1*, which provides access to a wide range of empirical studies, theoretical articles, and research reports. The studies included will be selected based on relevance, methodological quality, and applicability, using keywords such as "albinism," and "Artificial Intelligence in Education." Analysing the trends in research publications from 2015 to 2025, there is a marked increase in research on the use of artificial intelligence (AI) in education, with an impressive number of 16,393 articles published on this topic. In contrast, the field of education for albinism remains comparatively underrepresented, with only 1,789 articles published in the same period. This discrepancy suggests that while there is an interest in educational research in the context of albinism, the growth rate of research in this area is much slower, indicating less attention compared to other fields, such as the application of innovative technologies in education. Another relevant field is AI in special education, with 518 articles published, reflecting the progressive application of AI technologies to support individuals with special needs. Figure 1 highlights these differences and emerging trends.

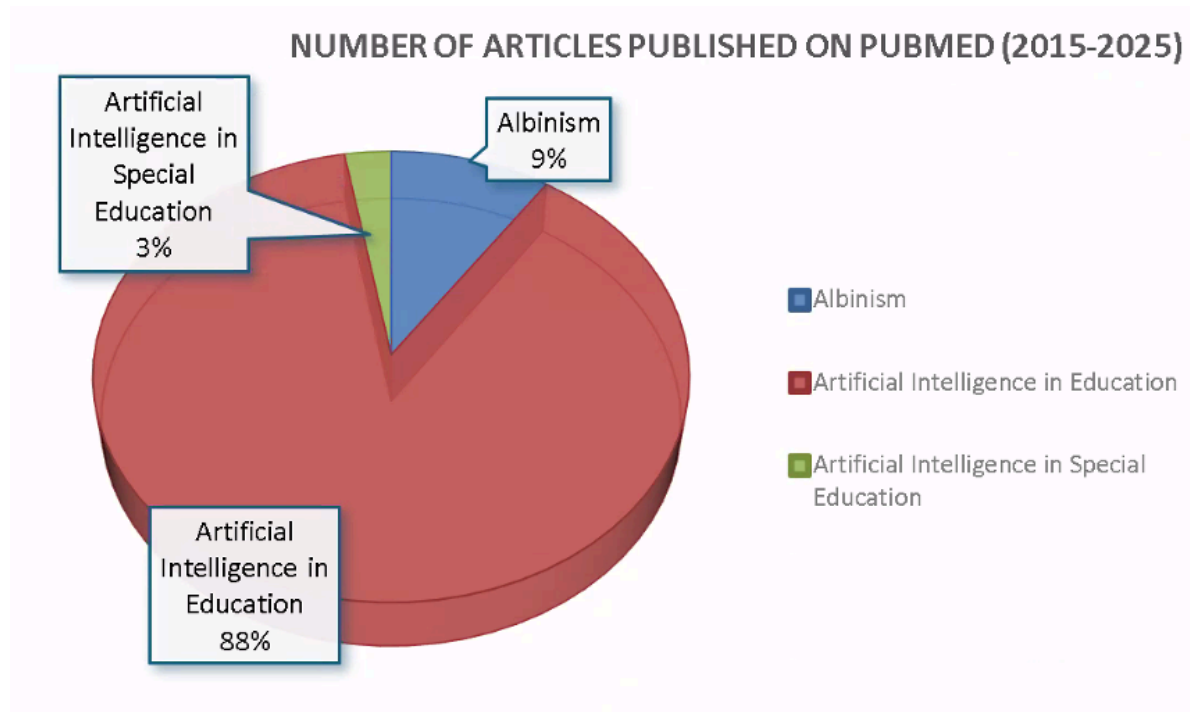


Figure 1. Trends in Research Publications on Albinism, Neuroeducation, and Artificial Intelligence in Education (2015-2025)

3. Results: Analysis of Key Findings and Trends in the Literature

3.1. Educational Technologies and Artificial Intelligence (AI)

Chen, Zou, and Xie (2020) investigate the evolution of educational technologies over half a century, highlighting major trends such as technology-assisted pedagogy, hybrid learning, and the use of educational games. In a subsequent paper, the same authors apply topic structural modelling to uncover emerging themes, including collaborative and online learning, highlighting the profound influence of digital tools on the instructional process. This research shows how educational technologies can individualise learning, which is particularly relevant for students with albinism, for whom customised materials contribute to increased accessibility and improved academic performance (Chen, Zou, & Xie, 2020; Chen et al., 2020).

Similarly, Roll and Wylie (2016) analyse the evolution of the field of AI in Education (AIED) over a period of 25 years, examining 47 articles published in the Journal of AIED in 1994, 2004, and 2014. They delineate two major trends: on the one hand, the evolutionary process, which improves educational practice through collaboration and various technologies; on the other hand, the revolutionary process, which integrates technology into the daily lives of students (Roll & Wylie, 2016).

More recently, Rodríguez-Hernández et al. (2021) implemented artificial neural networks (ANNs) to predict academic performance, achieving an accuracy of 82% in classifying high results and 71% for low ones. These results illustrate the potential of AI to adapt education to the profile of each learner. Transposed into the context of students with albinism, this model of personalisation of materials and pedagogical methods could revolutionise the learning process, ensuring a more accessible and inclusive educational environment (Rodríguez-Hernández et al., 2021).

Regarding the methodological perspective, the tools used to predict academic performance, artificial neural networks, represent a powerful option, allowing the analysis of large amounts of data and identifying complex relationships between variables (Somers & Casal, 2009; Garson, 2001; Lau, Sun, & Yang, 2019). Artificial neural networks are algorithms inspired by the human

brain, used to analyse and learn from complex data. They identify patterns and relationships in large datasets and can make precise predictions through iterative training processes. They are used in many fields, including predicting academic performance. Unlike traditional methods, such as linear or logistic regression and correlation analysis, which impose certain statistical assumptions (such as data normality or the independence of observations), ANNs can handle more complex and nonlinear relationships without these assumptions (Field, 2009). Furthermore, studies show that violating assumptions in traditional methods can lead to estimation errors and incorrect results (Nimon, 2012; Osborne & Waters, 2002).

Matheny et al. (2020) focus on the application of machine learning algorithms to tailor treatments and training to the individual needs of patients or students, a principle that can support patients with albinism by personalising educational and medical interventions (Matheny et al., 2020). On the other hand, Garg (2020) emphasises the use of AI in medical education for personalising the curriculum and assessing students, an approach that can be extended to adapting educational materials and teaching methods for students with albinism, considering their visual and cognitive needs. Julien (2024) analyses the impact of AI in inclusive education, identifying its advantages and challenges. AI can improve educational accessibility and personalise the learning process by adapting educational materials, such as adjusting fonts or converting texts to audio, thus benefiting students with albinism. However, the effectiveness of this technology depends on overcoming issues related to technology, connectivity, and pedagogy (Julien, 2024). In support of this, organisations such as the National Organisation for Albinism and Hypopigmentation (NOAH) provide educational resources for parents and teachers, including a "SchoolKit" that offers recommendations for adapting materials and teaching strategies to the specific needs of students with albinism (NOAH, n.d.).

3.2. Academic Performance and Socio-Economic/Cognitive Factors

Modern technology significantly improves the way standardised tests are used to assess academic performance (Kuncel & Hezlett, 2007; Morris, 2011). For example, tests such as the Scholastic Assessment Test (SAT) administered in the USA (Sackett et al., 2012) or the Swedish Scholastic Aptitude Test (SweSAT) administered in Sweden (Cliffordson, 2008) are extensively used to predict future academic achievement. They are used to predict future academic success. In Colombia, the SABER 11 and SABER PRO tests are essential for evaluating students, providing valuable insights into their academic preparation and skills (ICFES versions, 2021a, 2021b) (Rodríguez-Hernández et al., 2021). These tools contribute to more informed selection and planning of educational interventions. On the other hand, many studies have investigated the factors that influence academic performance, which are broad and variable. For example, McKenzie and Schweitzer (2001) emphasise that academic, cognitive, demographic, and psychosocial factors are essential in explaining educational success.. At the same time, in regions with stigmatisation, such as Africa, children with albinism face major educational and social barriers, fueled by myths and prejudices (Gaigher, Lund, & Makuya, 2002; Franklin et al., 2018; Bradbury-Jones, Isham, & Taylor, 2018). Educational and health interventions, recommended by Lund and Gaigher (2002), are essential for their integration into education, helping to overcome barriers related to health and stigma.

The study conducted by Musso et al. (2013) applied artificial neural networks to predict the academic performance of a sample of 864 students, achieving 100% accuracy in identifying the weakest and best performers. A third model classified students into three performance classes with an accuracy ranging from 87% to 100%. The analysis highlighted the determining factors as reaction time to mathematical operations, parental occupations, and level of executive control skills.

In the medical field, AI is strengthening its role through the ability to quickly process a large data volume, which improves the accuracy of diagnoses and the efficiency of personalised treatments (Karmakar, 2022; Köse et al., 2021). At the same time, the use of AI algorithms involves risks such as calculation errors and confidentiality issues of patient data (Pashkov, Harkusha, &

Harkusha, 2020), requiring the development of strict ethical regulatory frameworks to protect users (Dave & Patel, 2023). For patients with albinism, these technologies can facilitate early identification of vision disorders and support training of healthcare professionals and patients in managing associated complications. Klemen and McAvinue (2015) propose that genetic and environmental features of albinism increase the risk of ADHD, and the use of AI could improve early detection and personalisation of educational interventions. In a previous study, Kutzbach et al. (2008) examined the neurological development of 78 children with albinism and found no significant delays in either motor development or school performance; however, they emphasised the need for assistive and intelligent technologies to adapt educational materials to the children's visual and cognitive requirements. Thus, both studies highlight the essential role of AI in personalising the educational process and supporting people with albinism.

3.3. Educational Integration of Students with Albinism

The study by Kutzbach et al. (2009), using the NEI-VFQ questionnaire, shows that 68% of participants with albinism encountered difficulties in daily activities due to visual impairments, highlighting the need for assistive educational technologies to support students in accessing educational materials. These technologies can improve their academic performance and quality of life. In the same direction, Goldstand, Koslowe, and Parush (2005) find a significant link between visual impairments and the students' academic performance, emphasising the importance of accurately assessing visual abilities to identify and support students with difficulties.

Table 1. Factors Influencing the Education of Students with Albinism and Proposed Solutions

Category	Cause (Research Hypothesis)	Research (Methods & Instruments)	Solutions (Results Obtained)	Source
Educational Technologies & AI	Educational technologies can improve the academic performance of students with albinism through personalisation and adaptation of materials	AI models, adaptive platforms, educational data analysis, personalised tests	Improved educational accessibility and learning personalisation (e.g., adjusting visual materials and fonts)	Julien (2024), Matheny et al. (2020), Garg (2020)
Academic Performance & Cognitive Factors	Cognitive and socio-economic factors influence the academic performance of students with albinism	Neural networks, statistical analyses (e.g., regression, data modelling)	Increased accuracy in predicting academic performance (100% accuracy for extreme score groups)	McKenzie & Schweitzer (2001), Musso et al. (2013), Klemen & McAvinue (2015)
Stigmatization & Inclusion	Social stigmatisation and visual impairments affect the access and performance of students with albinism in education	Surveys, case studies, visual assessments, interviews, performance data analysis	The use of assistive technologies improves access to educational materials and reduces stigmatisation	Kutzbach et al. (2009), Goldstand et al. (2005), Keeffe (1990), McKenzie & Schweitzer (2001)

Their study results suggest that adjusting educational materials can support the learning of students with albinism, particularly through technology that automatically adjusts visual materials. In this context, Keeffe (1990) emphasises the importance of educational and visual assessments for students with albinism, noting that despite visual impairments, they possess superior cognitive

abilities. The study highlights the need for assistive technologies to support the educational process and adapt educational materials. In addition, the study by Cole et al. (1987) compares the cognitive functions of children with albinism to those of children with visual impairments, observing a discrepancy between verbal and performance abilities, which cannot be explained solely by reduced visual acuity. This suggests neuroanatomical and neurophysiological particularities that may influence information processing and should be considered when developing educational materials and interventions for children with albinism.

Thus, Table 1 provides a summary of the main factors influencing the education of children with albinism, highlighting the causes, research methods used, and proposed solutions in various studies. Each category explores essential aspects of the education of these students, such as the use of educational technologies and AI, the impact of cognitive and socio-economic factors on academic performance, as well as the role of social stigmatisation and visual impairments in access to and success in education. The solutions presented in the studies include assistive technologies and personalised learning, which have shown significant positive effects in improving accessibility and educational performance for students with albinism.

3.4. Technologies and Innovation in the Education of Children with Albinism

Recently, innovative technologies, especially AI, have been proposed as solutions to support the education of children with special needs. The study by Bhargava and Sharma (2021) highlights the use of AI to create personalised educational tools that adapt to the specific needs of children with neurodevelopmental disorders, facilitating learning by adjusting materials and providing immediate feedback. Li et al. (2025) used interactive multimedia files to enhance active learning in medical education, demonstrating a significant increase in scores and academic performance through case study approaches.

The study by Copley and Ziviani (2007) applied an assessment method for assistive technology based on teams for children with multiple disabilities, using tools such as the Lifespace Access Profile; thematic data analysis showed significant improvements in collaboration among educational teams. The study by Zapf (2016) used a mixed approach to evaluate the impact of assistive technologies in the education of children with severe disabilities, demonstrating improvements in communication and autonomy. These studies suggest the effectiveness of technological methods but emphasise the need for further evaluations to measure their direct impact on learner outcomes.

The studies by Mistry, Brock, and Lindsey (2023) and Plotzky et al. (2021) examine the use of virtual reality (VR) in medical education, highlighting the benefits of this technology in professional training. Mistry, Brock, and Lindsey (2023) show that VR allows medical students to practice interactions with virtual patients, make diagnoses, and apply treatments, improving speed and accuracy in interventions, reducing risks, and developing empathy. Plotzky et al. (2021), referencing Shorey (2019), identify four main purposes for VR in nursing education: learning technical skills, preparing for emergencies, developing physical abilities, and improving communication. The study shows that although VR is increasingly used, there is limited long-term research on its effectiveness. Both studies highlight that VR is an innovative method that improves professional skills and patient safety.

Recent studies propose innovative methods for improving education. Ding, Yun, and Li (2023) use multimedia technology and visual behaviour analysis of students to adapt educational content based on the needs of each student. Zeng, Zhao, and Wen (2023) combine visual and textual data using neural networks to assess the quality of digital education, improving the assessment by 10%. Liang et al. (2019) developed an interactive system based on wearable devices that collects students' physical data and adjusts the teaching pace in real time, using a cloud system to predict performance and detect anomalies. Hu (2023) uses IoT, fuzzy control, and deep learning to adjust teaching in real time, improving the educational process by analysing students' behaviour in the classroom.

Recent research has introduced cutting-edge approaches that harness advanced technologies to elevate both educational outcomes and speech-recognition performance. Gnanamanickam, Natarajan, and K. R. (2021) devised a hybrid method combining nonlinear spectral subtraction with a Hidden Markov Model to bolster speech transcription in noisy medical settings, achieving a lowest-observed error rate of 9.5%. Krishnamurthy et al. (2022) investigated gamification within medical training, showing that interactive games and virtual simulations foster deeper learning and more effective collaborative decision-making among students. Akl et al. (2010) evaluated the influence of educational games on learners' competencies, reporting generally positive trends but underscoring the necessity for additional empirical validation. Zakrajsek et al. (2024) presented a blueprint for creating accessible Braille and tactile graphics, stressing the critical interplay between fine motor coordination and cognitive processing in tactile learning. Finally, Anaje et al. (2023) assessed WhatsApp-based health education interventions, documenting a statistically significant 5.23% increase in participants' sun-protection knowledge, as verified by Mann-Whitney U tests and Spearman correlations.

3.5. Synthesis of Findings

Collectively, these studies illuminate the transformative potential of advanced digital tools across educational and healthcare domains: from virtual-reality simulations for clinical training to sophisticated noise-robust speech-recognition algorithms and interactive learning games. They concurrently highlight implementation challenges, such as the need for rigorous outcome validation and the practical hurdles of deploying complex technologies in real-world settings. By mapping both successes and setbacks, this body of work provides a nuanced perspective on how novel technological solutions can be optimised for diverse learner populations.

In the context of albinism, AI stands out as a pivotal enabler of truly inclusive education, tailoring instructional materials and assistive interfaces to the unique visual and cognitive profiles of these students, thereby fostering greater accessibility, engagement, and academic achievement.

Figure 2 illustrates how these technologies enhance the educational process, especially in the context of albinism, by adapting visual content, providing AI instant feedback, offering voice assistance, using augmented reality (AR) and virtual reality (VR), educational gamification, tactile devices, and digital Braille.

Visual impairments often hinder information access, but AI introduces advanced tools that improve readability, interaction, and the overall learning experience. Through these technologies, students benefit from a more accessible and efficient educational environment, where visual content adaptation optimises contrast and text size, and instant feedback helps correct mistakes in real-time.

Voice assistance and AR/VR features facilitate a deeper understanding of concepts, while gamification and tactile devices enhance interactivity and accessibility. These innovations contribute to a more equitable and effective education for students with albinism, breaking down visual barriers and providing equal opportunities for all.

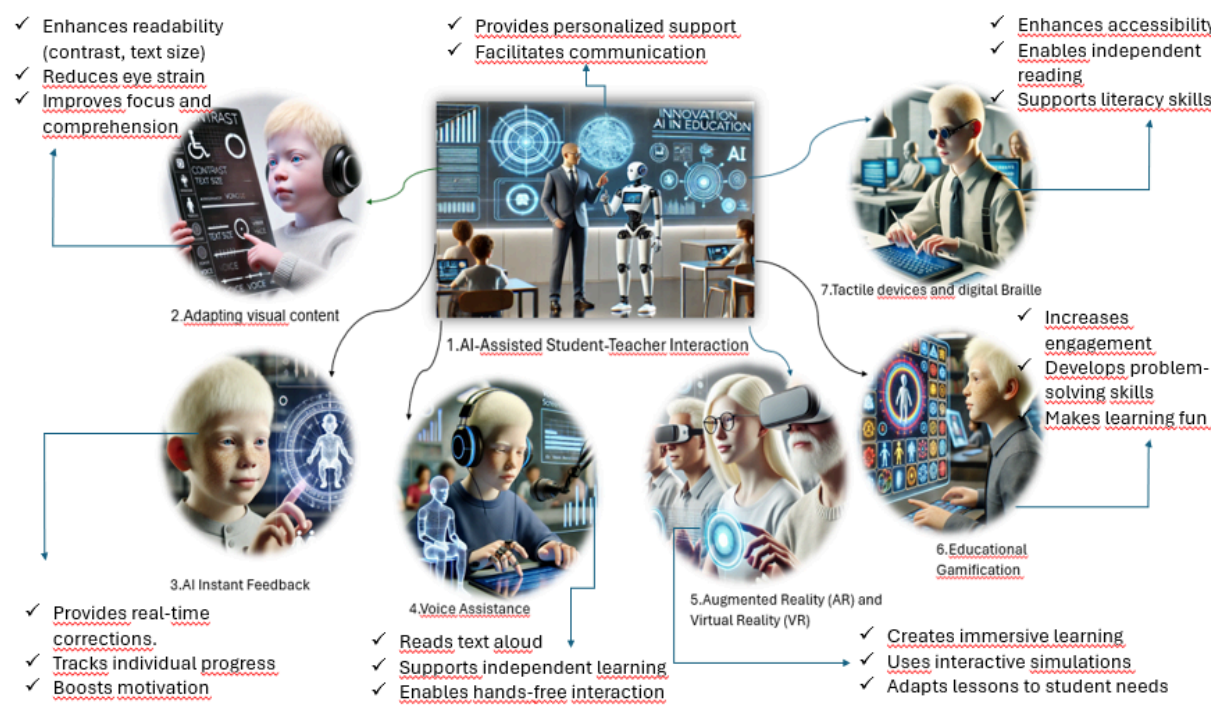


Figure 2. AI Technology for Inclusive Education- Innovations and Benefits for Students with Albinism: Adapting visual content, AI Instant Feedback, Voice Assistance, Augmented Reality (AR) and Virtual Reality (VR), Educational Gamification, Tactile devices and digital Braille

4. Preliminary Conclusions

Based on the studies presented, we can say that the use of advanced technologies, such as AI and neuro-education, in the education of students and patients with albinism could effectively address their specific needs. Personalising the educational process through visual and interactive content adaptation could significantly contribute to improving accessibility and the understanding of concepts, thus overcoming the visual barriers imposed by albinism.

On the other hand, it is important to note that the implementation of these technologies involves considerable challenges. While augmented reality, virtual reality, and voice assistance technologies have great potential to facilitate learning, there is a need to invest in appropriate infrastructure and the training of educational staff. Additionally, there is still a lack of extensive research to validate the effectiveness of these methods within the educational context of students with albinism.

In light of the above, it is possible that the integration of innovative solutions, such as educational gamification and tactile devices, could improve interactivity and contribute to a more accessible and enjoyable learning experience. However, the implementation of these technologies is not uniform and may be limited by access to the necessary equipment.

In conclusion, current evidence suggests that advanced technologies have a significant impact on inclusive education for students and patients with albinism. However, future research should focus on validating and adapting these solutions to better meet their specific needs, thus contributing to the creation of a more accessible and personalised educational system.

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