AI's ROLE IN NEUROEDUCATION, COGNITIVE NEUROSCIENCE, AND PERSONALIZED LEARNING: A SYSTEMATIC LITERATURE REVIEW

A. Leela Glory & M. Balasubramaniam

Abstract

The field of education is drastically improving every day in this technical era, where AI is utilised in real-time to help learners who face challenges by designing adaptive learning systems. By comprehending the principles of Psychology, Education, and how the brain processes and analyses information, the field of Neuroeducation emerged. Cognitive Neuroscience is the integration of Neuroscience and Psychology that studies the biological and mental processes of the brain. The role of AI-driven interventions is a field in education that has already been implemented and enhanced the individual learning outcomes of individuals by improving personalized learning, whereas the role of AI in Neuroeducation and Cognitive Neuroscience has carried out studies based on performance level and span of engagement, but very few studies have been carried out in relation to Cognitive, Metacognition criteria such as Retention and Attention span. The study on another very important aspect of Self-regulation has also not been covered in many studies. This gives rise to a gap if personalised learning with AI-enhanced technology actually lines up with how the brain carries out activities like analysing information and learning content. A Systematic Literature review has been done to analysewhether AI-enhanced technologies actually support or do not include Neuroeducation methods that can enhance learning outcomes in individuals and improve a personalised style of learning.

Keywords: Artificial Intelligence (AI), Neuroeducation, Cognitive Neuroscience, Personalised learning

Introduction

Personalised learning, which is to meet the requirements of individuals in their learning process, is an essential aspect, and in today's advanced technological era, it has been fulfilled to a great extent by putting into operation AI-driven tools like VR/AR, chatbots, Adaptive systems (Guduru, 2025), AI tutors (Atoui, 2024), etc. The usage of these tools to satisfy the unique requirements of students who can learn at their own convenience and pace has enhanced the learning outcomes in academics and the attention span of students. Though personalised learning has escalated and improved due to the utilisation of AI tools (Brittain, 2024), the amalgamation of Artificial Intelligence-driven methods in Cognitive-based Neuroscience and Neuroeducation is less investigated. Neuroeducation is a field that deals with the synergy of cognitive processes, like Metacognition, which has not had many studies done on it. Retention and Memory level are also not looked into in depth, and the main learning process of Self-regulation involved in Neuroeducation has not been explored much. These brain processes, like metacognition, which are very important for one's learning process which can enhance personalised learning and have not been dealt with. Keeping this gap in mind, AI approaches in the area of Neuroeducation require an SLR to be done. This paper carries out a Systematic Literature Review and presents the effects of AI-driven technologies in escalatingpersonalised learning (Brittain, 2024), emphasising the role of AI in Cognitive Neuroscience. This review highlights the present-day practices that are being implemented and the issues faced when AI is integrated with Neuroeducation.

Need and Significance of the Study

The improvement in Personalised learning among students due to the integration of AI-enhanced technologies is very evident in these modern days, due to the numerous AI tools available. These AI tools are developed to satisfy the diverse needs of individuals that are unique to each, enabling them to learn according to their grasping potential and pace. This has improved the attention span and focus among students, resulting in better academic performance.Ample studies have been done on them on this criterion, which lies on the surface of the learning process. There are, though, limited studies based on the role of AI in Cognitive Neuroscience, and less evidence, and there lies a need to spotlight this research gap. The synergy of AI in the education field is examined by this review, creating effective personalised outcomes. It also examines the synergy of AI with Cognitive Neuroscience and throws light on the theoretical and practical aspects to create learning environments that are evidence-based. By doing so, Educators and AI developers can adopt methods and technologies that will enhance Cognitive learning outcomes. This SLR creates a study for the upgrading of the field of AI-driven Neuroeducation in the future and implementation in the field of education.

Statement of the Problem

The benefits of Artificial Intelligence-enhanced technological tools in the education area to enhance personalised experiences are many and has been fulfilled to a great extent by the use of AI tools like chatbots, VR/AR, AI tutors, and Adaptive systems (Brittain, 2024),etc. The impact of these AI technologies in the context of academic performance (Vieriu & Petrea, 2025) and engagement level is revealed by many numbers of studies, but the effect of AI in the interdisciplinary field of Neuroeducation has not been dealt with. Cognitive approaches like Memory retention, Self-regulation, and Metacognition remain in the dark and have to be studied. Understanding the role of AI to initiate brain-based learning outcomes that are personalised to one's needs remains a gap. Thus, a systematic review has been carried out to check the effect of AI in the field of Neuroeducation.

Research Questions

1. How has personalised learning been enhanced inthe Education area by utilising Artificial Intelligence technologies like AI tutors, Adaptive systems, VR/AR, etc?
2. Have the methods and principles of Neuroeducation and Cognitive Neuroscience been incorporated by AI-based applications when it comes to criteria like Metacognition, Attention span, Memory retention, and Self-regulation?

Objectives

1. To find out the part AI plays in boosting personalised learning outcomes by the use of AI-based technological tools.
2. To find out how AI-based applications have integrated methods and principles of Neuroeducation and Cognitive Neuroscience to check levels of Metacognition, Attention span, Memory retention, and Self-regulation in learners.

Methodology

1. **Search Strategy:** In this Systematic Literature Review,the papers reviewed were extracted from Google Scholar and Springer. Some of the keywords that were used to view these papers were AI-driven technologies, personalised learning, Neuroeducation, Cognitive Neuroscience, and Metacognition. Papers between the span of 2020 to 2025 were referred to.
2. **Criteria for Inclusion and Exclusion:**
    - **Criteria for Inclusion:** The primary focus and aim of this study pivotedon enhancing personalised learning, attention span, learning outcomes, and metacognition by the integration of AI-based approaches with principles of Neuroeducation and Cognitive Neuroscience, referring to papers published during the span 2020 to 2025.

- **Criteria for Exclusion:** The criteria of Exclusion focused on works that were not published in English, not AI-based, and not related to the Education field.
- **Mini PRISMA Flow:** During the initial search process, 28 papers were identified. Application of the inclusion and exclusion criteria led to19 related studies being found and used for the SLR.

Literature Review

The importance of new types of teaching strategies and learning techniques to suit each student's preferences has been made possible by the blooming of newer technologies like AI tailored learning adaptive tools and instructional tools to increase engagement, and personalized learning, (Ellikkal& Rajamohan, 2024; Katona &Katonane, 2023; El-Sabagh, 2021) that permit learners to grasp new concepts at their own pace and effectively improving personalized learning in students of school and higher education. The application of Artificial Intelligence enabled Virtual teaching assistants, e-learning, and Adaptive systems in VR adaptive environments (Sajja et al., 2023; Wahid & Khan, 2024; Lau et al., 2024) can reduce cognitive load. Using AI tools like chatbots, VR simulators, and AI robots in the field of medicine, in training nurses during the Covid-19 phase, and dentists undergoing internship (Han et al., 2022; Hu et al., 2025), increased interest level, Studies showed that the amalgamation of AI in pedagogical strategies by using Gen AI helps in provide for students' unique requirements and personalized learning, as reported by Khan & Jian, (2023) and Laak & Aru, (2024). Learning materials to meet the unique challenges each student faces by utilising Machine learning capabilities, chatbots, and AI tutors, along with other forms of natural language processors, can give prompt feedback and help students with questions that require immediate answers (Gligorea et al., 2023). Thus, we see from this review that the application of AI in the sphere of education definitely creates a boost in the personalised experience for learners.

The combination of intelligent AI technologies with brain-based learning techniques is created by integrating Neuroeducation with AI and Neuroscience, which is the science of how the most complex organ, the brain, controls many mental processes such as analysing data, perceiving information, responding to situations, problem-solving, critical thinking, and decision-making (Boon, 2024). The AI and Neuroscience principles have a strong effect to ensure personalized learning outcomes about efficacy, and AI-tailored technologies, such as ML algorithms and ML Models, can initiate feedback so that students can learn at their own convenience and speed, thus increasing attention span, memory retention, and problem-solving ability, and these Neuroeducation systems can also help in the early detection of learning disabilities (Shiwlani et al., 2024; Sonia & Oscar, 2025). Studies show that in the case of individuals suffering from Albinism, the integration of AI and Neuroeducation enhances personalised learning, providing real-time feedback, creating an

inclusive environment to boost learning outcomes (Danila et al., 2025). The amalgamation of Deep learning, Neuropedagogy, Neuroimaging and Artificial Intelligence can create optimized learning processes in teachers and students proving that this convergence can increase learning processes in individuals, and AI in secondary science education in a Neuroscience perspective can escalate critical thinking, personalized learning (Camargo, C. D. B., & Fernández, A. H. 2024; Frendo & Vassallo, 2025). The synergy of AI and Cognitive Neuroscience is studied by a review of Cognitive overload theory, Educational Neuroscience, AI, and ML to analyse their effectiveness, whereas CNNs, RNNs, and SVMs make AI adaptive systems scalable, and Multimodal approaches increase the robustness in K-12 and adult learners. Instructional strategies can be improved by using Neurophysiological tools like EER, fMRI to detect neurological conditions (Gkintoni et al., 2025). Using an alternate flipped classroom pedagogy method based on Neuroeducation to help in-service teachers who are dealing with constrained resources promotes Heutagogy (Self-determined learning) (Pretorius, 2025) so they can improve pedagogical methods and promote a learner-centric learning outcome. There are very few studies that show the relation between AI, Neuroeducation, and Metacognition.

Findings

Objective 1: The findings related to personalised learning enhanced by AI in education in the review showed that AI-based tools for adaptive learning enhance student motivation, escalating personalised learning, improving concept learning (Ellikkal& Rajamohan, 2024; Katona &Katonane, 2023; El-Sabagh, 2021). Studies revealed that by using Virtual teaching assistants, e-learning adaptive tools, chatbots, and AI robots can reduce cognitive overload, increase focus, self-directed learning towards metacognition, personalized learning, clinical competence, precision, and aid in tracking human behaviour (Sajja et al., 2023; Wahid & Khan, 2024; Lau et al., 2024; Han et al., 2022; Hu et al., 2025). AI tutors, Machine algorithms, and NLP can produce immediate feedback leading to better learning (Gligorea et al., 2023). ChatGPT,which is a Gen-AI tool, can cater to the individual learning needs by providing content related to their learning abilities, thus bridging the long-standing gap between technological advancement and the education-enhancing personalised learning, as reported by Khan & Jian, (2023) and Laak & Aru, (2024).

Objective 2: Thefindings related to Integrating AI with Neuroeducation and Cognitive Neuroscience showed that the amalgamation of Cognitive Neuroscience in the field of education enables techniques that enhance learning using brain-based activities in the learning stages of students (Boon, 2024; Khan et al., 2023). AI and Neuroeducation techniques promote inclusivity, provide feedback, improve retention, comprehension, predictive analytics, EEG, and eye tracking for adaptive learning and cognitive ability detection (Shiwlani et al., 2024; Sonia & Oscar, 2025). Studies show that in the case of

students suffering from Albinism, AI tools create content tailored to their needs, creating an equitable environment to enhance learning (Danila et al., 2025). Neuropedagogy, Neuroimaging, AI, and Deep learning technologies can be used as per an individual's neurocognitive ability to create optimised and positive learning outcomes for teachers and students, promoting logical thinking (Camargo, C. D. B., & Fernández, A. H. 2024; Frendo & Vassallo, 2025), also escalating the interaction between the teacher and student. An increase in learning efficacy is noticed by the utilisation of AI and ML, and by giving personalised instructions that are based on Neurophysiological data in real-time, the cognitive overload can be managed automatically. Early interventions can be provided to students to enhance personalised learning outcomes by tracking the Cognitive state of studentsutilisingNeurophysiological tools like EER, fMRI(Gkintoni et al., 2025). The inclusion of Neuroscience principles into flipped classrooms enables the initiation of reflective practices and learner autonomy, as stated by Pretorius (2025).Findings reveal that studies related to Neuroeducation, Metacognition, and AI are scarce in number.

Discussions

Several studies show that personalised learning is enhanced by the use of adaptive technologies **(**Katona &Katonane, 2023; Sajja et al., 2023; Khan, 2024; Lau et al., 2024) by the integration of AI, reducing stress and enhancing personalised learning. However, there is a gap in the effect of these interventions on metacognition. Some studies show that there could be a cognitive overload due to these tools (Khan, 2024; Lau et al., 2024). Partial metacognition and focus on metacognition support is seen (Sajja et al., 2024; Katona & Katonane, 2023; Han et al., 2022).

The synergy of AI with Neuroeducation and Cognitive Neuroscience shows immediate feedback provided by the use of these tools (Shiwlani et al., 2024; Sonia & Oscar, 2025; Gkintoni et al., 2025; Danila et al., 2025) that aids in providing better outcomes. The requirement for ethical considerations has been emphasised by some studies (Danila et al., 2025; Camargo, C. D. B., & Fernández, A. H. 2024; Frendo & Vassallo, 2025; Gkintoni et al., 2025), whereas others do not address ethical implications. Some studies reveal that personalised learning is increased by personalised neurocognitive profiles and the use of AI (Camargo, C. D. B., & Fernández, A. H. 2024; Sonia & Oscar, 2025; Frendo & Vassallo, 2025). Metacognition is exhibited only in one study (Pretorius, 2025), but others lack metacognition. However, it is noticed that more studies related to AI, Neuroeducation, and Metacognition that analysed self-regulation, Memory retention, and critical thinking must be carried out.

Conclusion

Thus, from this Systematic Literature review, it is highlighted that utilising AI adaptive tools and technologies in the education area escalates personalised learning, and its

integration with Neuroeducation and Cognitive Neuroscience creates opportunities for equity and inclusiveness. Also, by using various Neurophysiological tools like EEG, fMRI, brain conditions can be studied, and Neurological conditions can be detected.

Recommendations

The future studies based on the synergy of AI in Neuroeducation, Cognitive Neuroscience approaches must prioritise the ethical implications, and data privacy,making sure that behavioural and Neurophysiological data collected is used responsibly. Future studies could be to carry out a review, especially to analyse the effect of AI in the field of Generative AI and assistive tools used related to students with disabilities, and a review can be carried out on AI applied in other fields other than education.

References

1. Atoui, H. (2024). *Enhancing Learning with AI-Powered Tutoring and Support Systems - London School of Science & Technology*. London School of Science & Technology. https://www.lsst.ac/blogs/enhancing-learning-with-ai-powered-tutoring-and-support-systems/#:~:text=Virtual%20Tutors%20and%20Chatbots, conversations%20(Huang%2C%202022).
2. Boon, S. (2024). Brain-Based Learning: Understanding how the brain shapes education. https://www.longdom.org/open-access/brainbased-learning-understanding-how-the-brain-shapes-education-108782.html?utm_source= chatgpt.com
3. Brittain, A.-M. (2024). *Tailoring education and personalized learning with AI*. HP Tech Takes. https://www.hp.com/cma/ng/shop/tech-takes/personalized-learning-ai-education
4. Camargo, C. D. B., & Fernández, A. H. (2024*). Neuropedagogy and neuroimaging of artificial intelligence and deep learning*. (2024b). Questa Soft. https://www.ceeol.com/search/article-detail?id=1337838
5. Danila et al., (2025). Artificial Intelligence and Neuroeducation: Enhancing Education for Students or Patients with Albinism. *BRAIN BROAD RESEARCH IN ARTIFICIAL INTELLIGENCE AND NEUROSCIENCE*, *16*(2), 134. https://www.edusoft.ro/brain/index.php/brain/article/view/1803
6. Ellikkal, S., & Rajamohan, L. (2024). *[Title of the article]*. *X Journal of Management*, 22(1), 28–[last page]. https://www.emerald.com/xjm/article/22/1/28/1273239
7. El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on the development of students' engagement. *International Journal of*

Educational Technology in Higher Education, *18*(1). https://educationaltechnology journal.springeropen.com/articles/10.1186/s41239-021-00289-4

8. Frendo, C. S., & Vassallo, D. (2025b). Educational Neuroscience meets AI: a framework for secondary science teaching. *Malta Journal of Education*, *06*(01). https://doi.org/10.62695/rrui1028
9. Gkintoni, E., Antonopoulou, H., Sortwell, A., &Halkiopoulos, C. (2025). Challenging Cognitive Load Theory: The Role of Educational Neuroscience and Artificial Intelligence in Redefining Learning Efficacy. *Brain Sciences*, *15*(2), 203. https://doi.org/10.3390/brainsci15020203
10. Gligorea et al., (2023). *Adaptive learning using artificial intelligence in e-learning: A literature review*. *Education Sciences*, *13*(12), Article 1216. https://doi.org/10.3390/educsci13121216
11. Guduru, S. K. (2025). *Streamlining program management with artificial intelligence: A comprehensive survey*. *International Journal of Engineering Sciences & Research Technology*, *14*(2), 26-35. https://www.ijesrt.com/index.php/J-ijesrt/article/view/165
12. Han et al., (2022). Analysis of the effect of an artificial intelligence chatbot educational program on non-face-to-face classes: a quasi-experimental study. *BMC Medical Education*, *22*(1). https://doi.org/10.1186/s12909-022-03898-3
13. Hu et al., (2025). The role of artificial intelligence in enhancing personalised learning pathways and clinical training in dental education. *Cogent Education*, *12*(1). https://doi.org/10.1080/2331186x.2025.2490425
14. Katona, J., &Katonane, N. (2025). Integrating AI-based adaptive learning into the flipped classroom model and discussions in programming education. https://www.sciencedirect.com/science/article/pii/S2666920X25000323?utm_source=chatgpt.com
15. Khan, M. J., & Jian, O. (2023). *Personalised learning through AI*. Advances in Engineering Research. Retrieved from https://pdfs.semanticscholar.org/d749/87236f87428893eec23c8489d3117f1cd296.pd
16. Khan, M. Y. a. W. M. Y. (2024). *A Study on Personalized Learning Experience through AI-driven User Profiling in E-learning Platforms*. https://ijisae.org/index.php/IJISAE/article/view/5523
17. Khan, Z. A., Adnan, J., & Raza, S. A. (2023). Cognitive Learning Theory and Development: Higher Education case study. In *IntechOpen eBooks*. https://doi.org/10.5772/intechopen.110629
18. Laak & Aru, (2024). *AI and personalized learning: bridging the gap with modern educational goals*. arXiv.org. https://arxiv.org/abs/2404.02798

19. Lau et al., (2024). *Adaptive Gen-AI Guidance in Virtual Reality: A multimodal exploration of engagement in Neapolitan Pizza-Making*. arXiv.org. https://arxiv.org/abs/2411.18438
20. Pretorius, L. (2025). An active learning intervention for in-service teachers: self-determination theory, heutagogy, neuroeducation, and the (altered) flipped classroom in practice. *Curriculum Perspectives*. https://doi.org/10.1007/s41297-024-00299-y
21. Sajja et al., (2024). Artificial intelligence-enabled intelligent assistant for personalized and adaptive learning in higher education. *Information, 15*(10), 596. https://www.mdpi.com/2078-2489/15/10/596
22. Shiwlani et al., (2024). View *of Artificial Intelligence in Neuroeducation: A Systematic Review of AI Applications Aligned with Neuroscience Principles for Optimizing Learning Strategies*. (n.d.-b). https://www.ojs.jdss.org.pk/journal/article/view/1278/1195
23. Sonia, A., & Oscar, E. (2025). *AI-powered neuroeducation: Applying machine learning to enhance cognitive development and learning outcomes*. ResearchGate. https://www.researchgate.net/publication/393802829_AI-Powered_Neuroeducation_Applying_Machine_Learning_to_Enhance_Cognitive_Development_and_Learning_Outcomes
24. Vieriu, A. M., & Petrea, G. (2025). The impact of artificial intelligence (AI) on students' academic development. *Education Sciences, 15*(3), 343. https://doi.org/10.3390/educsci15030343