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The Impact of Digital Technologies and AI on Adult Learning: From Digital Literacy to Neuroplasticity

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Abstract: *This article explores the urgent issue of developing digital skills and stimulating neuroplasticity in adults during rapid digital transformation. It examines how information and communication technologies (ICT) and artificial intelligence (AI) contribute to effective adult education. The article analyses the theoretical foundations of digital literacy and neuroplasticity. It also discusses practical strategies for enhancing these areas through ICT and AI. To support this analysis, the study applies several research methods. These include a theoretical review of scientific literature, comparative analysis, and case study approaches. The methods are used to investigate real-life examples of adult learning with tools such as online courses, AI-powered tutors, and neurofeedback systems. The findings show that ICT and AI significantly expand access to education and support personalised learning. Besides, they help improve cognitive functioning, increase learning motivation, and promote neuroplasticity in adult learners. The article presents some examples of digital tools that personalise learning and support cognitive development. These include AI tutors, online learning platforms, and neurofeedback technologies. In addition, the article discusses the challenges and future ways of integrating ICT and AI into adult education. It highlights key issues such as ethics and accessibility. Finally, the article emphasises that digital literacy and neuroplasticity are essential for successful ageing and lifelong learning. It concludes by underlining the critical role of ICT and AI in creating inclusive, engaging, and effective learning environments for adults.*

Keywords: *cognitive development; digital learning; adult education; online courses; learning environment; educational technologies.*

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1. Introduction

The digital world is evolving rapidly, creating opportunities and challenges, especially for adults. As technology becomes more integrated into daily life, adults need to update their skills to adapt to new ways of communicating and working. In this regard, developing digital literacy and stimulating neuroplasticity play crucial roles in helping them adapt successfully.

Digital literacy exceeds basic computer skills. It involves critically evaluating information, communicating effectively online, and using digital tools for learning and work. For those who did not grow up in the digital era, acquiring these skills can be challenging. However, it also opens new opportunities for personal and professional growth.

Neuroplasticity refers to the brain's remarkable ability to change and adapt throughout an individual's life. Recent studies indicate that engaging in learning and cognitive activities can enhance memory, attention, and various other mental functions in adults (Weaver & Jaeggi, 2021). This underscores the importance of lifelong learning for maintaining cognitive health.

To support adults in developing digital skills and fostering neuroplasticity, a collaborative approach is essential. Governments, educational institutions, and community organisations must join forces to create accessible and effective learning opportunities. This collaboration will empower adults to navigate the digital landscape with confidence and unlock their full potential.

This article explores how information and communication technologies (hereinafter "ICT") and artificial intelligence (hereinafter "AI") contribute to digital literacy and cognitive development in adults. It examines how advanced technologies can improve adult education and discusses the challenges and future possibilities of using ICT and AI in learning.

2. Theoretical Principles of Digital Literacy and Neuroplasticity in Adult Education

As society undergoes rapid digital transformations, adult education is also evolving. Adults must not only learn new technologies but also develop cognitive skills to adapt to a changing environment effectively. Understanding the theoretical foundations of digital literacy and neuroplasticity is essential for creating effective programmes for adult education.

Digital literacy encompasses more than just technical skills; it involves the ability to search for, evaluate, and utilise information from digital sources, as well as the capacity to communicate and collaborate effectively online. Additionally, it requires critically assessing media content and safely navigating various digital tools. Understanding cybersecurity principles and safeguarding personal data is also essential (Kucher & Rozhnova, 2024).

The theoretical framework of digital literacy is based on several key principles. Firstly, digital competence plays a vital role in lifelong learning and personal growth. Secondly, skills are developed through interaction with others and engagement with digital resources. Lastly, digital literacy hinges on critical thinking and the capability to analyse information effectively.

According to Voronkin (2015), neuroplasticity is the brain's ability to change and adapt throughout life. It includes structural plasticity, which refers to physical changes in the brain, such as forming new neural connections. It also involves functional plasticity, where brain activity shifts, allowing different areas to take on new roles.

At the same time, the concept of neuroplasticity is intrinsically linked to learning. Acquiring new knowledge stimulates neural connections, while cognitive engagement, when balanced, supports brain adaptability and function. Digital literacy and neuroplasticity are interconnected. Strengthening digital skills enhances neuroplasticity, while an adaptive brain makes learning digital tools easier.

A solid understanding of these concepts is essential for designing effective adult education programmes. The integration of ICT and AI enables the creation of an innovative learning environment. These technologies not only develop digital literacy but also support cognitive flexibility, ensuring that adults can successfully adapt to the digital world.

3. The Role of ICT and AI in Organising Effective Learning for Adults

According to Hotko and Chaikovska (2015), today's world requires constant updating of knowledge and skills, making lifelong learning essential. In this process, ICT and AI play an essential role since they significantly improve the accessibility, efficacy, and personalisation of education.

ICT supports distance learning, which is crucial for working individuals who may not always be able to attend traditional educational institutions. Online courses, webinars, interactive platforms, e-books, and mobile applications allow learners to gain knowledge at times and places that suit them. Furthermore, the main advantages of ICT in adult education include constant access to learning materials and flexibility in the learning process. Learners can set their own pace, engage with interactive content, and access multimedia resources. Additionally, they can quickly retrieve up-to-date information.

AI offers new possibilities for adult education by enabling the personalisation of learning experiences. Machine learning algorithms analyse the user's knowledge and suggest the most effective learning path. For example, adaptive platforms adjust task difficulty based on a student's progress. AI also offers opportunities for personalised content based on the learner's needs and abilities. It provides automatic assessment and feedback, along with virtual tutors and chatbots for consultations. Additionally, AI enables data analysis to improve curricula and supports automated systems for motivation and assistance.

While there are significant advantages to incorporating ICT and AI in adult education, several challenges persist in their implementation. The primary obstacles include users' levels of technological literacy, access to reliable high-speed Internet, and the necessity to update curricula to stay aligned with technological advancements.

As highlighted by Abdullah, Karpudewan, and Tanimale (2021), the potential for leveraging ICT and AI in education is notably diverse. These technologies can enhance learning by making it more effective, accessible, and engaging. In the future, we can anticipate further progress in interactive technologies, as well as in augmented and virtual reality, along with improved adaptive learning platforms.

Consequently, ICT and AI play a crucial role in advancing adult education. They offer flexibility, accessibility, and personalised learning experiences, thereby enriching the knowledge acquisition process. As these technologies continue to evolve, they are expected to present even more opportunities for lifelong learning and professional development.

4. Practical Aspects of Digital Literacy and Neuroplasticity and Their Development with ICT and AI

In today's digital landscape, foundational technological skills are crucial, accompanied by the ability to engage in continuous learning and demonstrate adaptive flexibility. Digital literacy, combined with the brain's neuroplasticity, plays a pivotal role in this development. Within this framework, information and communication technology (ICT) and artificial intelligence (AI) emerge as powerful tools to facilitate growth.

Bissessar and Youssef (2021) define digital literacy as the ability to search for, analyse, use, and create information using digital technologies. It encompasses skills such as navigating the Internet safely, identifying misinformation, safeguarding personal data, and effectively utilising digital tools for both learning and professional purposes.

The main elements of digital literacy include:

- a) *technical skills* (knowing how to use devices, software, and cloud services);
- b) *information literacy* (applying critical thinking to analyse and assess information);
- c) *cybersecurity* (understanding safe online practices to protect personal data);
- d) *communication skills* (effectively engaging and interacting in digital environments).

Digital skills can be developed through interactive online courses, e-learning platforms, mobile applications, and chatbots.

Neuroplasticity refers to the brain's ability to change based on experience, learning, and interaction with digital technologies. It enables individuals to acquire new skills and adapt to technological changes. Factors that support neuroplasticity include regular learning, exposure to innovative technologies, cognitive training, and adapting to changes in the digital world.

Ching et al. (2020) emphasise that ICT and AI contribute to digital literacy and neuroplasticity. With the help of adaptive educational platforms, AI, and interactive technologies, learning becomes more effective and individualised. Key applications of ICT and AI include:

- 1) *adaptive learning systems* (Platforms such as Coursera, Duolingo, and Khan Academy that adjust to the user's level);
- 2) *virtual assistants and chatbots* (tools that offer personalised learning support);
- 3) *augmented and virtual reality (AR/VR)* (technologies that provide interactive learning experiences for deeper understanding);
- 4) *gaming techniques and brain trainers* (methods designed to enhance cognitive skills and memory);
- 5) *big data and AI* (tools that help tailor learning programmes based on user data) (Zawacki-Richter et al., 2019).

Digital literacy and neuroplasticity are crucial for successfully navigating the digital landscape of today. By leveraging information and communication technology (ICT) and artificial intelligence (AI), individuals can enhance their skills through access to adaptive platforms, personalised educational programs, and advanced cognitive training. As these technologies continue to evolve, they create new opportunities for lifelong learning and personal growth amidst a rapidly changing technological environment.

5. Examples of Online Courses, AI Tutors, Neurofeedback, and Other Tools for Personalising Learning and Enhancing Cognitive Functions

The latest technologies offer new possibilities for personalised learning and boosting cognitive functions. Online courses, AI tutors, neurofeedback techniques, and other tools play a key role in effective knowledge acquisition. They also help adapt education to individual needs and improve cognitive flexibility.

Online courses have become one of the most effective tools for developing knowledge and skills. They allow learners to study at their own pace, adjust learning speeds, and use interactive methods to grasp information.

Examples of online learning platforms include:

- a) Coursera, Udemy, and Khan Academy – platforms offering adaptive courses that adjust to learner proficiency levels, ensuring customised learning experiences;
- b) Duolingo and Memrise – AI-driven language-learning platforms that generate individualised learning plans to support self-paced progression;
- c) edX and FutureLearn – platforms delivering certified university-level courses, incorporating diagnostic assessments and interactive activities to optimise learning outcomes (Luckin et al., 2016).

AI tutors represent a new form of personalised education. These smart systems track student progress and offer tailored recommendations for further learning. They automatically adjust the difficulty of tasks, provide additional explanations, and help keep students motivated (Bozkurt & Sharma, 2020).

Honchar et al. (2021) identify several AI-based tutoring systems:

1. Socratic (Google AI), which provides step-by-step guidance in solving mathematics and science problems;
2. ChatGPT and GPT-4, interactive language models that clarify complex subjects in accessible terms;
3. ALEKS (McGraw Hill), an adaptive platform that assesses users' knowledge and generates individualised learning pathways.

Chornodon et al. (2021) explain that neurofeedback is a method for improving cognitive functions. It allows brain training and enhancement of cognitive abilities through brain activity analysis. This method helps improve focus, memory, and cognitive resilience.

Examples of neurofeedback tools include *Muse*, *Emotiv*, and *NeuroSky*, namely, portable devices that monitor neural activity and help enhance concentration through exercises. *Myndlift* is an application used for neurofeedback training to reduce stress and improve focus. *BrainHQ* offers brain-training exercises that adapt to the user's cognitive abilities (Chen & Wu, 2015).

In addition to AI tutors and neurofeedback, various technological solutions are enhancing cognitive development and supporting personalised learning. Virtual and augmented reality (VR/AR) provide immersive learning experiences, with platforms like *Google Expeditions* and *Oculus Education leading the way*. Gamification, which incorporates game mechanics into educational settings, serves as another valuable resource. Platforms such as *Kahoot!*, *Quizlet*, and *Duolingo* make learning more engaging and interactive. Lastly, adaptive learning systems like *Smart Sparrow* and *DreamBox Learning* automatically tailor content to fit the individual needs of each student, thereby ensuring a personalised learning experience.

Therefore, the advancement of personalised learning and cognitive function stimulation is facilitated by these cutting-edge technologies. Online courses, AI tutors, neurofeedback, and other tools enable education to adapt to individual needs while improving concentration, memory, and learning capabilities. As these technologies continue to evolve, they open up new opportunities for education and personal development.

6. Empirical Investigation on the Use of Digital Technologies and AI in Adult Education: A Comparison of Approaches in 2005 and 2025

Methodology of the study

Sample: Two groups of adult learners were recruited, each consisting of 20 individuals:

First (control) group. This group comprised individuals who studied in 2005 before the integration of digital tools and AI into educational frameworks. Data were collected retrospectively using archival learning materials, surveys of former course participants, and interviews with instructors from that period.

Second (experimental) group. This group consists of adult learners studying in 2024-2025, who utilise current digital platforms, interactive materials, and adaptive learning systems powered by AI. These systems include personalised recommendations, chatbots for learning support, and progress analysis features.

Data collection methods encompassed:

- 1) questionnaires with the same structure for both groups, focusing on motivation, satisfaction with the learning experience, and achieved outcomes;
- 2) interviews with participants and instructors;
- 3) observations of the learning process (for the current group);
- 4) content analysis of learning materials and educational platforms.

Methodological approaches comprised:

- 1) comparative analysis, examining both retrospective and current data;
- 2) statistical analysis of questionnaire data, including quantitative indicators of academic success, motivation, and satisfaction;
- 3) thematic analysis of responses to open-ended questions.

The results of the study are summarised in Figure 1.

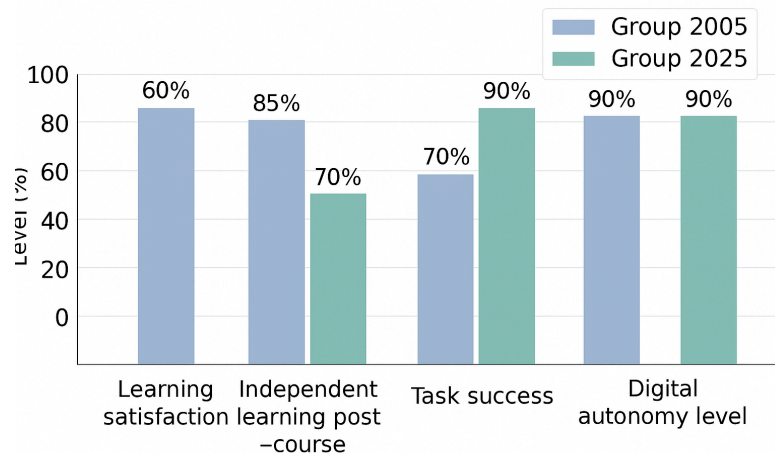


Figure 1. A comparison of adult learning outcomes in 2005 and 2025
Source: the authors' own conception

For a comprehensive interpretation of the results, it is essential to consider the socio-cultural changes that have taken place over the past two decades. In addition to the implementation of ICT and AI, other factors may have influenced the observed outcomes. These include changes in the labour market, access to online education, and improvements in digital literacy.

Comparison with other studies

An OECD study (2023) confirms that digital technologies can enhance adult education, as long as there is sufficient support and motivation. So et al. (2024) report that AI-based adaptive learning increases adult learner engagement by 30-40%.

Digital technologies and AI significantly improve the adult learning experience, particularly through personalised learning and flexibility. Current approaches also promote greater autonomy and long-term motivation for learning.

Therefore, educational institutions should actively integrate AI tools to personalise learning. They should develop digital education programmes for adults with varying levels of digital literacy. Additionally, to ensure smooth adaptation to new technologies, institutions should offer support through tutors and mentors.

7. Challenges and Opportunities of Using ICT and AI, Including Ethical and Accessibility Issues

Information and communication technologies (ICT) and artificial intelligence (AI) play a growing role in adult education. They enable cognitive personalisation, provide access to a wide range of knowledge, and improve the overall effectiveness of education. However, the use of these technologies also brings several challenges.

One significant issue is technological inequality, especially in regions with limited access to reliable internet and digital devices. Another challenge is the inadequate level of digital literacy among certain adult populations. Ethical concerns also emerge, particularly regarding the privacy of personal data utilised on educational platforms and the potential risks of confidentiality breaches. Furthermore, AI algorithms can introduce bias, which may lead to discrimination. Adapting educational programs to keep pace with technological advancements presents another obstacle. It is also challenging to regularly update learning materials and effectively integrate traditional and digital learning methods for optimal impact.

Prospectively, there are several opportunities for improvement. These include expanding digital literacy programmes for adults and investing in infrastructure to ensure equal access to digital learning resources. Ensuring the ethical use of AI is also a priority, which can be achieved by developing transparent algorithms that minimise bias. Integrating new technologies, such as

augmented reality (AR) and virtual reality (VR), can further enhance learning experiences by creating immersive environments (Nerubasska, Palshkov, & Maksymchuk, 2020).

While ICT and AI offer great potential for personalised adult education, they also come with challenges (Egloffstein & Ifenthaler, 2021). Addressing accessibility issues, maintaining ethical standards, and incorporating innovative solutions will help ensure that these technologies are used effectively, providing adults with equal opportunities for personal and professional development.

8. Conclusion

This article highlights the increasing significance of digital literacy and neuroplasticity in adults, particularly amidst rapid digital transformations. It investigates how information and communication technology (ICT) and artificial intelligence (AI) can enhance effective adult learning. The article reviews the theoretical foundations of digital literacy and neuroplasticity while exploring practical methods for nurturing these skills through ICT and AI. It presents relevant examples, such as online courses, AI tutors, neurofeedback, and various tools designed to personalise learning experiences and stimulate neurocognitive development. Additionally, the article underscores the challenges and prospects of integrating ICT and AI in adult education, with a focus on ethical considerations and accessibility issues.

Finally, the article highlights the importance of digital literacy and neuroplasticity for successful ageing and lifelong learning. It defines the role of ICT and AI in creating accessible, effective educational environments for adults. While ICT and AI offer significant benefits, their use also raises challenges such as ethical considerations, accessibility, and the technological literacy of users.

References

- Abdullah, M. N. S., Karpudewan, M., & Tanimale, B. M. (2021). Executive function of the brain and its influences on understanding of physics concept. *Trends in Neuroscience and Education*, 24, Article 100159. <https://doi.org/10.1016/j.tine.2021.100159>
- Bissessar, S., & Youssef, F. F. (2021). A cross-sectional study of neuromyths among teachers in a Caribbean nation. *Trends in Neuroscience and Education*, 23, Article 100155. <https://doi.org/10.1016/j.tine.2021.100155>
- Bozkurt, A., & Sharma, R. C. (2020). Emergency remote teaching in a time of global crisis due to Coronavirus pandemic. *Asian Journal of Distance Education*, 15(1), i–vi. <https://doi.org/10.5281/zenodo.3778083>
- Chen, C. M., & Wu, C. H. (2015). Effects of different video lecture types on sustained attention, emotion, cognitive load, and learning performance. *Computers & Education*, 80(1), 108–121. <https://doi.org/10.1016/j.compedu.2014.08.015>
- Ching, F. N. Y., So, W. W. M., Lo, S. K., & Wong, S. W. H. (2020). Preservice teachers' neuroscience literacy and perceptions of neuroscience in education: Implications for teacher education. *Trends in Neuroscience and Education*, 21, Article 100144. <https://doi.org/10.1016/j.tine.2020.100144>
- Chornodon, M., Gryshkova, N., Myronova, N., Ivanytska, B., Semen, N., & Demchenko, N. (2021). Study of gender conceptual sphere: Historiography of the question. *Postmodern Openings*, 12(3), 15–33. <https://doi.org/10.18662/po/12.3/325>
- Egloffstein, M., & Ifenthaler, D. (2021). Tracing digital transformation in educational organizations. In D. Ifenthaler, S. Hofhues, M. Egloffstein, & C. Helbig (Eds.), *Digital transformation of learning organizations* (pp. 41–57). Springer. https://doi.org/10.1007/978-3-030-55878-9_3
- Honchar, L., Derkachova, O., Shakhrai, V., Saienko, V., Hladoshchuk, O., & Voropayeva, T. (2021). Formation of psychological readiness of the teacher to implement information and communication technologies in professional activities. *International Journal of Education and Information Technologies*, 15(38), 364–371. <https://doi.org/10.46300/9109.2021.15.38>

- Hotko, O., & Chaikovska, O. (2015). Informatsiyno-komunikatsiyni tekhnolohiyi – yak suchasnyy zasib navchannya v osviti [Information and communication technologies as a modern teaching tool in education]. *Molod i rynok [Youth & Market]*, 4, 130–134. http://nbuv.gov.ua/UJRN/Mir_2015_4_28
- Kucher, V. V., & Rozhnova, T. Ye. (2024). Vplyv tsyfrovnykh tekhnolohii na pedahohichnu praktyku [The influence of digital technologies on pedagogical practice]. In H. Yelnykova (Ed.), *Materialy III mizhnarodnoho naukovoho forumu "Adaptyvni protsesy v osviti" [Proceedings of the 3rd International Scientific Forum "Adaptive Processes in Education"]* (pp. 169–172). Yuston.
- Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson. <https://static.googleusercontent.com/media/edu.google.com/ru//pdfs/Intelligence-Unleashed-Publication.pdf>
- Nerubasska, A., Palshkov, K., & Maksymchuk, B. (2020). A systemic philosophical analysis of the contemporary society and the human: New potential. *Postmodern Openings*, 11(4), 275–292. <https://doi.org/10.18662/po/11.4/235>
- OECD. (2023). *Education at a glance 2023: OECD indicators*. OECD Publishing. <https://doi.org/10.1787/e13bef63-en>
- So, H.-J., Lee, Ch., Lee, G.-Y., & Kim, M. J. (2024). *Artificial intelligence, blockchain and extended reality in lifelong learning*. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000391599>
- Voronkin, O. S. (2015). Informatsiyno-komunikatsiyni tekhnolohii u vyshchii osviti yak ob'ekt psykholoho-pedahohichnykh doslidzhen (druha polovyna XX – pochatok XXI stolittia) [Information and communication technology in higher education as an object of psychology-pedagogical researches (the second half of XX century – beginning of XXI century)]. *Informatsiyni tekhnolohii v osviti [Information Technologies in Education]*, 22, 57–79. http://nbuv.gov.ua/UJRN/itvo_2015_22_7
- Weaver, A. N., & Jaeggi, S. M. (2021). Activity engagement and cognitive performance amongst older adults. *Frontiers in Psychology*, 12, Article 620867. <https://doi.org/10.3389/fpsyg.2021.620867>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – Where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), Article 39. <https://doi.org/10.1186/s41239-019-0171-0>