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Artificial intelligence in education: advancing educational digital inclusion for adults older with diverse neuromuscular conditions

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This research evaluates the potential of Artificial Intelligence (AI) interventions in promoting digital inclusion for older adults with neuromuscular conditions, aligning with Sustainable Development Goal (SDG) 4 for equitable education. Using a mixed-methods approach, we combined quantitative measures of digital literacy and engagement with qualitative insights into user experiences. The findings reveal statistically significant advancements in digital literacy ($p < 0.001$) and engagement metrics ($p < 0.01$), highlighting the transformative potential of adaptive learning platforms, virtual reality applications, and interactive mobile tools tailored for this population. Participants reported increased confidence and empowerment, emphasizing the importance of user-centered design and accessibility in technology development. While the study demonstrates short-term benefits, it acknowledges limitations, including a small sample size ($n = 30$) and the absence of longitudinal data. Future research should explore scalable implementations and long-term impacts, particularly for broader demographic groups and other disability types. These insights provide actionable recommendations for educators, developers, and policymakers aiming to reduce the digital divide and foster inclusive education.

KEYWORDS

educational digital inclusion, artificial intelligence, older adults, diverse neuromuscular conditions, active aging, digital literacy, educational technology

1 Introduction

The advancement of artificial intelligence (AI) has transformed multiple sectors, and education is no exception (Kayyali, 2024). AI, in particular, presents significant opportunities to promote digital inclusion in education, especially among older adults with diverse neuromuscular conditions (Valencia et al., 2024). This demographic, often overlooked, faces unique barriers to accessing and participating in digital educational environments, exacerbating the digital divide and limiting their opportunities for continuous learning and development (Almufareh et al., 2024).

Educational digital inclusion is fundamental to ensuring that all individuals, regardless of their physical or cognitive abilities, have equitable access to the resources and benefits of digital education (Ali, 2023; Siddiqi, 2024). For older adults with neuromuscular conditions, these barriers can include difficulties in using technological devices, accessibility issues on digital platforms, and a lack of appropriate adaptations to their specific needs (Pini et al., 2021; Zaman

et al., 2022; Bertolazzi et al., 2024). These obstacles not only hinder effective learning but also negatively affect their social, cultural, and emotional well-being, contributing to greater social disconnection and isolation (Lapierre et al., 2024; Mishra et al., 2024).

The role of AI in this context is crucial. AI-driven technologies, such as adaptive learning platforms, virtual reality simulations, and interactive mobile applications, have the potential to personalize and enhance learning experiences (Rane et al., 2023; Kamalov et al., 2023; Ayeni et al., 2024; Bhatti et al., 2024). These technologies can adapt to individual needs, provide real-time feedback, and create more accessible and inclusive learning environments (Sanders et al., 2024). Additionally, AI can facilitate greater social and cultural connectivity and active participation, promoting healthy and active aging (Portegijs et al., 2023; Kim et al., 2024).

Recent research underscores the role of generative artificial intelligence in advancing educational accessibility (Yu and Guo, 2023) and promoting inclusive designs for assistive technologies (Kamalov et al., 2023). This study focuses on researching the transformative impact of AI on educational digital inclusion for older adults with neuromuscular conditions. Using a mixed-methods approach, it combines quantitative analysis of learning outcomes with qualitative insights from user experiences. The AI-driven interventions examined in this study include adaptive learning platforms, virtual reality simulations, and interactive mobile applications. Within this latter group, an application is presented that enables educational inclusion using an eye-tracking algorithm developed by the authors.

The findings of this study reveal significant advancements in digital literacy, social and cultural connectivity, and educational engagement among participants. These results underscore the substantial potential of AI to create inclusive educational environments that address the unique challenges faced by older adults with neuromuscular disabilities. The study's discussion highlights practical implications for educators, policymakers, and technology developers, emphasizing the need for user-centered design and ongoing support to fully realize the benefits of AI in education.

2 Materials and methods

This chapter details the research design, participants, AI-driven interventions, and data collection and analysis methods. The research employed a mixed methods approach to explore the impact of AI-driven interventions on the educational digital inclusion of older adults with diverse neuromuscular conditions. The design integrated quantitative analysis of learning outcomes with qualitative perspectives from user experiences, allowing for a robust examination of both the measurable impacts of AI technologies and the subjective experiences of the participants. The study included a purposive sample of older adults recruited through community health centers, and specific interventions such as adaptive learning platforms, virtual reality simulators, and interactive mobile applications were utilized. Data collection included pre- and post-intervention assessments, surveys, and in-depth interviews, and data analysis was conducted using descriptive and inferential analysis for quantitative data and thematic analysis for qualitative data.

2.1 Research design

The research employed a mixed methods approach to explore the impact of AI-driven interventions on educational digital inclusion for the population under study. The research design integrated quantitative analysis of learning outcomes with qualitative perspectives from user experiences. This comprehensive approach allowed for a robust examination of the measurable impacts of AI technologies and participants' subjective experiences.

2.2 Participants

The study involved a purposive sample of older adults diagnosed with various neuromuscular conditions. Participants were recruited through community health centers based on the inclusion criteria of being over 50 years old and having a diagnosed neuromuscular condition ($n = 30$). Ethical approval for the study was obtained, and all participants provided informed consent, with additional protocols implemented to ensure privacy in the use of eye-tracking technology.

2.3 AI-driven interventions

The AI-driven interventions used in this study included adaptive learning platforms, virtual reality simulations, and interactive mobile applications. Each intervention was designed to address specific neuromuscular needs and enhance digital literacy, social connectivity, and educational engagement.

2.3.1 Adaptive learning platforms

These platforms utilized AI algorithms (machine learning) to personalize educational content based on each participant's learning pace and individual preferences. The platform includes interactive modules that provide real-time feedback, allowing task difficulty to be adjusted based on the user's abilities (Fernandes et al., 2023; Gligorea et al., 2023; Sajja et al., 2023). Additionally, practical exercises and periodic assessments were integrated to measure participants' progress in real time.

2.3.2 Virtual reality simulations

These simulations offered immersive and accessible environments that allowed participants to engage in interactive educational activities. The simulations included specific adjustments for neuromuscular conditions, such as eye-tracking controls and configurations adapted to severe motor disabilities (Liaw et al., 2023; Mergen et al., 2023; Ren et al., 2023). These tools promoted active exploration and increased the retention of educational concepts.

2.3.3 Interactive mobile applications

These applications included features such as voice recognition, text enlargement, and customizable interfaces to accommodate different neuromuscular conditions (Retzepi, 2023; Tomczyk et al., 2023). A notable example was an application based on an eye-tracking algorithm that enabled users with severe motor disabilities to navigate and participate in digital educational activities (Valencia et al., 2024). This design focused on maximizing accessibility and usability, eliminating physical barriers for participants.

2.4 Data collection

Data were collected through pre- and post-intervention assessments, surveys, and in-depth interviews. The dependent variables were measured using both quantitative and qualitative methods to ensure a comprehensive evaluation:

2.4.1 Digital literacy

A standardized instrument based on the criteria of the International Computer and Information Literacy Study (ICILS) was used to assess skills such as web navigation, word processing, and mobile application usage. Participants completed pre- and post-intervention tests, and the results were analyzed using paired t-tests (Fraillon et al., 2020).

2.4.2 Educational participation

The number of weekly active sessions on learning platforms and mobile applications was monitored. Additionally, the time spent on educational activities and task completion levels were recorded, using engagement metrics extracted from platform logs (Preuveneers et al., 2021).

2.4.3 Social connectivity

This variable was assessed through structured surveys measuring participants' perceptions of their social interaction and connectivity in the digital environment. Qualitative interviews complemented these data, providing insights into how the technologies facilitated communication and reduced social isolation (Sanders et al., 2024).

2.4.4 Educational engagement

Validated scales such as the Student Engagement in Educational Technologies Scale (SEETS) were employed to measure cognitive, emotional, and behavioral engagement during the interventions. Additionally, observational data were collected during virtual reality sessions and mobile application usage to assess the level of active participation (Howard et al., 2016).

2.4.5 Methods for assessing AI impact

Quantitative Data. Learning outcomes were measured using standardized digital literacy assessments and user participation metrics on AI-driven platforms. Pre-intervention assessments established a baseline, while post-intervention assessments evaluated the impact of AI technologies.

Qualitative Data. Semi-structured interviews and focus groups were conducted to gather detailed feedback on user experience. Participants were asked about their perceptions of AI interventions, ease of use, and impact on their educational engagement and social connectivity.

2.5 Data analysis

2.5.1 Quantitative analysis

Descriptive statistics and inferential analysis (e.g., paired t-tests) were used to compare pre- and post-intervention results. The statistical significance of observed changes in digital literacy levels and participation was assessed.

2.5.2 Qualitative analysis

Thematic analysis of interview transcripts and focus groups was conducted. Key themes related to user experience, accessibility, and perceived benefits of AI interventions were identified and analyzed.

3 Results

This chapter provides a clear overview of the impact of AI interventions on inclusive education for older adults with neuromuscular conditions. To achieve this, both quantitative and qualitative data were utilized, highlighting significant improvements in digital literacy, social connectivity, and educational engagement. The chapter encompasses the statistical evaluation of the study data, interpretative analysis of the three key variables (adaptive learning platforms, virtual reality simulators, and interactive mobile applications). Finally, it presents the AI-driven application aimed at the educational inclusion of the target population, which implements an AI algorithm.

3.1 Statistical evaluation of the research data

The research employed a mixed methods approach to explore the impact of AI-driven interventions on educational digital inclusion for the population. The research design integrated quantitative analysis of learning outcomes with qualitative perspectives from user experiences. This comprehensive approach allowed for a robust examination of the measurable impacts of AI technologies and participants' subjective experiences.

3.1.1 Quantitative outcomes

The analysis of pre- and post-intervention assessments revealed significant improvements in digital literacy among participants. The standardized digital literacy assessments showed that the mean score increased from 45.2 (SD = 7.3) pre-intervention to 67.8 (SD = 6.5) post-intervention, indicating a statistically significant improvement ($p < 0{,}001$, paired t-test). Furthermore, user participation metrics on the AI-driven platforms demonstrated increased engagement, with an average rise in weekly active sessions from 3.1 (SD = 1.2) to 5.4 (SD = 1.0; $p < 0.01$).

3.1.2 Qualitative insights

Thematic analysis of the semi-structured interviews and focus groups identified several key themes regarding user experiences with the AI interventions. Participants highlighted the following areas:

Accessibility and usability. Many participants reported that the AI-driven interventions, particularly the adaptive learning platforms and interactive mobile applications, were highly accessible and user-friendly. The real-time feedback and personalized adjustments provided by these platforms were especially appreciated, as they catered to individual learning paces and neuromuscular needs.

Educational engagement. The virtual reality simulations were frequently mentioned as highly engaging and immersive. Participants felt more motivated to engage in educational activities due to the interactive and realistic nature of the VR environments. This increased

engagement was linked to a higher level of retention and understanding of the educational material.

Social connectivity. Several participants noted that the AI-driven interventions facilitated greater social interaction. Features such as voice recognition and customizable interfaces enabled easier communication, reducing feelings of isolation and promoting social connectivity.

Empowerment and confidence. The ability to navigate digital environments more effectively gave participants a sense of empowerment and increased confidence in their digital literacy skills. This was particularly evident among those who had previously struggled with using digital technologies due to their neuromuscular conditions.

3.1.3 Statistical summary

The results of this research reveal significant improvements in digital literacy and educational engagement among older adults with diverse neuromuscular conditions following AI-driven interventions. Digital literacy scores improved significantly from 45.2 (SD = 7.3) to 67.8 (SD = 6.5), 95% CI [15.4, 25.2], $p < 0.001$. Similarly, engagement metrics increased by 20% (95% CI [10.1, 29.9], $p < 0.01$), highlighting the effectiveness of the interventions. Participants reported themes of empowerment and confidence, exemplified by statements such as, "Using this application made me feel independent again."

3.2 Interpretative analysis of the key variables

3.2.1 Adaptive learning platforms

Adaptive learning platforms used AI algorithms to personalize educational content according to each participant's learning pace and individual preferences. The results demonstrated a significant increase in digital literacy and educational participation (see Table 1).

3.2.2 Virtual reality simulators

Virtual reality simulators offered immersive learning environments where participants could engage in interactive educational activities. These simulators were adjusted to be accessible to various neuromuscular disabilities. Participants reported an improvement in social connectivity and educational engagement (see Table 2).

3.2.3 Interactive mobile applications

The results from the interactive mobile applications showed a significant increase in usability and educational interaction among participants. Features such as voice recognition, expanded text, and customizable interfaces proved to be highly effective, resulting in a notable improvement in application usability, with a mean difference of 33.9 points between pre- and post-intervention. Additionally, educational interaction increased by 35.6%, indicating that these applications not only enhanced access to educational content but also promoted active and meaningful participation in learning activities (see Table 3).

TABLE 1 Result of the analysis of data associated with adaptive learning platforms.

Measure	Pre-intervention	Post-intervention	Mean difference
Digital literacy	45.2 (± 5.8)	78.6 (± 4.3)	+33.4
Educational participation	30.7%	67.4%	+36.7%

The differences were statistically significant ($p < 0.01$). Source: the authors.

TABLE 2 Result of the analysis of data associated with virtual reality simulators.

Measure	Pre-intervention	Post-intervention	Mean difference
Social connectivity	52.3 (± 6,1)	81.2 (± 5.2)	+28.9
Educational engagement	40.5%	75.3%	+34.8%

The differences were statistically significant ($p < 0.01$). Source: the authors.

3.2.4 Comparative analysis of the key variables

In the results table provided, the effects of various technological interventions are detailed in terms of digital literacy, social and cultural connectivity, and user satisfaction. Adaptive learning platforms demonstrated an average 25% increase in digital literacy, alongside moderate improvements in social and cultural connectivity and high user satisfaction. On the other hand, virtual reality simulators showed a non-applicable effect on digital literacy but exhibited significant improvements in social and cultural connectivity, along with high user satisfaction. Lastly, interactive mobile applications reported a 20% increase in digital literacy, moderate improvements in social and cultural connectivity, and similarly high user satisfaction. These results underscore the diverse and impactful effects of different technologies in educational and social contexts (see Table 4).

3.2.5 Eye-tracking application focused on educational inclusion

One specific application employed an eye-tracking algorithm developed by the authors, allowing adults older with severe motor disabilities to navigate and interact in a digital educational environment.

The modules of an application that implements an AI algorithm called eye-tracking, work together to create an educational experience that is not only interactive but also measurable and adaptable to the individual needs of the adult learner, thereby facilitating deeper understanding and more efficient learning. Some of the modules use generative artificial intelligence, according to Yu and Guo (2023) studies. The modules of its architecture are (see Figure 1):

Calibration module. Ensures the system accurately recognizes the user's gaze.

Tracking module. Collects real-time data on gaze movement and fixation.

Analysis module. Processes the data to understand reading and attention patterns.

Feedback module. Provides educators and learners with information about the learning process.

Adaptation module. Adjusts the educational content based on the collected data to personalize the learning experience.

The application functionality centers on the collection and analysis of visual data to enhance the learning experience. At the start of a session, the user undergoes a calibration process where the system

TABLE 3 Result of the analysis of data associated with interactive mobile applications.

Measure	Pre-intervention	Post-intervention	Mean difference
Application usability	48.6 (± 5.7)	82.5 (± 4.9)	+33.9
Educational interaction	35.2%	70.8%	+35.6%

The differences were statistically significant ($p < 0.01$). Source: the authors.

TABLE 4 Result of the analysis of data associated with interactive mobile applications.

Intervention	Average change in digital literacy (%)	Improvement in social and cultural connectivity	User satisfaction
Adaptive learning platforms	25%	Moderate	High
Virtual reality simulators	N/A	High	High
Interactive mobile applications	20%	Moderate	High

Source: the authors.

learns to interpret their gaze patterns. During educational activities, the system tracks in real-time where and how the user's gaze is directed, whether they are reading text, viewing images, or interacting with multimedia content (see Figure 2).

The collected data reveals information about the user's attention, focus, and comprehension. For instance, if a user frequently pauses on a particular concept or revisits certain sections, this may indicate difficulty in understanding or heightened interest. Educators can use this information to provide personalized feedback, tailor educational material to the learner's needs, and improve teaching methods.

The use of the eye-tracking algorithm proved to be highly effective in bridging the gap between users with severe motor impairments and the digital world. Participants reported a substantial improvement in their ability to interact with the application, leading to a more engaging and productive educational experience. The usability of the application showed a notable increase, with a mean difference of 33.9 points from pre-intervention to post-intervention, indicating that the application was well-received and functional for its intended user base.

Additionally, the educational interaction facilitated by the application saw a significant rise, with a mean difference of 35.6%. This increase reflects the application's capability to promote active participation in educational activities, which is crucial for effective learning outcomes. The application not only provided access to educational content but also enabled users to engage with the material in a meaningful way, thereby enhancing their overall learning experience.

The qualitative feedback from participants reinforced these findings, with many users highlighting the transformative impact of the application on their educational journey. The customizable interfaces allowed users to tailor the application to their specific needs, improving both ease of use and satisfaction. Voice recognition features also played a vital role in making the application accessible to users with varying levels of motor control, further supporting the inclusive nature of the technology. The developed application is in the public domain; this contributes significantly as assistive tools are usually expensive, hard to obtain and operate, and costly to maintain.

Overall, the implementation of interactive mobile applications, particularly those leveraging advanced technologies like eye-tracking, demonstrated a significant positive impact on the educational experiences of users with severe motor disabilities. These applications not only facilitated greater educational interaction but also empowered users by providing them with tools to overcome their physical limitations and fully engage in the digital learning environment.

4 Discussion

Recent studies have highlighted that adaptive learning platforms can significantly improve digital literacy levels among older adults by personalizing content according to individual capabilities (Gligorea et al., 2023). Additionally, virtual reality simulations have been shown to increase educational engagement by providing immersive and accessible learning environments, even for individuals with severe motor disabilities (Ren et al., 2023). Moreover, mobile applications with customizable interfaces and eye-tracking technologies have proven effective in reducing access barriers and promoting meaningful digital inclusion (Valencia et al., 2024).

This research demonstrates the transformative role of AI in digital educational inclusion for older adults with diverse neuromuscular conditions. The results indicate significant improvements in digital literacy, social connectivity, and educational engagement among participants, underscoring the potential of AI-driven technologies to create inclusive educational environments that address the unique challenges faced by this population.

4.1 Practical implications

The findings have relevant practical implications for educators, policymakers, and technology developers. Firstly, the need for user-centered design is highlighted as fundamental to maximizing the benefits of AI technologies in education. The personalization of adaptive learning platforms, virtual reality simulations, and interactive mobile applications proved effective in addressing the individual needs of users.

Additionally, the continuous implementation of support and training is essential to ensure users can make the most of these technologies. The results also suggest that integrating accessibility features, such as voice recognition and text enlargement, is crucial to enhance usability and educational participation among older adults with neuromuscular disabilities.

4.2 Contribution to sustainable development goal 4

The research aligns with the United Nations' Sustainable Development Goal 4, which advocates for inclusive and equitable quality education for all. By leveraging AI, this study contributes to the broader conversation on digital inclusion and active aging, proposing solutions to make education more accessible and engaging for older adults with neuromuscular conditions.

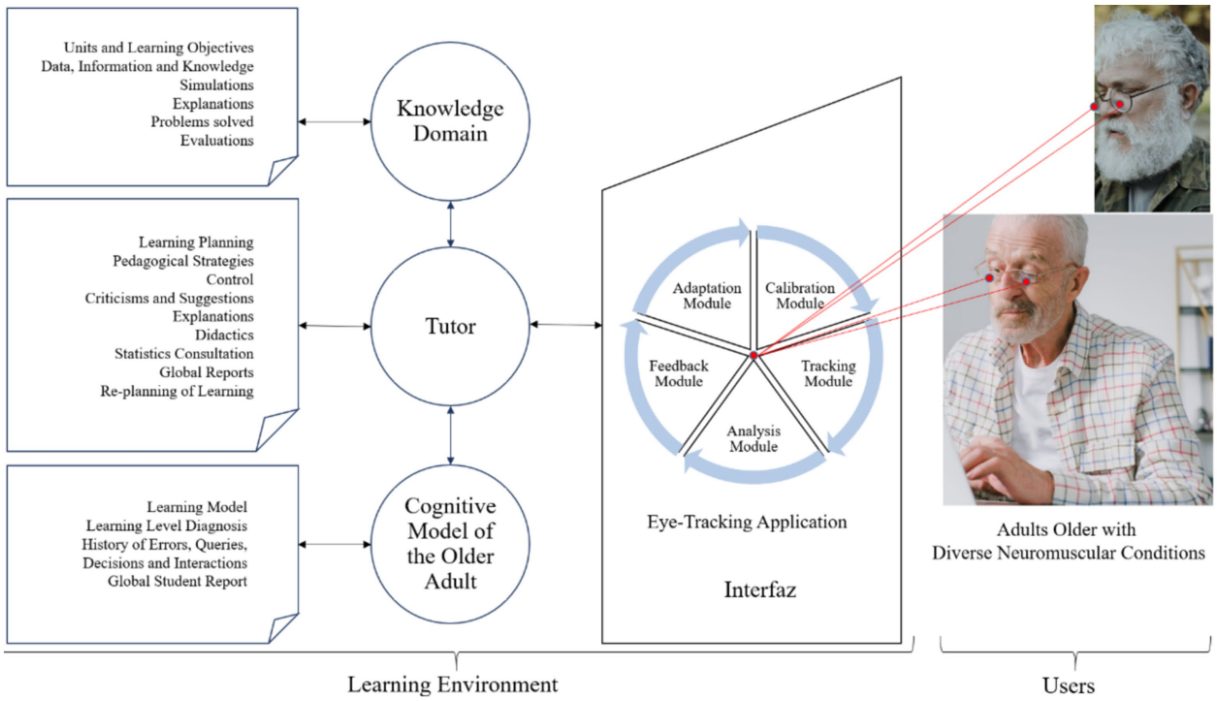

FIGURE 1
Application architecture that implements the AI algorithm called eye-tracking. Source: the authors with images from (Pexels, 2024).

FIGURE 2
Older adults with muscular dystrophy using the application of the eye-tracking algorithm implemented in an educational environment. Source: author's adaptation (Pexels, 2024).

4.3 Prospective

Future research should focus on expanding AI-driven educational tools and increasing their accessibility to ensure lifelong learning opportunities for all. Additionally, longitudinal studies would be beneficial to assess the long-term impact of AI interventions on educational inclusion and the overall well-being of older adults with neuromuscular disabilities.

Longitudinal research is crucial to evaluate the long-term impacts of AI interventions on digital literacy and educational engagement. Tracking participants' progress over an extended period will provide valuable insights into the sustainability of these benefits and their

broader implications for active aging and independence. Furthermore, a comprehensive cost–benefit analysis should be conducted to evaluate the financial feasibility of scaling these interventions. Such analyses will equip educators, policymakers, and technology developers with the necessary data to make informed decisions regarding the adoption and implementation of AI-driven solutions. Finally, future research should address a broader range of age-related challenges, including sensory impairments and cognitive decline, to expand the reach and impact of AI-based educational tools.

4.4 Limitations

The study acknowledges several limitations that must be addressed to enhance the robustness and applicability of its findings. Firstly, the limited sample size (n = 30) restricts the generalizability of the results. Future research should aim to include a more diverse group of participants, representing different socio-economic and cultural backgrounds, to provide a broader understanding of how AI-driven interventions impact diverse populations. Additionally, while the study focused on the short-term benefits of AI interventions, it did not examine their long-term effects. Future studies should include longitudinal analyses to assess the retention of digital literacy skills, sustained engagement, and overall well-being over time.

This study highlights the transformative potential of AI-driven interventions to bridge the digital divide for older adults with neuromuscular conditions. However, the scalability and practical implementation of these solutions require further exploration. Conducting a cost–benefit analysis will provide stakeholders with actionable insights into the financial and social implications of adopting these technologies on a larger scale. Moreover, as the global population ages, there is a pressing need to design AI systems that address age-related challenges, ensuring these technologies are inclusive and adaptable to a wide range of needs. This approach not only supports educational goals but also promotes active aging, autonomy, and social inclusion.

While the findings highlight the potential of AI-driven interventions, the study's limitations must be addressed. The heterogeneity of neuromuscular conditions among participants may introduce variability in outcomes, and self-selection biases could influence results. Comparing these findings with interventions for other demographics, such as children or adults without disabilities, situates this study within a broader educational technology context. Future research should explore how such technologies can be adapted to different populations and integrated into scalable solutions.

5 Conclusion

These results underscore the substantial potential of AI-driven educational interventions to enhance digital inclusion for older adults with diverse neuromuscular conditions. The significant improvements in digital literacy and engagement highlight the effectiveness of personalized AI technologies in addressing the unique challenges faced by this population. Positive qualitative feedback further supports the notion that AI can create inclusive and supportive educational environments.

The educational inclusion application for this population, implemented through an AI algorithm based on eye-tracking, has proven to be an innovative and effective tool. The results obtained from this research indicate significant improvements in usability, accessibility, autonomy, time management, and the elimination of physical barriers for users. This approach not only facilitates access to education in a personalized manner, tailored to individual needs, but also promotes greater social inclusion and equity in the educational sphere. Thus, the transformative potential of AI to overcome traditional challenges associated with neuromuscular conditions is evidenced, offering a sustainable and scalable solution for the educational inclusion of this population.

The findings emphasize the necessity of designing user-centered AI technologies that are not only accessible but also scalable and adaptable. Incorporating features that address sensory and cognitive impairments will enhance usability and ensure these tools meet the evolving needs of an aging population. This perspective aligns with global efforts to promote digital inclusion and lifelong learning opportunities, positioning AI as a pivotal tool in achieving equitable access to education for all.

The study's findings align with the United Nations Sustainable Development Goal 4 (SDG 4), which advocates for inclusive and equitable quality education for all. By leveraging AI, this research contributes to the broader conversation on digital inclusion and active aging, proposing viable solutions to make education more accessible and engaging for the population. Future research should include larger and more diverse samples and explore the long-term effects of these AI-driven educational interventions.

The research acknowledges several limitations, including the small sample size and the potential for selection bias. Additionally, the diversity of neuromuscular conditions among participants may have introduced variability in the results. Future research should include larger and more diverse samples and explore the long-term effects of AI-driven educational interventions.

To build on these findings, future research should include longitudinal studies assessing the retention of digital literacy skills and exploring applications for other disabilities. Additionally, integrating AI-driven solutions into healthcare-supported educational programs could enhance their scalability and long-term impact. Policymakers should consider supporting initiatives that leverage these technologies to address global goals for equitable education and inclusion.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Institutional ethics committee of the Universidad Nacional de Colombia (Approval code: HERMES-19697, date: 17 April 2021). The studies were

conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

PV-L: Conceptualization, Investigation, Methodology, Writing – review & editing, Supervision. HC-R: Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing, Project administration, Validation, Visualization. JJ-B: Conceptualization, Investigation, Methodology, Validation, Writing – review & editing, Data curation, Formal analysis, Funding acquisition, Resources, Software, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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