

**Artificial Intelligence (AI) in Multilingual Education: Investigating Its Potential in Supporting the Preservation and Instruction of Indigenous Languages in Formal Education**

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## **Abstract**

Linguistic diversity is a fundamental aspect of human civilization, but many indigenous languages are at risk of extinction due to inadequate formal education and preservation efforts. In multilingual societies, especially in African countries, the decline of indigenous languages threatens cultural heritage and identity. This study examines the role of artificial intelligence (AI) in supporting the preservation and teaching of indigenous languages within formal education systems. The research explores how AI technologies such as Language Learning Applications (LLA), Speech Recognition (SR), and Machine Translation (MT) can contribute to the revitalization of endangered languages, promote linguistic diversity, and ensure cultural sustainability in educational contexts. The study highlights the potential of AI in overcoming barriers like limited resources and access to instructional support, while also addressing challenges related to technological limitations, cultural sensitivity, and unequal access to technology. It emphasizes the need for collaboration among policymakers, educators, technologists, and indigenous communities to create AI solutions that are effective and culturally appropriate. The findings offer valuable insights into the intersection of AI and multilingual education, proposing actionable strategies to preserve and promote indigenous languages for future generations.

**Keywords:** Artificial Intelligence, Indigenous Languages, Language Preservation, Multilingual Education, Cultural Sustainability

## **Introduction**

The linguistic landscape of language learning is rapidly evolving, with artificial intelligence (AI) technologies transforming the way languages are taught and learned. Okata and Adebayo (2024) explore how AI-driven tools, such as natural language processing (NLP), speech recognition, and machine translation, are reshaping traditional language education methods to meet modern educational demands. They argue that these technologies can enhance language instruction by providing personalized learning experiences, addressing linguistic diversity, and preserving endangered languages.

A major factor driving the adoption of AI in language education is the need to bridge gaps in access to quality language instruction. Okata and Adebayo (2024) highlight how AI technologies can promote autonomous learning by offering immediate feedback and interactive engagement through digital platforms. This perspective aligns with research from Tono, Satake, and Miura (2014), who found that the use of corpus tools for coded error feedback in second language (L2) writing tasks significantly improved students' writing accuracy. The authors suggest that AI tools can similarly provide context-specific feedback to foster learner autonomy and improve language proficiency.

In addition to promoting autonomous learning, AI technologies are playing a significant role in developing speaking and listening competencies. According to van Doremalen et al. (2016), automatic speech recognition (ASR) systems have proven effective in enhancing pronunciation and listening skills. Okata and Adebayo (2024) emphasize that ASR technologies can particularly benefit learners in remote areas where access to language instructors is limited. By integrating ASR into AI-driven platforms, learners receive real-time pronunciation feedback, thereby enhancing their communicative competence.

However, concerns about the ethical implications of AI in education remain. Vincent (2022) warns against the potential misuse of AI-generated answers in educational settings, which could hinder critical thinking and cognitive development. Okata and Adebayo (2024) acknowledge these concerns and stress the importance of incorporating ethical guidelines and human oversight when deploying AI tools in language learning. They argue that while AI can enhance learning experiences, it should complement traditional teaching methods rather than replace them.

Task-specific applications of AI tools also hold promise in language education. Walker et al. (2011) underscore the importance of tailoring ASR applications to meet the unique needs of learners in vocational contexts, such as training nurses. This aligns with Okata and Adebayo's (2024) recommendation to design AI-driven tools for specific learning objectives, whether for academic, professional, or cultural purposes.

Moreover, AI technologies have the potential to preserve endangered languages by creating digital resources, including dictionaries, grammar guides, and interactive lessons. Wang, Hwang, and Chang (2021) highlight how chatbots can facilitate language learning through interactive dialogues. Okata and Adebayo (2024) argue that AI-driven language preservation initiatives can ensure that indigenous languages remain accessible to future generations, thereby safeguarding cultural heritage.

The application of AI in language learning and preservation offers transformative possibilities for enhancing educational outcomes and safeguarding linguistic diversity. As Okata and Adebayo (2024) caution, the effective use of these technologies requires thoughtful integration and human oversight. Addressing ethical considerations and tailoring AI tools to meet diverse learner needs, educators can maximize the potential benefits of AI while mitigating risks, ensuring that technology serves as an enabler rather than a replacement in language education.

## **Literature Review**

The integration of artificial intelligence (AI) in language learning has gained significant traction in recent years. Okata and Adebayo (2024) provide a comprehensive review of key AI technologies and their applications in language education, highlighting the transformative potential of AI-driven tools in enhancing language instruction. Their study emphasizes that AI technologies such as natural language processing (NLP), speech recognition, and machine translation can bridge the gap between traditional language learning methods and modern

educational needs. These tools not only facilitate personalized learning experiences but also address the challenges posed by linguistic diversity and the preservation of endangered languages.

Okata and Adebayo (2024) argue that AI technologies can support learners by providing immediate feedback, promoting autonomous learning, and enhancing engagement through interactive platforms. This perspective aligns with findings from other researchers, such as Tono, Satake, and Miura (2014), who demonstrated the positive impact of using corpora in second language (L2) writing tasks. Their study found that students who received coded error feedback through corpus tools showed significant improvement in their writing accuracy. This suggests that AI tools can similarly provide context-specific feedback, thereby promoting learner autonomy and improving language proficiency.

Moreover, van Doremalen et al. (2016) examined the effectiveness of automatic speech recognition (ASR) systems in language learning and found that these systems offer significant benefits in improving pronunciation and listening skills. Okata and Adebayo (2024) also emphasize the role of ASR technologies in developing speaking and listening competencies, especially for learners in remote areas where access to language instructors may be limited. The integration of ASR into AI-driven language platforms ensures that learners receive real-time pronunciation feedback, thereby enhancing their communicative competence.

Vincent (2022) raises concerns about the potential misuse of AI-generated answers in educational settings, warning that reliance on AI without critical oversight could hinder learners' cognitive development. Okata and Adebayo (2024) acknowledge these concerns and stress the importance of incorporating ethical guidelines and human oversight when deploying AI tools in language education. They argue that while AI technologies can enhance learning experiences, educators must ensure that these tools are used to complement, rather than replace, traditional teaching methods.

Walker et al. (2011) highlight the importance of task-specific applications of ASR in language learning, particularly in vocational contexts such as training nurses. This task-specific approach aligns with Okata and Adebayo's (2024) recommendation to tailor AI tools to meet the unique needs of different learner groups. They argue that AI-driven language tools should be designed to address specific learning objectives, whether for academic, professional, or cultural purposes.

Wambsganss, Janson, and Leimeister (2022) explored the impact of automated feedback on argumentative writing and found that AI-powered feedback systems can enhance the quality of student writing by providing targeted suggestions for improvement. Similarly, Okata and Adebayo (2025) emphasize that AI-driven writing evaluation tools can support language learners by offering personalized feedback, thereby promoting self-regulation and improving overall writing proficiency.

Okata and Adebayo (2024) also discuss the potential of AI in preserving endangered languages by creating digital resources such as dictionaries, grammar guides, and interactive language lessons. This view is supported by Wang, Hwang and Chang (2021) who highlighted the role of chatbots in promoting language learning through interactive dialogues. By incorporating AI technologies into language preservation efforts, educators can ensure that indigenous languages remain accessible to future generations, thus safeguarding cultural heritage.

In conclusion, the application of AI in language learning and preservation offers transformative possibilities for enhancing educational outcomes and safeguarding linguistic diversity. However, as Okata and Adebayo (2024) caution, the effective use of these technologies requires thoughtful integration and human oversight. By addressing the ethical considerations and tailoring AI tools to meet diverse learner needs, educators can maximize the potential benefits of AI while mitigating potential risks, ensuring that technology serves as an enabler rather than a replacement in language education.

### **Challenges in Preserving Indigenous Languages**

One of the primary challenges in preserving indigenous languages is their exclusion from formal education systems. Many educational policies prioritize dominant national or global languages, leaving indigenous languages without institutional support. Additionally, the lack of written materials and teaching resources in these languages exacerbates the issue. Many indigenous languages also lack standardized orthographies, dictionaries, and textbooks, which are essential for creating effective educational resources. The absence of qualified teachers proficient in these languages further limits opportunities for formal education in indigenous languages, especially for younger generations.

### **AI in Language Preservation**

AI technologies have demonstrated considerable potential in efforts to preserve languages. Tools such as natural language processing, machine learning, and speech recognition can be employed to document endangered languages, create digital resources, and develop language-learning applications. For instance, AI-driven chatbots and virtual assistants can offer interactive language lessons, making the process of language acquisition more accessible and engaging. Machine learning can also be used to develop personalized language learning tools, enabling learners to progress at their own pace. Additionally, AI-powered platforms can facilitate the creation of digital dictionaries, grammar guides, and interactive modules, which can be made accessible to a global audience.

In the scholarly context of Okata & Adebayo (2024), the role of Artificial Intelligence (AI) in language teaching and learning is critically explored, offering insights into the transformative potential of AI technologies in multilingual education. The authors' comprehensive review on the applications of AI in language documentation, learning, and translation is directly relevant to the statistical evidence of AI's efficacy in enhancing these areas. This academic discussion integrates key insights from Okata & Adebayo with empirical data, elucidating the broader

implications of AI in preserving and advancing multilingual education, particularly for indigenous languages.

### **1. Language Documentation: AI as a Tool for Linguistic Preservation**

Okata & Adebayo (2024) emphasize the centrality of AI in the documentation of indigenous languages, noting its capacity to facilitate the transcription, archiving, and preservation of oral traditions. Their analysis underscores the potential of AI-powered tools specifically those utilizing Natural Language Processing (NLP) to automate transcription, making the process more efficient and less time-intensive. The authors suggest that this can drastically reduce the time spent on linguistic fieldwork and increase the accuracy of linguistic documentation.

Empirical data supports this argument, with AI-driven transcription tools showing up to a 20-fold increase in transcription speed compared to manual efforts, thereby significantly accelerating the documentation process for endangered languages. For example, in efforts to preserve the Niger-Congo languages in West Africa, AI technologies have been leveraged to transcribe oral literature, which is an essential component in preserving these languages' structural and cultural integrity. This is particularly relevant given the UNESCO estimate that 40% of the world's languages are endangered, many of which lack comprehensive written documentation. AI's role in increasing the speed and accuracy of documenting these languages can be viewed as a key mechanism in preventing the loss of linguistic diversity.

Furthermore, AI's potential to streamline the process of data organization and archiving offers an opportunity to build robust linguistic databases that can be accessed globally. This aligns with the vision of Okata & Adebayo, who assert that AI tools, by digitizing linguistic resources, create a lasting record of languages that can be continually studied and revitalized.

### **2. Language Learning Applications: Enhancing Learner Engagement and Efficiency**

In the area of language learning, Okata & Adebayo (2024) explore AI's transformative influence on language acquisition, highlighting personalized learning through adaptive systems that tailor content to the needs and progress of individual learners. The review underscores that AI-powered learning platforms such as Duolingo and Rosetta Stone leverage sophisticated algorithms to adjust difficulty levels and provide real-time feedback, which enhances learner engagement and motivation.

Statistical evidence corroborates these claims, with studies indicating that learners using AI-driven platforms experience 30–60% faster learning rates compared to traditional classroom settings. In particular, Duolingo reports that users improve by an average of 0.5 CEFR levels per month, which represents a significant leap in language proficiency. This personalized approach to language learning is particularly advantageous for under-resourced languages, including indigenous ones, which may not have the comprehensive curriculum or resources of widely spoken languages.

Moreover, the integration of gamification in AI-powered learning platforms has proven to increase learner retention rates by up to 35%, according to recent studies. Okata & Adebayo (2025) suggest that gamified, AI-driven language tools foster a more engaging learning environment by incorporating elements of challenge and reward. This is particularly pertinent for the revitalization of indigenous languages, as such tools can make learning these languages more engaging, thereby attracting younger generations to preserve their linguistic heritage.

The authors also discussed the broader implications of AI's adaptive capabilities, noting that it allows learners to engage with the language at their own pace, offering contextualized feedbacks that address individual strengths and weaknesses. This capacity for individualized learning, when applied to indigenous languages, can significantly enhance retention and fluency, addressing the unique challenges faced by learners of minority languages.

### **3. Machine Translation: Promoting Linguistic Inclusivity and Cross-Cultural Communication**

Okata & Adebayo (2024) extensively address the role of AI in machine translation, particularly its potential to bridge communication gaps between speakers of indigenous languages and global lingua franca. The authors highlight the advances in Neural Machine Translation (NMT), which significantly enhance translation quality by employing deep learning algorithms that process linguistic structures in more sophisticated, context-sensitive ways. This development, according to the authors, plays a crucial role in fostering linguistic inclusivity, enabling speakers of indigenous languages to participate in global conversations without losing the nuances of their native tongues.

Empirical research supports these claims, with Google Translate and similar platforms showing a 50% improvement in translation accuracy over traditional statistical methods. Machine translation tools now support over 100 languages, including many indigenous languages, enabling real-time communication and content sharing between previously isolated linguistic communities. Statistical reports also suggest that AI translation tools are used by over 500 million people daily, marking a profound shift in how languages are used in digital spaces. The Okata & Adebayo review underscores that such advancements are especially beneficial for speakers of indigenous languages, who often face barriers to participation in digital platforms and global discourses.

Furthermore, AI-driven machine translation systems contribute to the visibility of indigenous languages in digital contexts, fostering a more inclusive global digital culture. Okata & Adebayo advocate for the use of AI not only as a tool for translation but also as a means of cultural preservation, as these tools allow indigenous communities to share their languages and cultures with a global audience.

## **Implications for Future Research and Policy**

The discussion of AI's applications in multilingual education, as explored by Okata & Adebayo (2024), provides a nuanced understanding of the technological advances reshaping language documentation, learning, and translation. Statistically, AI's impact is undeniable, with measurable improvements in documentation speed, learning efficiency, and translation accuracy. The authors' review critically emphasizes the potential of AI in linguistic preservation and cultural inclusivity, particularly for indigenous languages that have historically been marginalized.

Moving forward, the integration of AI into multilingual education must be coupled with targeted policies and frameworks that support the digital inclusion of underrepresented languages. As AI technologies continue to evolve, further research into their applications and limitations will be essential to ensure that their benefits are maximized while preserving the linguistic and cultural integrity of the languages they aim to support. The continued collaboration between linguists, technologists, and educators will be crucial in shaping an AI-powered future that is equitable, inclusive, and linguistically diverse.

The integration of Artificial Intelligence (AI) in indigenous language education presents significant opportunities, but it is not without its challenges. As Okata & Adebayo (2024) discuss, while AI can offer profound advancements in language teaching, learning, and preservation, the deployment of AI in these contexts faces several constraints. The challenges of technological limitations, cultural sensitivity, and access to technology are key factors that need to be addressed for AI to effectively contribute to the preservation and revitalization of indigenous languages.

### **1. Technological Limitations**

One of the primary challenges highlighted in the context of indigenous language education is the lack of digital resources for many indigenous languages. These languages often lack the large corpora of text data required to effectively train AI models. AI systems, particularly those used in **Natural Language Processing (NLP)** and **speech recognition**, rely on vast amounts of linguistic data to function accurately. For widely spoken languages, such data is abundant, but for indigenous languages, the scarcity of written and recorded materials poses a significant challenge.

**Okata & Adebayo (2024)** point out that this limitation significantly affects AI's ability to learn the intricate grammatical structures, syntax, and phonetics of indigenous languages. Without a robust dataset, AI models may produce inaccurate translations, transcriptions, or learning recommendations, undermining their usefulness in language education.

- **Statistical Evidence:** In comparison to languages like English or Mandarin, many indigenous languages, such as those spoken by small communities in sub-Saharan Africa or the Amazon, may have only a few thousand words documented or transcribed.



This data deficit makes it difficult for AI tools to effectively learn the patterns necessary for language processing. For instance, a study on AI-driven translation models found that languages with over 10 million speakers tend to have a 95% or higher translation accuracy rate, while languages with fewer than 500,000 speakers often see a significant drop in translation quality—sometimes falling below 50%.

## **2. Cultural Sensitivity**

Another critical challenge in AI-driven indigenous language education is ensuring cultural sensitivity. Okata & Adebayo (2025) stress that AI tools must be designed and implemented in ways that respect and preserve the cultural heritage of indigenous communities. Language is deeply intertwined with culture, and language learning tools that ignore cultural contexts can perpetuate stereotypes or misrepresent linguistic practices.

For indigenous communities, language is not only a means of communication but also a vehicle for cultural expression and tradition. If AI tools fail to capture these cultural nuances, they risk distorting the language or undermining the values that the language represents. For example, certain terms or phrases in indigenous languages may have specific cultural connotations or be used only in particular social contexts. An AI model that lacks the ability to understand these contexts may inadvertently provide inaccurate or culturally insensitive translations, making language learning a less meaningful experience.

- **Statistical Evidence:** A study by the European Commission (2021) found that 30% of AI-powered translation tools used for minority languages failed to account for cultural context in their translations. This was particularly evident in languages with strong cultural traditions, where the tools often mistranslated words tied to cultural practices or values, leading to misunderstandings. The impact of such inaccuracies is particularly harmful in educational settings, where learning the correct cultural context is vital.

## **3. Access to Technology**

The issue of access to technology remains a major barrier to the widespread use of AI in indigenous language education. In many rural and remote areas, access to digital devices, internet connectivity, and electricity is still limited. These infrastructural challenges restrict the ability of many indigenous communities to fully engage with AI-powered educational tools.

- **Okata & Adebayo (2024)** emphasize that without reliable access to technology, the potential benefits of AI in language education cannot be realized. For instance, in parts of Sub-Saharan Africa, Latin America, and Asia, where many indigenous languages are spoken, there is a digital divide that prevents communities from utilizing AI tools for language learning or preservation. The lack of widespread internet access means that even if AI-powered language apps or platforms are available, they are inaccessible to large segments of the population.

- **Statistical Evidence:** According to a report by ITU (International Telecommunication Union, 2022), approximately 40% of the world's rural population still lacks access to reliable internet services. This digital divide is even more pronounced in regions where indigenous communities live, as only 15% of rural households in Africa had internet access in 2021. Without this foundational access, the implementation of AI-powered educational tools is significantly hampered, limiting the reach and effectiveness of AI in indigenous language preservation efforts.

## **Conclusion**

The challenges of technological limitations, cultural sensitivity, and access to technology present significant obstacles to the effective use of AI in indigenous language education. While AI has the potential to revolutionize the teaching and learning of endangered languages, these challenges must be addressed to ensure that AI tools are both effective and respectful of the cultures they aim to support.

Okata & Adebayo (2024) provide a framework for understanding these challenges, emphasizing that AI tools must be designed with indigenous contexts in mind and that global efforts to bridge the digital divide are essential for equitable access to AI technologies. Additionally, collaboration with indigenous communities is crucial in developing AI systems that are culturally appropriate and capable of capturing the unique linguistic features of these languages.

To overcome these barriers, the research and development of AI in language education must be collaborative, inclusive, and culturally aware. With ongoing efforts to address technological limitations, improve cultural sensitivity, and increase access to technology, AI has the potential to play a pivotal role in preserving and revitalizing indigenous languages for future generations.

## **Conclusion**

Artificial Intelligence (AI) holds considerable promise for supporting the preservation, revitalization, and instruction of indigenous languages, offering innovative solutions that can address long-standing challenges in multilingual education. AI technologies can facilitate language documentation, improve language learning experiences, and bridge communication gaps, helping to ensure that indigenous languages are not only preserved but also actively taught to new generations. However, the realization of this potential is contingent on overcoming several challenges, including technological limitations, cultural sensitivity, and unequal access to technology. These challenges require a concerted effort from various stakeholders, including policymakers, educators, technologists, and indigenous communities themselves.

As AI continues to evolve, its role in enhancing linguistic diversity and cultural preservation will grow, provided that efforts are made to tailor these technologies to the unique needs of indigenous languages and communities. Collaboration among stakeholders is critical to the development of AI-driven solutions that not only promote the effective use of indigenous

languages but also ensure that these languages are treated with the respect, nuance, and cultural significance they deserve. In order for AI to serve as a powerful tool for educational and linguistic equity, it must be inclusive, culturally sensitive, and widely accessible.

## **Recommendations**

1. **Develop AI-driven language learning applications specifically designed for indigenous languages:** To address the technological limitations in indigenous language education, it is essential to develop language learning applications that are tailored to the unique linguistic features of these languages. These applications should incorporate AI-powered features such as speech recognition, natural language processing, and personalized learning pathways to make the learning process more engaging and effective for learners of all ages.
2. **Integrate indigenous languages into national education policies to ensure institutional support:** For AI technologies to be effectively incorporated into indigenous language education, it is vital that national education policies prioritize the inclusion of indigenous languages. Governments should create policies that mandate the integration of indigenous languages into curricula, ensuring that educational institutions provide the necessary support, training, and resources to both teachers and students.
3. **Invest in digital infrastructure to enhance access to AI tools in rural and underserved areas:** One of the primary barriers to using AI for indigenous language education is limited access to technology. Governments and organizations should invest in digital infrastructure to ensure that communities in rural and underserved areas have access to the internet, digital devices, and other technologies that are essential for utilizing AI tools. This can be achieved through subsidies, partnerships with tech companies, and the creation of community-based digital hubs.
4. **Ensure cultural sensitivity in AI solutions by involving indigenous communities in the development process:** It is critical that AI-driven solutions for indigenous language education are culturally sensitive and accurately reflect the traditions, values, and linguistic intricacies of the communities they serve. Indigenous communities must be actively involved in the development and implementation of AI tools, ensuring that these technologies are not only linguistically accurate but also culturally appropriate and respectful.
5. **Promote public awareness campaigns to highlight the importance of preserving indigenous languages:** Public awareness campaigns are essential in raising awareness about the importance of preserving indigenous languages and the role AI can play in this process. These campaigns should emphasize the value of linguistic diversity, the role of language in cultural identity, and the need for collective action to ensure the survival of endangered languages. Such initiatives can engage both indigenous and non-indigenous populations, fostering a broader commitment to language preservation.

Addressing these recommendations, AI can become an invaluable tool in preserving and promoting indigenous languages, empowering communities to safeguard their linguistic

heritage for future generations while ensuring equitable access to education in the digital age. Through collaborative efforts and strategic investment, AI-driven language solutions can contribute to the broader goal of linguistic and cultural sustainability.

## References

- Okata, N. G., & Adebayo, A. A. (2025). Exploring (AI) Artificial Intelligence's role in language teaching and learning: A review of key technologies and their applications. *Beyond Babel: BU Journal of Language, Literature, and Humanities*, 8(2), 50–73. <https://doi.org/10.5281/zenodo.14599743>
- Tono, Y., Satake, Y., & Miura, A. (2014). The effects of using corpora on revision tasks in L2 writing with coded error feedback. *ReCALL*, 26(2), 147–162. <https://doi.org/10.1017/S095834401400007X>
- van Doremalen, J., Boves, L., Colpaert, J., Cucchiaroni, C., & Strik, H. (2016). Evaluating automatic speech recognition-based language learning systems: A case study. *Computer Assisted Language Learning*, 29(4), 833–851. <https://doi.org/10.1080/09588221.2016.1167090>
- Vincent, J. (2022, December 5). AI-generated answers temporarily banned on coding Q&A site Stack Overflow. *The Verge*. <https://www.theverge.com/2022/12/5/23493932/chatgpt-ai-generated-answers-temporarily-banned-stack-overflow-llms-dangers>
- Walker, N. R., Cedergren, H., Trofimovich, P., & Gatbonton, E. (2011). Automatic speech recognition for CALL: A task-specific application for training nurses. *Canadian Modern Language Review*, 67(4), 459–479. <https://doi.org/10.3138/cmlr.67.4.459>
- Wambsganss, T., Janson, A., & Leimeister, J. M. (2022). Enhancing argumentative writing with automated feedback and social comparison nudging. *Computers & Education*, 191, 104644. <https://doi.org/10.1016/j.compedu.2022.104644>
- Wang, J., Hwang, G.-W., & Chang, C.-Y. (2021). Directions of the 100 most cited chatbot-related human behavior research: A review of academic publications. *Computers and Education: Artificial Intelligence*, 2, 100023. <https://doi.org/10.1016/j.caeai.2021.100023>