

Digital Technologies in Indigenous Education: Perspectives for the Training and Digital Inclusion of Macuxi Teachers

Ana Cláudia Luiz Borges Barros

PhD student in the Graduate Program in Language,

Federal Institute of Education, Science and Technology of Roraima, Brasil

<https://orcid.org/0000-0002-5049-8367>

E-mail: ana.barros@ifrr.edu.br

Tiago Santos Barreto Thomaz

Master in Educational Sciences, Educational Administration,

Federal Institute of Education, Science and Technology of Roraima, Brasil

<https://orcid.org/0000-0001-7972-4981>

E-mail: tiagoduninthomaz@gmail.com

Clinton Junior George

Master's Degree in International Relations (in progress)

Federal Institute of Education, Science and Technology of Roraima, Brasil

E-mail: clinton.george@ifrr.edu.br

Lysne Nozenir de Lima Lira

PhD in Education,

Federal Institute of Education, Science and Technology of Roraima, Brasil

<https://orcid.org/0000-0003-4284-5266>

E-mail: lysne.lima@ifrr.edu.br

Rogério Pinto de Sousa

PhD student in the Graduate Program in Language,

Federal Institute of Education, Science and Technology of Alagoas, Brazil

<https://orcid.org/0000-0002-1619-938X>.

E-mail: rogeriopinto040@gmail.com

Lucas Socoloski Gudolle

PhD in Informatics in Education,

Federal Institute of Education, Science and Technology of Roraima, Brasil

<https://orcid.org/0000-0002-6037-1116>

E-mail: lucas.gudolle@ifrr.edu.br

Magno de Oliveira

Doctoral Program in Biotechnology - PPG Bionorte –

Federal University of the State of Tocantins – UFT, Brasil

E-mail: magnoempresa@gmail.com

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Abstract

This study analyzes the integration of digital technologies in Macuxi indigenous education, focusing on the challenges, strategies and teacher training necessary for effective implementation. The research examines how Information and Digital Communication Technologies (DIT) can be incorporated into the indigenous educational context, respecting their cultural particularities and specific needs. The methodology is based on a systematic review of the literature and analysis of practical experiences, identifying the main barriers and opportunities in the digital inclusion of this community. The results indicate that the integration of digital technologies in education depends on a participatory and meaningful teacher training process, in addition to a review of curricula and pedagogical practices. The study reveals that the use of educational technologies constitutes a fundamental human right, although there are important limitations in terms of infrastructure and adequate conditions for its use. The research also identifies the need to develop didactic-pedagogical and

technical-digital skills in teachers. The conclusions point to the importance of a balanced approach that combines teacher training, digital educational resources and adequate infrastructure, integrated into the school curriculum. The study recommends the development of more robust and coordinated public policies to guarantee access and full participation of the Macuxi community in the digital era, promoting more inclusive and culturally sensitive education.

Keywords: Digital Technologies, Teacher Training, Digital Inclusion, Macuxi People

1. Introduction

Digital inclusion in Macuxi indigenous education represents a fundamental field of study to understand technological transformations in the educational context of traditional communities, because as stated (Nascimento et al., 2024), digital technologies have significantly modified the way human beings interact and think, especially in the current period of massive information.

In the context of Macuxi indigenous education, says (Nascimento et al., 2024), the integration of Digital Information and Communication Technologies (TDICs) demands more participatory teacher training and a review of curricula and pedagogical practices. The process of digital inclusion in these communities needs to consider specific cultural aspects and the particularities of the local educational environment. Training teachers to work in the context of cyberculture requires the development of specific technological and linguistic skills, characteristics of the multiliteracies that constitute the civic life of teachers and students (Santos et al., 2024). This training must respect the traditions and ancestral knowledge of the Macuxi community. Digital literacy in indigenous education contributes to the formation of critical and autonomous students, promoting a collaborative learning environment that values both traditional knowledge and new technologies (Pedra et al., 2024). The implementation of TDICs in indigenous schools requires adequate infrastructure and specific public policies.

In this way, the development of digital skills in the Macuxi community represents an important step towards reducing educational and economic disparities (Nascimento et al., 2024), therefore, the continued training of indigenous teachers in digital technologies should be a priority in educational policies. Public policies aimed at digital inclusion in Macuxi education need to guarantee not only access to technologies, but also their significant appropriation by the community, as advocated (Moreira et al., 2023). The objective is to strengthen cultural identity while developing the skills necessary for participation in the digital society.

2. Theoretical Foundation

2.1 Indigenous Education in Brazil

Indigenous education in Brazil has a complex historical trajectory, marked by different moments and educational policies. The educational process of Brazilian indigenous peoples was initially strongly influenced by religious missions, which sought to catechize and “civilize” native populations (Da Silva et al., 2023). The 1988 Federal Constitution established important milestones for indigenous education, guaranteeing indigenous peoples the right to a specific, differentiated, intercultural and bilingual school education. This legal recognition allowed the development of pedagogical practices that respect the cultural particularities of each ethnic group. The current indigenous educational system seeks to integrate traditional knowledge with contemporary academic knowledge. Indigenous schools develop their own curricula that include both the mother tongue and Portuguese, preserving cultural aspects specific to each community.

The training of indigenous teachers, explains (Nóvoa & Santos, 2023), represents a fundamental element for the quality of education in communities. Teacher training programs need to consider the cultural and linguistic specificities of each people, preparing educators who can act as mediators between different knowledge systems. Indigenous schools face structural issues such as limited access to teaching resources and inadequate infrastructure. In many regions, school units operate with basic conditions, requiring adaptations to incorporate new technologies and teaching methodologies.

2.2 Importance of Digital Inclusion in Indigenous Education

As explained (Nascimento et al., 2024), digital inclusion in indigenous education represents a fundamental element for the educational and social development of traditional communities. Digital technologies have substantially modified the modes of interaction and thinking, especially in the current context of massive information. The process of integrating Digital Information and Communication Technologies (TDICs) into indigenous education requires participatory teacher training and a review of curricula and pedagogical practices that respect cultural specificities.

According to (Pedra et al., 2024), the development of digital skills in indigenous communities constitutes an essential step towards reducing existing educational and economic disparities. The implementation of digital technologies must occur naturally and adapted to the specific needs of the community. According to (Rangel, 2023), the indigenous school calendar, which respects natural cycles and cultural activities important to the people, can benefit from technological integration, allowing new ways of recording and sharing traditional knowledge. In this way, the integration of digital technologies in indigenous education can strengthen the preservation of cultural memory through the digital recording of oral narratives and traditional practices. In this way (Nascimento et al., 2024) explains that technological resources, when adapted to the specificities of the Macuxi community, enable the creation of bilingual and interactive teaching materials that value both ancestral knowledge and the digital skills necessary for participation in contemporary society.

2.3 Macuxi People: History, Culture and Education

According to (Peres Cruvinel Ribeiro, 2022), The Macuxi people, traditional inhabitants of the Roraima region, in the territory officially recognized as Raposa Serra do Sol Indigenous Land, have a rich history and culture that is intertwined with the formation of Brazilian identity. Settled mainly in the farming and mountainous regions of northeast Roraima, the Macuxi have kept their culture alive for generations. The Macuxi social organization is based on community principles, with a strong emphasis on the oral transmission of knowledge and cultural values. The Macuxi language, belonging to the Karib linguistic family, remains a central element of cultural identity, even with the increasing use of Portuguese (Santana et al., 2023). In traditional Macuxi education, knowledge is transmitted through daily practices, rituals and oral narratives. Elders play a fundamental role as guardians and transmitters of ancestral knowledge, keeping the cultural memory of the people alive.

Macuxi indigenous education has unique characteristics that reflect the rich cultural heritage

and traditional knowledge of this people. According to (Peres Cruvinel Ribeiro, 2022), the educational process in Macuxi communities integrates elements of formal education with ancestral knowledge, constituting its own and culturally relevant educational model. As pointed out (Nascimento et al., 2024), Macuxi indigenous schools are located mainly in the state of Roraima, where they develop pedagogical practices that value both the mother tongue and Portuguese, in a bilingual education system. This educational approach seeks to preserve cultural identity while providing students with the tools necessary to interact with contemporary society. (Alves et al., 2022), explains that the Macuxi educational system faces structural issues such as limited internet access and insufficient technological resources. In several regions, schools operate with basic infrastructure, requiring adaptations to incorporate digital technologies into their pedagogical practices.

The training of indigenous Macuxi teachers must include specific aspects of the culture and worldview of the people, integrating traditional methodologies with contemporary pedagogical practices. According to (Santana et al., 2023), educators act as mediators between ancestral knowledge and modern educational demands.

The school calendar in Macuxi communities respects natural cycles and cultural activities that are important to the people, such as rituals, celebrations and harvest periods. Rangel (2023) says that this specific temporal organization allows formal education to harmonize with traditional cultural practices. According to Cardoso and Darwich (2023), the teaching materials used in Macuxi schools are developed considering the linguistic and cultural particularities of the community, these pedagogical resources incorporate elements of local culture, traditional stories and knowledge about the territory, strengthening the cultural identity of students.

And as for school management in Macuxi communities, this relies on the active participation of community leaders and elders, who contribute to defining educational guidelines aligned with the needs and aspirations of the people. This community participation strengthens the link between formal education and traditional values.

In Suma, we can share with (Reis et al., 2024), when he states that the integration of digital technologies in Macuxi education represents a new chapter in the history of these people, bringing challenges and opportunities for the preservation and transmission of traditional knowledge, in which schools seek to balance the use of technological resources with the maintenance of ancestral cultural practices.

2.4 Teacher Training for the Use of Digital Technologies

As argued by (Cruz Rosas & Zantut Nutti, 2023), teacher training for the use of digital technologies constitutes a central element in the transformation of contemporary pedagogical practices. Teachers need to develop specific skills to integrate TDICs effectively into their classes.

The training process for teachers to use digital technologies requires an approach that integrates technical and pedagogical knowledge, and, in the case of Macuxis teachers, cultural aspects as well. This integration allows teachers to use technological tools in a

contextualized and meaningful way (Reis et al., 2024). Therefore, educational institutions need to offer continuing education programs that address the real needs of teachers in the digital context and guarantee investment in adequate technological infrastructure for the teacher training process, as this infrastructure allows teachers to apply the knowledge acquired in their pedagogical practice.

Therefore, the technological training of teachers must consider the cultural and social specificities of each school community, especially when we talk about an indigenous community such as the Macuxis.

3. Research Methodology

This research is characterized as a qualitative investigation of a documentary nature, based on the systematic analysis of the literature on digital inclusion in Macuxi indigenous education. According to Da Silva et al. (2023), the qualitative methodology allows us to examine in depth aspects related to teacher training and integration of digital technologies in the indigenous educational context.

The documentary study focuses on the analysis of scientific articles, theses, dissertations and official documents that address the topic of digital inclusion in indigenous education, with a specific focus on the Macuxi community. The selection of documents followed criteria based on their relevance and timeliness. As for data collection procedures, this involved systematic searches in academic databases such as SciELO, CAPES Journal Portal, Google Scholar and Brazilian Digital Library of Theses and Dissertations. The search terms included combinations of keywords related to Macuxi indigenous education and digital technologies. The inclusion criteria for the documents included: - Publications from the last 5 years (2019-2024) - Texts in Portuguese, English or Spanish - Documents that specifically address Macuxi indigenous education - Studies on teacher training and digital technologies in the indigenous context.

It is important to highlight that this investigation respects the ethical principles of scientific research, including the adequate recognition of the sources consulted and the preservation of the authenticity of the information. As this was documentary research, there was no need to submit it to the Ethics Committee.

Data analysis followed the principles of content analysis, with thematic categorization of selected documents. The categories of analysis emerged from the literature itself, considering aspects such as teacher training, technological infrastructure and pedagogical practices. The analytical process included three main stages: - Preliminary reading and organization of the material - Identification and categorization of main themes - Interpretation and synthesis of results.

4. Results and Discussion

4.1 Resistance to the Adoption of New Technologies, Strategies for Digital Integration and Public Policies

Data analysis reveals that 45% of teachers express concern about the possible loss of traditional pedagogical practices when adopting digital technologies in the classroom (Nascimento et al., 2024). According to (Da Cruz et al., 2024), this resistance manifests itself especially among more experienced educators, who value ancestral methods of transmitting knowledge and question the effectiveness of digital tools to preserve specific cultural aspects of the Macuxi community. It also manifests itself through the concern of elders and community leaders with the preservation of traditional methods of transmitting knowledge.

In this sense, it is important to outline strategies for the integration of digital technologies, which requires a systematic approach that considers both the technical and cultural aspects of the community. Nascimento et al. (2024) explain that the effective implementation of these strategies must start from a balanced model that integrates four fundamental elements: adequate technological infrastructure, continued teacher training, culturally adapted educational resources and specific public policies for the indigenous context. It is also necessary to coordinate partnerships with support organizations and institutions. Collaboration between government institutions, non-governmental organizations and private entities can provide technical, financial and pedagogical resources necessary for the effective implementation of digital inclusion programs.

According to Carvalho et al. (2021), such partnerships must generate public policies to promote indigenous digital inclusion that can include investments in technological infrastructure, teacher training and development of educational resources adapted to cultural specificities, through technological training programs with Macuxi teachers so that they can make use of Digital Technologies, which integrate traditional knowledge and digital technologies, and that promote continuous monitoring and support for these teachers.

4.2 Infrastructure and Technological Resources

Analysis of the data collected reveals that the technological infrastructure in Macuxi indigenous schools has significant limitations. According to (Nascimento et al., 2024), data collected through systematic searches in academic databases indicate that approximately 30% of the planned technology laboratories were not installed in schools, and 66% have inadequate installation. Narciso et al. (2024) explain that Macuxi schools operate with obsolete equipment or in insufficient quantity to meet student demand. This limitation directly impacts the quality of teaching and the development of digital skills.

According to Nascimento et al. (2024), internet access is restricted in several regions and the available equipment is insufficient to serve the entire school community. In the same sense (Pedra et al., 2024), he explains that the technological resources existing in Macuxi schools require regular maintenance and updating. The research identified that many school units operate with obsolete equipment or an inadequate quantity for the number of students. The documents analyzed reveal that equitable access to technologies constitutes a central

challenge for digital inclusion in Macuxi schools.

4.3 Teacher Training and Digital Skills

Training Macuxi teachers to use digital technologies requires a specific approach that integrates traditional knowledge with technological skills. According to (Santos et al., 2024), data indicate that continuing education programs do not always consider the particularities of the indigenous context.

According to (Cardoso & Darwich, 2023), the development of digital skills among Macuxi teachers occurs in a heterogeneous manner. Some teachers demonstrate greater familiarity with technologies, while others need more intensive support to integrate digital resources into their pedagogical practices.

4.4 Curriculum Integration of Technologies

For (Rangel, 2023), the incorporation of digital technologies into the Macuxi school curriculum requires adaptations that respect the natural cycles and cultural activities of the community. The indigenous school calendar, with its specificities, directly influences the way technologies are used in the educational process. Available digital teaching materials rarely consider the linguistic and cultural characteristics of the Macuxi people. The research identified the need to develop digital educational resources that incorporate elements of local culture and traditional knowledge.

4.5 Language and Cultural Barriers

Linguistic and cultural barriers in the implementation of digital technologies in Macuxi education manifest themselves in different ways. According to Urquiza et al. (2024), the need for bilingual and culturally adapted teaching materials represents one of the main obstacles to effective digital inclusion. The integration of digital technologies needs to consider the specific cultural and linguistic aspects of the Macuxi people, including their traditional forms of knowledge transmission and social organization. Faria (2024), adds that technological resources must incorporate elements of local culture and respect the community's own learning processes.

Available digital teaching materials rarely consider the cultural and linguistic specificities of the Macuxi people, which makes their effective use in the educational process difficult. Santos et al. (2023), argue that adapting these resources requires joint work between educators, community leaders and experts in educational technology.

5. Final Considerations

After the discussions and points highlighted throughout this research, it is concluded that the analysis of digital inclusion in Macuxi indigenous education revealed fundamental aspects about the processes of technological integration in pedagogical practices. According to Alves et al. (2022), 68% of teachers recognize the importance of digital technologies for knowledge, although only 18% of communities have stable internet access. Regarding the technological infrastructure in Macuxi schools, it is clear that there are significant limitations, with 66% of

computer labs installed inadequately (Nascimento et al., 2024). This reality demands substantial investments in equipment and connectivity to enable effective digital inclusion.

Furthermore, future work could incorporate factorial design of experiments (Oliveira et al., 2018) to systematically evaluate the effectiveness of different digital inclusion strategies, considering variables such as infrastructure, teacher training and cultural preservation.

It is also concluded that teacher training for the use of digital technologies requires an approach that integrates technical and pedagogical knowledge specific to Macuxi culture. It is important to highlight that training programs need to incorporate active methodologies and innovative practices that allow teachers to use technologies in a contextualized way (Reis et al., 2024), since the integration of digital technologies in Macuxi education represents an opportunity to strengthen cultural identity while developing skills necessary for participation in contemporary society.

In this sense, it is essential to formulate integrated educational policies that recognize the sociocultural and linguistic specificities of the Macuxi peoples. Such policies should coordinate intersectoral actions between the Ministries of Education, Communications, and Indigenous Peoples, with a view to creating structural plans for connectivity and technological maintenance in indigenous territories. The implementation of public policies aimed at indigenous digital autonomy—with investments in sustainable energy, adequate infrastructure, and equitable access to the internet—is an essential condition for digital inclusion to transcend its instrumental nature and become an instrument for community strengthening and informational sovereignty. In addition, it is recommended that programs be created to promote the production of indigenous digital content, encouraging communities themselves to develop educational and audiovisual materials aligned with their cosmologies, narratives, and learning styles.

Similarly, teacher training programs should prioritize continuous, participatory, and culturally situated approaches based on active and collaborative methodologies that promote the meaningful integration of technologies into the indigenous educational context. Universities, federal institutes, and education departments need to develop partnerships with indigenous leaders and organizations in order to build bilingual and intercultural training curricula. In addition, the development of culturally adapted digital resources—such as educational platforms in indigenous languages, contextualized learning applications, and repositories of traditional knowledge—can contribute to the appreciation of Macuxi identity and the expansion of the digital skills of teachers and students. Thus, digital inclusion is consolidated not only as an access policy, but as an emancipatory process that articulates technology, culture, and self-determination in strengthening contemporary indigenous education.

Finally, for the future development of digital inclusion in Macuxi education, it is recommended: the implementation of continuing training programs that take into account the cultural and linguistic specificities of the Macuxi people; investment in technological infrastructure suited to the needs of indigenous schools, the development of culturally adapted digital educational resources, the establishment of partnerships with support institutions and the creation of specific public policies for indigenous digital inclusion.

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Authors' contributions

All authors contributed significantly to the conception, development, and writing of this article. Ana Claudia L. B. Barros and Tiago Santos Barreto Thomaz were responsible for the overall coordination of the study, literature review, and data analysis, in addition to overseeing the integration of Macuxi cultural perspectives. Lysne Nozenir de Lima Lira and Clinton Junior George collaborated on the methodology, data collection, and critical analysis of the challenges of digital inclusion, with a focus on infrastructure and teacher training. Magno de Oliveira, the overall responsible, contributed to the theoretical contextualization and review of public policies, ensuring the articulation between technical and cultural aspects and translation. Rogério Pinto de Sousa e Lucas Socoloski Gudolle contributed to the writing of the article. All authors actively participated in the writing, review, and approval of the final version of the manuscript, ensuring the accuracy and academic rigor of the work. The discussions and conclusions reflect a consensus among the authors, highlighting the importance of balanced approaches to digital inclusion in indigenous education, respecting the particularities of the Macuxi community.

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The authors declare that they have no financial or relational conflicts of interest that may have influenced the work reported in this article.

Informed consent

Not applicable.

Ethics approval

The Publication Ethics Committee of the Macrothink Institute. The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE). This study did not involve research with human beings or animals, and was based exclusively on a literature review and document analysis. Therefore, it was not necessary to submit the work to a research ethics committee. All data used are in the public domain and duly referenced, following academic ethical principles.

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The data supporting the results of this study are available upon request from the corresponding author.

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No additional data available.

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