EDUCATION IN RURAL AND URBAN ENVIRONMENTS: SCHOOL AWARENESS STRATEGIES THROUGH SOFTWARE AND CLIMATOLOGY TEACHING AS A PRACTICAL EXAMPLE

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Kennedy José Alves da Silva[1], Edson Osterne da Silva Santos[2], Francisdalva da Silva Santos[3], Antonio Francisco do Nascimento Silva[4], Laiane dos Santos Silva[5], Noé da Silva Carvalho[6], Antônia Rafaela Oliveira Vanderlei[7], Rafael Araújo Silva[8], Ana Carla Ferreira Carcará da Silva[9] and José Manoel Morais Silva[10]

Abstract

This article investigates the relevance of using software in rural and urban environments, taking climatology teaching as an example and highlighting its contribution to pedagogical practice in educational contexts. The study is justified by the need to make teaching more dynamic and aligned with the contemporary demands of the twenty-first century. Its general objective is to analyze the effects of

[1] Master's Degree in Geography (PPGgeo/UFPI)
E-mail: profkjose@gmail.com
Lattes: http://lattes.cnpq.br/6486047277790904
[2] Doctoral Candidate in Geography (PROPGEO/UVA)
E-mail: edsonosterne23@gmail.com
Lattes: http://lattes.cnpq.br/4318087538278709
[3] Undergraduate Student in Geography (UESPI)
E-mail: silvafrancidalva923@gmail.com
Lattes: http://lattes.cnpq.br/0593505894332022
[4] Graduate in Pedagogy (FACAPI)
E-mail: toinhofrancisco302@gmail.com
Lattes: http://lattes.cnpq.br/0066152891744023
[5] Bachelor's Degree in Chemistry (UFPI); Agricultural Technician (CTT)
E-mail: layannesantos2020@gmail.com
Lattes: http://lattes.cnpq.br/9425963450668542
[6] Master's Degree in Geography (PPGgeo/UFPI)
E-mail: carvalhonoe614@gmail.com
Lattes: http://lattes.cnpq.br/7750716456039484
[7] Master's Degree in Geography (PPGgeo/UFPI)
E-mail: antoniarafaelaoliveirava@gmail.com
Lattes: https://lattes.cnpq.br/3695347862419650
[8] Teaching Degree in Chemistry (UFPI)
E-mail: faelaraujo32@gmail.com
Lattes: https://lattes.cnpq.br/8992051506580150
[9] Teaching Degree in Chemistry (IFPI)
E-mail: anaacarlacarcara@gmail.com
Lattes: http://lattes.cnpq.br/4472426584431855
[10] Bachelor's Degree in Geography (UEMA/Caxias)
E-mail: josemanoelcx14@gmail.com
Lattes: http://lattes.cnpq.br/8297487088103418

software use by Geography teachers when teaching climatology in the classroom. Methodologically, the study adopts a qualitative, exploratory approach that includes a literature review, field research involving interviews with teachers, and an analysis of technological tools. The results indicate that software promotes more meaningful and contextualized learning, despite structural limitations. It is concluded that technological integration constitutes an essential pedagogical advancement for connecting students with the demands of the contemporary geographical context.

Keywords: Climatology, Educational technologies, Geography, Software, Teacher training.

INTRODUCTION

The effectiveness of this technological integration in climatology teaching extends to both urban and rural contexts, requiring school awareness strategies adapted to the socio-territorial characteristics of each setting. Whereas approaches in urban areas frequently focus on monitoring microclimates and heat islands, those in rural areas concentrate on understanding agricultural cycles and the dynamics of agrarian landscapes, using software as an essential means of enabling students to interpret their environment critically.

Climatology, the science that studies climate, is one of the most important branches of Geography. It investigates climates and their variations at different scales, contributing to an understanding of phenomena ranging from global climate change to local microclimatic alterations at the micro, meso, and macro scales. As Ahrens (2019) emphasizes, climatology offers a unique perspective because it addresses the interaction between climatic phenomena and ecological systems, facilitating an understanding of how human activities are shaped by climate and, in turn, influence the environment. This scientific field enriches environmental analysis, informs territorial planning, and assists in mitigating socio-environmental impacts, understood as negative or positive changes caused by human activities in the environment.

Despite its relevance, climatology teaching presents significant pedagogical challenges, particularly because of the complexity of its concepts and the need to interpret technical data and graphical representations. In this context, technological tools have emerged as indispensable allies. According to Castellar (2019, p. 65), "[...] the use of digital technologies in Geography teaching expands opportunities for engaging with abstract content, promoting more dynamic learning that is connected to students' realities." Tools such as climate simulation software, geospatial analysis platforms, and weather-monitoring applications allow students and teachers to access and analyze real-time climate data, fostering more meaningful and contextualized learning.

This article is grounded in the importance of improving pedagogical practices through the integration of technologies, with the aim of enhancing everyday school life by connecting climatology teaching with the use of software to enrich the teaching and learning process.

The research question guiding the study is: How can software contribute to climatology teaching and to the development of students' critical thinking? The general objective of this study is to analyze the effects of software use by Geography teachers when teaching climatology in the classroom.

Methodologically, the study adopted a qualitative, exploratory approach combining a literature review, field research, interviews with Geography teachers, and an analysis of applied technological tools. By exploring the effects of this approach on teaching practice and the teaching-learning process, this study also seeks to contribute to the development of more effective Geography teaching, regarding climatology teaching as innovative and aligned with the demands of the twenty-first century. The organization of the article reflects this approach, beginning with an introduction to the topic, proceeding through the development of its sections and subsections, and culminating in the presentation of the conclusions and references.

In the field of teacher education, particularly through courses such as Teacher Education and Geography Teaching and Urban Climatology, significant alternatives for professional development may be envisioned. These courses prepare future teachers to integrate technologies into pedagogical practice

critically and reflectively, thereby offering a relevant avenue for advancing the understanding of climatology teaching.

In academic and institutional settings, this preparation usually occurs primarily through Graduate Programs in Geography at the master's and doctoral levels, through specific courses and research groups dedicated to geographical climatology and teaching methodologies. In addition, professional learning environments such as Teacher Education and Professional Development Centers, teaching degree programs at public higher education institutions, and extension projects linked to the Pedagogical Residency Program or undergraduate research also regularly serve as settings for developing this technological and conceptual integration.

As Callai (2013, p. 88) argues, "[...] Geography teaching must be intrinsically linked to technological and social transformations, providing students with tools to understand and act within geographical space autonomously and responsibly." This preparation is not limited to technical proficiency but also involves developing methodologies that encourage critical thinking and interdisciplinary analysis.

METHODOLOGY

This study adopts a qualitative, exploratory approach aimed at understanding the potential and challenges of integrating technological tools into climatology teaching. The methodology was divided into four main stages: a literature review, field research, interviews with teachers, and an analysis of technological tools applied to climatology teaching.

The first stage consisted of a detailed literature review on the use of technologies in Geography teaching, with an emphasis on climatology. Works by authors such as Castells (2015) were consulted. Castells addresses the importance of the network society and the transformation of education through technological integration, discussing the effect of technological innovation on school curricula and teacher education. According to Castells (2015, p. 31), "[...] the role of technologies in teaching is

fundamental to building an informed and critical society in which students become active participants in knowledge." The review also highlighted references on teacher education based on Tardif (2014), who emphasizes the relevance of continuing education to teaching effectiveness. The bibliographic materials were selected according to criteria such as theoretical relevance and practical applicability, using keywords related to educational technology, climatology, and teacher education.

The second stage involved field research with basic education Geography teachers from public and private schools in the municipality of Barras, Piauí, encompassing different socioeconomic contexts.

The third stage consisted of conducting the interviews, a process directly linked to the two preceding stages. The sample consisted of 10 teachers with different levels of experience and education. Participants were selected through convenience sampling to represent a range of pedagogical practices and school contexts. Data were collected through semi-structured interviews conducted from November to December 2024. The interviews explored teachers' perceptions of the use of technological tools in climatology teaching, the challenges encountered when implementing these technologies, and possible solutions for overcoming the identified limitations.

The semi-structured interview methodology enabled a flexible approach, allowing participants to express their opinions specifically while remaining aligned with the central themes of the research (Minayo, 2013). The interviews were recorded, transcribed, and analyzed using the content analysis technique proposed by Bardin (2016), which made it possible to identify recurring categories and themes in the interviewees' statements, such as challenges relating to school infrastructure and perceptions of teacher education.

The fourth stage focused on analyzing technological tools applied to climatology teaching. Four main types of tools were selected: (I) climate simulation software; (II) geographic information systems (GIS); (III) meteorological data platforms; and (IV) interactive audiovisual resources. Selection was based on their educational relevance, accessibility, and capacity to promote meaningful learning. The

analysis considered both the specialized literature and teachers' accounts, identifying practical applications and the limitations of each tool.

The choice of these tools was based on the increasing use of such technologies in educational contexts and their potential contribution to climatology teaching. As Castellar (2019, p. 105) notes, the "[...] incorporation of technological tools into Geography teaching makes it possible to overcome the limitations of traditional teaching, facilitating the understanding of complex topics such as climatology and promoting more interactive and engaging learning." Each tool was assessed in terms of its applicability, accessibility, and capacity to promote meaningful learning based on the visualization of forecast data and students' interaction with those data.

The qualitative data were triangulated by combining information from the literature review, fieldwork, interviews, and observations arising from the analysis of technological tools. According to Denzin (2017), "[...] triangulation increases the validity and reliability of research results by integrating different data sources and analytical techniques." The results were organized into thematic categories: (a) pedagogical benefits; (b) structural benefits and challenges; and (c) the effects of technologies on climatology teaching, enabling the identification of patterns and categories in the qualitative data (Bardin, 2016).

This combination of methods provides a comprehensive and contextualized perspective, offering a basis for improving teacher education and pedagogical practice in Geography teaching. Furthermore, the study findings underscore the importance of investments in school infrastructure and continuing education aligned with contemporary educational demands.

DIGITAL TECHNOLOGIES IN CLIMATOLOGY TEACHING

This section addresses the integration of technological innovations and geotechnologies into climatology teaching and the study of landscape dynamics. It highlights the use of specific applications, geospatial data platforms, simulation software, Geographic Information Systems (GIS), and virtual

learning environments. It discusses the role of these tools in facilitating an understanding of complex atmospheric concepts, as well as the relevance of teacher education focused on Environmental Education (EE) and technology-enhanced teaching, with a view to overcoming methodological challenges and promoting interactive learning.

TECHNOLOGICAL INNOVATIONS APPLIED TO CLIMATOLOGY TEACHING

Technological innovations have significantly transformed climatology teaching, making it more interactive and accessible. One notable example is the ClimaCE application, developed by the Professional Master's Program in Climatology and Applications in Portuguese-Speaking Countries and Africa (CPLP), encompassing Angola, Brazil, Cabo Verde, Guinea-Bissau, Equatorial Guinea, Mozambique, Portugal, São Tomé and Príncipe, and Timor-Leste, at the State University of Ceará (Universidade Estadual do Ceará – UECE). Available for Android, ClimaCE is intended to facilitate the teaching and learning of climatological concepts by providing access to meteorological topics, explanations of factors that influence rainfall in Ceará, interesting facts, and interactive quizzes (Universidade Estadual do Ceará, 2019).

Furthermore, the use of geotechnologies has proven effective in geographical climatology teaching. Tools such as Windy enable the dynamic visualization of climate data, assisting in the understanding of elements such as temperature, humidity, and atmospheric pressure. Studies indicate that integrating these technologies into the classroom can enrich the teaching-learning process, making it more dynamic and effective (Araújo; Andrade, 2023).

Interactive multimedia has also been explored as a pedagogical resource. Projects such as "Climatologia Fácil" demonstrate that, with appropriate teacher mediation, multimedia can make lessons more dynamic and motivate students, facilitating their understanding of complex topics related to weather and climate (Steinke, 2014).

These innovations reflect a growing trend toward incorporating digital technologies into climatology teaching, providing students with modern tools that facilitate an understanding of climate-related concerns and their implications for everyday life.

Climate and geospatial data platforms

Digital platforms have transformed how climatology is taught. Tools such as Google Earth, NASA POWER, INMET, and INPE provide access to updated or near-real-time climate data, allowing the visual exploration of climate dynamics across different regions and time scales. These technologies are particularly useful for illustrating abstract concepts such as atmospheric circulation and temperature variations. By viewing three-dimensional models, students can understand how geographical factors influence local and global climate patterns.

According to Bartholo and Brito (2018, p. 120), "[...] the use of climate simulators and databases in the classroom expands students' capacity for critical analysis, enabling a deeper understanding of climate dynamics and their socio-spatial implications." Integrating these technologies allows students to conduct practical analyses of climate variations and their correlations with the environment. The platforms mentioned represent only a very small proportion of the digital resources that can be used to make instruction more dynamic and to obtain climatological and other information.

Simulation and monitoring software

Climate simulators, such as those used to forecast weather events or analyze long-term changes in climate, have proven to be powerful teaching tools. In addition, portable sensors capable of measuring temperature, humidity, and air quality provide students with opportunities to collect and interpret real data.

These practical experiences help consolidate theoretical concepts in a more engaging manner. According to Valente (1999), "[...] these technologies bring teaching closer to students' realities,

facilitating an understanding of scientific and environmental concepts." He discusses the potential of these technologies to connect teaching with students' realities, enabling more practical and meaningful learning.

Virtual learning environments such as Google Classroom, Moodle, and GeoGebra are tools for organizing and disseminating content interactively. These platforms support collaborative activities and dynamic assessments, promoting more meaningful learning. According to Pereira (2020), digital platforms and technological tools have the potential to make teaching more interactive and foster interdisciplinarity. The author emphasizes the importance of integrating data and resources from different fields of knowledge, such as climatology, with other subjects, thereby promoting more engaging and collaborative education.

Geographic Information Systems (GIS)

Geographic Information Systems (GIS), such as ArcGIS and QGIS, are widely used to map and analyze spatial data. In climatology teaching, these tools allow students to explore relationships between climatic factors and environmental phenomena such as deforestation and urbanization. Almeida and Oliveira (2018) argue that "[...] GIS promotes a visual and detailed understanding of climatic phenomena, facilitating the development of solutions to socio-environmental challenges."

GIS provides a tool that integrates spatial data, enables the analysis of climate patterns, and promotes an interactive and practical approach that is essential to student learning. This methodology, based on the use of software such as ArcGIS and QGIS, can support the creation of thematic maps and simulations of climate scenarios.

Virtual learning environments

Digital platforms such as Google Classroom and Moodle complement teaching by providing spaces for organizing content, conducting dynamic assessments, and carrying out collaborative activities.

These tools are particularly effective in promoting interdisciplinarity by integrating climate data with other fields of knowledge. Pereira (2020) emphasizes that "[...] digital platforms enable a form of interactivity that enhances learning, making it more engaging and relevant."

The courses Teacher Education and Geography Teaching and Urban Climatology, for example, offered by the Graduate Program at the Federal University of Piauí (Universidade Federal do Piauí – UFPI), play a central role in preparing future teachers to integrate technologies into climatology teaching in both the classroom and everyday life. This integration requires technical and methodological proficiency. Teachers must understand how the tools operate and use them didactically in conjunction with innovative pedagogical planning, since the inclusion of technologies must be aligned with curricular objectives that foster active and interdisciplinary learning.

The analysis of climate information should encourage debate on climate change, sustainability, and social impacts. According to Callai (2013, p. 112), "[...] teacher education must prepare teachers to act as mediators of knowledge, with the skills required to incorporate technological innovations into effective pedagogical strategies." Thus, teacher education extends beyond mastery of geographical content, promoting teaching that connects theory and practice through modern tools.

BENEFITS AND CHALLENGES OF USING TECHNOLOGIES IN EDUCATION

The incorporation of technologies into education has transformed teaching, offering benefits such as greater access to educational resources, personalized learning, and the development of essential digital skills. However, it also presents challenges, including unequal access, teachers' difficulties in adapting, and risks related to distraction and online safety. To maximize the benefits and mitigate the challenges, investments must be made in infrastructure, teacher education, and digital inclusion policies, thereby ensuring equitable and safe education for all students.

This issue is even more significant in the current twenty-first-century context of various Brazilian states and municipalities, where regulations and projects are aligned with Federal Law No. 15,100/2025,

which restricts the use of cell phones in educational institutions. Although the legal landscape imposes severe barriers, a situation also reflected in stringent international legislation such as the French ban on devices and the total-restriction guidelines adopted in the Netherlands and China, it is understood that these electronic devices can be repurposed to support the teaching-learning process through effective pedagogical planning, student awareness, and prior communication with school administrators.

Pedagogical benefits

Educational technologies contribute to student engagement and the development of critical skills such as data analysis and interpretation. The interactivity provided by software and digital platforms facilitates the understanding of complex topics. One of the teachers interviewed stated: “[...] access to real data and simulators makes learning more dynamic and connected to students’ everyday lives” (Teacher interview, 2024).

These tools provide numerous benefits that increase classroom engagement by making lessons more dynamic and relevant to students’ realities. They develop practical skills because the use of real data allows theoretical knowledge to be applied in practice, while promoting education for citizenship through critical analysis of climate data, which fosters environmental awareness and more effective action.

This path requires overcoming certain challenges, ranging from specialized teacher education, as many teachers lack the training required to use these tools effectively, to significant technological inequality and inadequate infrastructure in under-resourced schools, which limit the implementation of these tools.

This may result in a declining learning curve, as teachers and students may initially face difficulties adapting to technological tools. Continuing teacher education has therefore been regarded as a crucial factor in ensuring the success of educational innovations. According to the research, teacher education must be robust enough to meet modern educational needs and is essential for enabling teachers to act as highly effective mediators of knowledge by promoting pedagogical practices that integrate

theory and practice (Gatti, 2008). In this way, the use of technologies in climatology teaching becomes an accessible and transformative practice for Geography education.

We emphasize that the results indicate that the use of digital technologies, such as climate simulation software and meteorological data platforms, positively affects both student engagement and the development of critical thinking. According to participants' responses, integrating these tools made the study of climatology more dynamic, providing a deeper and more contextualized understanding of climatic characteristics.

According to one of the teachers who participated in the study, "[...] students interact more with the content when they have access to real data and can visualize three-dimensional climate models" (Teacher interview, 2024). This suggests that teaching based on empirical data and virtual models can improve students' ability to apply theoretical concepts to real situations, fostering meaningful learning.

The interviews also highlighted that platforms such as Google Earth and meteorological applications facilitate the understanding of complex topics, including the spatial distribution of climates and changes in climate patterns over time. These tools allow students to visualize climate change on global and local scales, developing a more comprehensive and multidimensional understanding of climate and its variations. This type of immersive learning contributes to the development of critical skills such as data analysis and informed decision-making regarding the issues studied.

Challenges in teacher education

Despite the numerous advantages of using technologies in teaching, the lack of specific training in their use remains a significant obstacle. Many teachers report difficulty integrating tools such as Geographic Information Systems (GIS) into their lessons because they lack practical training. Perrenoud (2000) argues that teacher education must be robust and adapted to the technological demands of modern teaching.

Practical examples of efforts to overcome this challenge include initiatives such as the Ministry of Education's Continuing Education Program in Educational Technology, which provides training on the use of digital technologies in schools. In addition, some Departments of Education, such as that of the State of São Paulo, have offered in-person and online courses to train teachers in tools such as ArcGIS and Google Earth.

Nevertheless, even with these initiatives, many teachers feel insecure when using advanced technologies in the classroom. This creates resistance to the application of these tools, undermining their pedagogical potential. One teacher interviewed stated: "Although I have access to ArcGIS at school, I do not know how to use it in the classroom. I need more technical support" (Teacher interview, 2024). To overcome these limitations, it would be useful to implement mentoring programs in which experienced teachers share strategies and guide colleagues in the integration of technologies, or to enter into contracts with companies to provide teachers with the relevant knowledge.

EFFECTS OF TECHNOLOGIES

Differences in school infrastructure, particularly between urban and rural areas, hinder the large-scale implementation of technologies. Lauschner (2013) notes that inequalities in access to technological resources directly affect the quality of education, creating gaps that impede digital inclusion.

One successful public policy for addressing these inequalities is the Federal Government's Connected Education Program, which seeks to expand internet access in schools by prioritizing institutions located in remote areas. Another relevant initiative is the Connected Student Project, which provides mobile devices and internet connectivity to vulnerable students, allowing them to use technological tools even outside the school environment.

Some schools have also adopted creative solutions to reduce these gaps. One example is the use of mobile laboratories, as in the State of Ceará, where vans equipped with computers and internet access visit rural schools, providing students and teachers with access to technological resources. In Piauí, the

government distributed SIM cards, tablets, and Chromebooks to facilitate access for teachers and students in both urban and rural areas.

Despite these advances, the lack of specialized equipment and inadequate infrastructure remain major challenges. To mitigate these problems, it would be essential to establish public-private partnerships that facilitate equipment donations and the development of accessible technological solutions, particularly those designed for rural school contexts.

CASE STUDIES AND RESULTS OF THE EFFECTS

The study of specific cases involving the use of educational technologies offers valuable insights into the actual effects of these innovations on learning. A detailed analysis of experiences in different school contexts makes it possible to understand how digital tools influence academic performance, student engagement, and pedagogical effectiveness. Furthermore, the findings of these studies help identify good practices, challenges encountered, and areas for improvement, contributing to the development of more effective strategies for integrating technology into teaching. These cases make it possible to assess the transformative potential of technologies in education and guide future policies and practices intended to maximize their benefits.

TEACHERS' PERCEPTIONS AND EXAMPLES OF GOOD PRACTICES

The teachers interviewed emphasized that the use of technologies such as software and sensors increased student engagement. One teacher reported: "[...] with simulators, students can visualize how climatic factors are interrelated, which enriches classroom discussions."

In schools with better infrastructure, the integration of technologies has generated positive results. In the State of Piauí, where full-time education is offered in all schools within the state system, computer laboratories have been implemented to improve the teaching and learning process through the use of this software and other programs that assist teachers and students. For example, climate-monitoring sensors

have been used in practical projects, while in schools with fewer resources, tools such as Google Earth still offer significant opportunities for geographical and climatic analysis.

Conversely, in schools with limited resources, simpler tools such as free weather applications are more common, although they still contribute to a more interactive and visual approach to climatology teaching.

Chart 1 presents detailed examples of the applications, software, platforms, and physical data-collection resources recommended in the article for teaching climatology in Geography:

Chart 1

Technological tools and applications in climatology teaching

TOOLS	TECHNOLOGICAL CATEGORY	DESCRIPTION AND PEDAGOGICAL APPLICATION
ClimaCE	Mobile Application (Android)	Uses interactive quizzes, interesting facts, and dynamic explanations to stimulate interest in local meteorological topics.
Windy	Geotechnology/Application	Addresses abstract variables by enabling real-time visualization of wind, temperature, humidity, and atmospheric pressure data.
Google Earth	Geospatial Data Platform	Promotes the visual and immersive exploration of three-dimensional models, helping students understand climate change and the spatial distribution of climates in context.
NASA POWER	Climate Data Platform	Provides updated or near-real-time global climate data so that students can conduct practical analyses of complex dynamics such as atmospheric circulation.
INMET (National Institute of Meteorology – Instituto Nacional de Meteorologia)	Climate Data Platform	Provides historical and current meteorological databases that allow students to conduct empirical analyses of climate dynamics and their socio-environmental correlations.
INPE (National Institute for Space Research – Instituto Nacional de Pesquisas Espaciais)	Climate Data Platform	Functions as a research platform that makes it possible to correlate global and local climate behavior across different time scales.
QGIS	Geographic Information System (GIS)	Enables the creation of thematic maps, the correlation of spatial data, and simulations of climate scenarios involving anthropogenic impacts such as deforestation and urbanization. It can use platforms such as IBGE, BDIA, MAPBIOMAS, among others.
ArcGIS	Geographic Information System (GIS)	A GIS platform used to integrate data and analyze spatial patterns. Although it has strong potential for application, the manuscript notes that robust training and technical support are required to overcome teachers' resistance to its implementation.
Google Classroom	Virtual Learning Environment (VLE)	Serves as a virtual environment for organizing content and proposing interactive activities, extending pedagogical mediation beyond the spatial and temporal boundaries of the classroom.
Moodle	Virtual Learning Environment (VLE)	A digital channel that promotes collaborative learning and dynamic formative assessments, integrating different fields in support of interdisciplinarity.

GeoGebra	Virtual Learning Environment	An interactive platform that fosters the integration of quantitative data with mathematical and climatological representations, organizing content in an integrated manner.
Climatologia Fácil	Interactive Multimedia	A multimedia resource designed for Elementary Education that, through intentional teacher mediation, makes lessons more dynamic and facilitates the essential distinction between weather and climate.
Portable Sensors/Climate Monitoring	Physical Data-Collection Instrument	Physical data-collection instruments for temperature, humidity, and air quality that connect theoretical concepts with students' lived realities through school monitoring projects.

Source: Prepared by the authors (2026).

We understand that the incorporation of technological resources into Geography teaching should not be reduced to the technical and instrumental modernization of the classroom. On the contrary, we argue that tools such as monitoring software and climate platforms should support a counter-hegemonic and contextualized education, especially when directed toward the realities of Rural Education and Quilombola, Indigenous, and fishing communities. By placing scientific meteorological data in dialogue and tension with traditional knowledge and the practical experiences of these communities in the Semi-Arid Region, climatology teaching becomes territorialized. It equips students to understand critically the socio-environmental dynamics of their realities, transforming digital cartography and school climatology into languages of resistance, active citizenship, and affirmation of their identities and ways of life in the face of contemporary ecological conflicts.

FINAL CONSIDERATIONS

The use of software in rural and urban environments, including schools, provides professionals and students with opportunities to improve their practices and keep pace with technological trends. Moreover, the use of these tools can contribute to better lessons and learning while also promoting greater student participation, as reported by the teachers. In a society in which technology is increasingly present in everyday life and continues to advance, teachers must pursue professional development and acquire new skills to expand learning through the use of these tools. Technologies can therefore contribute to the development of teaching practice and improve the teaching and learning process, preparing teachers and students alike to keep pace with social transformations.

The results of this study reaffirm the relevance of technological tools in climatology teaching, highlighting their potential to transform pedagogical practices and promote more meaningful learning. Technologies such as climate simulation software, GIS, and meteorological data platforms were identified as tools that support the development of critical thinking and an understanding of complex concepts.

In light of the discussions presented, it is concluded that using software and various technological resources constitutes an important strategy for strengthening Geography teaching, particularly in climatology, because it brings theoretical content closer to situations observed in students' daily lives in both rural and urban environments. The tools analyzed foster the visualization, interpretation, and analysis of climate and geospatial data, contributing to more dynamic, contextualized, and meaningful learning while encouraging the development of critical thinking and the capacity to analyze socio-environmental phenomena.

However, the results also show that the use of these technologies depends on the availability of infrastructure, access to digital resources, and, above all, teacher education that enables their critical and pedagogically informed use. In this regard, the incorporation of software should not be understood merely as the modernization of teaching resources, but rather as an opportunity to transform pedagogical practices by enabling students to participate actively in the construction of knowledge and understand the relationships among society, nature, climate, and geographical space. Thus, integrating educational technologies, teacher education, and climatology teaching constitutes a relevant alternative for Geography education that is more closely aligned with contemporary demands, contributing to student awareness and to the development of individuals capable of interpreting and acting more consciously in response to transformations in rural and urban spaces.

Technological tools not only facilitate the understanding of abstract content but also increase student engagement by connecting climatology teaching with environmental and social realities. Nevertheless, the full implementation of these technologies faces challenges, including the need for teacher education and investment in infrastructure. This is particularly true in regions such as northern

and northeastern Brazil and in municipalities such as Barras, located 122 km from Teresina, the capital of Piauí, where the interviews were conducted and where inadequate access to the internet and equipment compromises technological integration.

It is recommended that continuing teacher education programs prioritize the development of technical and methodological skills related to the use of technologies. Such programs should include practical workshops on tools such as GIS, climate simulators, and educational platforms, focusing on their pedagogical application. It is also essential to establish collaborative networks among teachers to promote the exchange of experiences and strategies for overcoming practical limitations.

Regarding technological inequalities, public policies must be directed toward equipping schools with adequate infrastructure, including high-quality internet access and technological devices. Public-private partnerships can play a crucial role by providing technological resources and technical support to educational institutions.

The use of educational technologies supports the adoption of active methodologies in which students assume a leading role in constructing knowledge. Tools such as interactive maps, satellite images, and meteorological platforms encourage investigation, problem-solving, and evidence-based decision-making, making climatology teaching more meaningful and contextualized. The teacher thus acts as a mediator of the learning process, promoting autonomy, collaboration, and critical thinking.

For meaningful change to occur in Geography teaching, the government must move beyond rhetoric and put technology into practice in the classroom. There is no point in making software and climate data available if people in the most neglected regions have no means of using them. Teachers and students need proper infrastructure and genuine training. Only with this support will students cease to regard climatology as a dull, abstract theory and begin using what they have learned to understand and change the reality of their own neighborhoods.

In this context, technological resources should serve as instruments that bring climatological content closer to students' lived realities, enabling them to interpret climatic phenomena based on the spaces in which they live.

The incorporation of active methodologies into the teaching-learning process profoundly reconfigures the student's role. Students cease to occupy a passive position as mere recipients of information and instead become central agents in the construction of knowledge. This pedagogical approach not only makes teaching practice more dynamic but also strengthens critical thinking and intellectual autonomy, demonstrating that the essence of inquiry lies in valuing student agency as the organizing principle of truly meaningful education.

Finally, it is essential to integrate the use of technologies into pedagogical planning, fostering innovative and interdisciplinary practices. Geography teaching can become a space for critical analysis and civic practice, preparing students to face environmental and social challenges on the basis of geographical and technological knowledge. This study contributes to the debate and establishes pathways toward a more inclusive and innovative form of education aligned with the demands of the twenty-first century.

The incorporation of technologies into the school environment is highly important to the teaching-learning process because it allows students to make tangible what they hear from the teacher as mediator. This improves pedagogical practice and makes learning more meaningful for students as thinking individuals who actively construct their own knowledge. The teacher's role as mediator involves pursuing professional development and seeking to incorporate these technologies clearly and accessibly.

Finally, this study demonstrates that the coordinated use of digital tools in climatology teaching strengthens active methodologies and gives practical meaning to atmospheric phenomena, bringing scientific knowledge closer to students' lived realities. However, overcoming the structural and connectivity deficiencies observed in contexts such as Barras, Piauí, requires urgent investment in school infrastructure and continuing teacher education. Only through intentional and reflective pedagogical

mediation will software cease to be merely instrumental resources and become instruments of autonomy, enabling school climatology to strengthen critical thinking, appreciation for local knowledge, and socio-environmental engagement in rural and urban environments.

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