Development of an Educational Application for Recording Rainfall Data in Pinheiro, Maranhão, Brazil

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Abstract

Precipitation monitoring is fundamental for understanding climate variability, environmental planning, and water resource management, especially in regions with irregular rainfall regimes. This study aimed to develop and apply an educational application for recording, organizing, and analyzing pluviometric data in the municipality of Pinheiro, Maranhão, while promoting student engagement in scientific and technological practices. The Rain Observer application was developed using the Flutter framework and integrated with Google Forms and Excel Online, enabling automatic data storage and the creation of a continuous rainfall database. Daily precipitation measurements were conducted from January to August 2025 using a conventional 150 mm rain gauge installed at the Federal University of Maranhão, Campus Pinheiro, following GLOBE program protocols. The results indicate that the application improved data standardization, reliability, and recording efficiency, reducing errors associated with manual notes. The analysis revealed an average precipitation of 9.1 mm/day, with high temporal variability and rainfall events concentrated between January and April, typical of tropical climates. From an educational perspective, the project contributed to the development of scientific thinking, digital literacy, and environmental awareness, demonstrating the potential of educational applications for local climate data production and learning promotion in school environments.

Keywords: Application development, Mobile programming, GLOBE, STEAM

Research Question

Hypothesis: The use of an educational application for recording pluviometric data makes the process of data collection and storage more organized, efficient, and reliable, replacing the use of manual spreadsheets. In addition, it is assumed that this tool stimulates the engagement of elementary and high school students in climate monitoring and contributes to the development of scientific, digital, and environmental competencies in the school context in municipalities of the Baixada Maranhense and Maranhense Coastal Zone.

Question: How can an educational application improve the recording and organization of pluviometric data in Pinheiro, Maranhão?

How does student participation in rainfall monitoring through the application contribute to scientific learning and educational engagement?

In what ways does the use of digital tools strengthen students' scientific and technological literacy?
How can educational applications be used as tools for climate monitoring and for promoting learning in the school environment?

Introduction

Content Knowledge

Rainfall is one of the main elements for understanding climatic processes and for the sustainable planning of water resources, being fundamental for activities such as agriculture, environmental management, and the prevention of natural disasters. The absence or insufficiency of local rainfall records compromises the analysis of climate variability and hinders the formulation of effective public policies, especially in regions with irregular rainfall regimes, as occurs in much of the Brazilian territory. Studies indicate that systematic monitoring of precipitation is essential for understanding local climate patterns and for reducing socio-environmental vulnerabilities (Costa et al., 2020).

In this context, this study aims to develop and apply an educational application for the recording, organization, and analysis of rainfall data in the municipality of Pinheiro, Maranhão, integrating students into the climate monitoring process. It is hypothesized that the use of an automated digital tool contributes to making data collection more efficient, standardized, and reliable, while also promoting student engagement in scientific and technological practices. The use of the Rain Observer application, associated with the protocols of the GLOBE program, strengthens the production of local data and encourages citizen science, contributing both to the understanding of rainfall variability and to the improvement of the educational process.

Research Methods

Planning Investigations

Study area

The study area is located in the municipality of Pinheiro, within the Baixada Maranhense microregion, characterized by climatic conditions typical of tropical regions, with a hot and humid tropical climate of type Aw, according to the Köppen–Geiger classification (Lima et al., 2024). This climatic pattern, predominant in the state of Maranhão, is marked by high temperatures throughout the year and a pronounced rainfall seasonality, with a higher concentration of rainfall in the first months of the year and a reduction in precipitation volumes in the second half of the year.

Figure #1

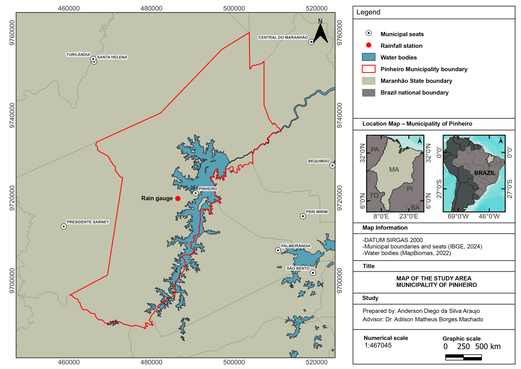
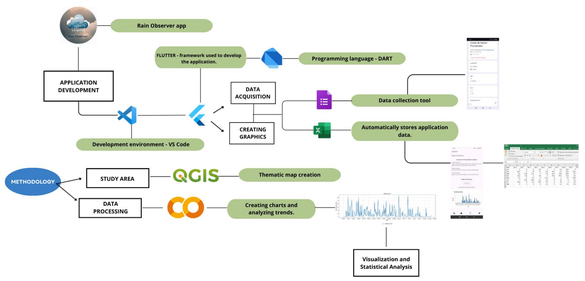


Figure #2

Methodological workflow of the study.



GLOBE Badges

Be a **Collaborator :** The project was collaboratively developed by undergraduate students from the Federal University of Maranhão (UFMA) to create an educational application for recording rainfall data in Pinheiro, Maranhão, Brazil. Using a participatory approach and the GLOBE Precipitation Protocol, students engaged in all project stages, from development to data collection. The initiative highlights the role of digital technologies and citizen science in producing local climate data, strengthening student training, and supporting environmental planning and water resource management.

Be a **Data Scientist:** The project involved daily collection of rainfall data using a rain gauge, following the GLOBE Precipitation Protocol, and recording the information in a digital system to build a structured dataset for Pinheiro, Maranhão. The data were analyzed to identify temporal patterns and local rainfall characteristics, demonstrating the systematic use of environmental data to understand atmospheric processes, despite limitations in time and spatial scale.

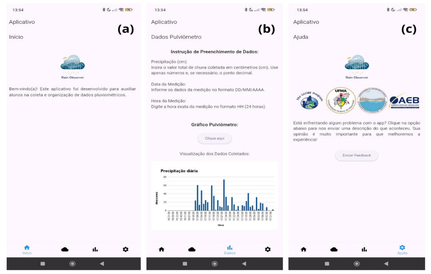
Be an **impact maker:** The project was developed to address the lack of systematized rainfall records, which limits climate understanding and environmental planning. By using a digital tool for standardized data collection, it improves the reliability and organization of pluviometric records and supports the creation of local historical series. Additionally, the project promotes student engagement in citizen science, strengthening scientific skills, environmental awareness, and community participation in climate monitoring.

Results

Analyzing Data

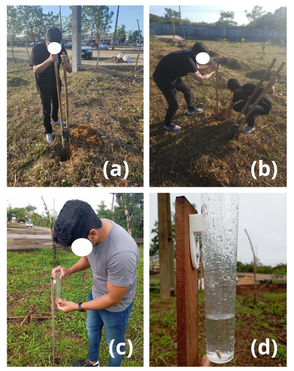
The implementation of the application resulted in advances in the quality, efficiency, and standardization of pluviometric precipitation recording (Figure 3), making the data collection process more reliable and reproducible in elementary and high schools. The use of technology enabled the organization, storage, and efficient retrieval of data, contributing to the construction of local historical precipitation series, which are fundamental for future analyses of climate variability in the municipality of Pinheiro.

Figure #3



During data collection and application development, as illustrated in Figure 4, undergraduate students actively participated in recording rainfall data, strengthening socio-emotional skills such as cooperation, responsibility, and leadership. The use of the application also promoted technological competencies, including data organization and the use of digital tools. Overall, student involvement in all stages of the scientific process contributed to the development of analytical, interpretative, and scientific communication skills.

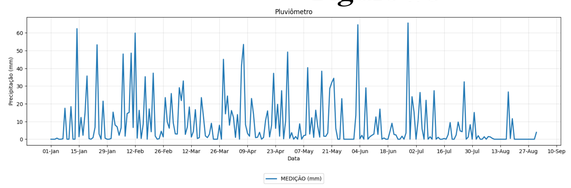
Figure #4



Field Photos

Graph 1 indicates high variability in daily precipitation, with rainfall concentrated mainly between January and April, when the highest peaks occur. From May to June, precipitation decreases in frequency and intensity, while from July onward, a predominance of dry days is observed, especially in July and August. This irregular rainfall pattern, typical of tropical regions, is associated with convective events and is illustrated by the field records presented in Figure 5.

Figure #5



Discussion

Interpreting Data

The analysis of Graph 1 indicates a high variability in daily precipitation, with rainfall concentrated in a few high-intensity events and several days with low or no rainfall. This pattern reflects a typical characteristic of tropical climate regions, in which precipitation is predominantly associated with short-duration convective systems. According to the IPCC (2023), such rainfall regimes tend to present an increase in the frequency of extreme events, even when mean precipitation values remain relatively stable, which is consistent with the results observed in this study.

The irregular temporal distribution of rainfall highlights the importance of continuous local monitoring, since analyses based only on monthly or annual averages may underestimate extreme precipitation events and their potential impacts. Studies have shown that the intensification of episodic rainfall directly influences hydrological dynamics and socio-environmental risks in tropical regions (Baek et al., 2023).

The application improves the organization and reliability of pluviometric data and promotes student engagement in scientific practices, strengthening active learning and participation in climate monitoring activities (Rodrigues et al., 2022).

In addition, the tool acts as a pedagogical resource by linking field data collection with analysis and interpretation, favoring interdisciplinary learning and the development of scientific and technological competencies, as highlighted by Mendes and Barros (2023) and Ghilardi-Lopes et al. (2023).

Conclusions

The development and application of the educational application Rain Observer proved to be effective in improving the process of collecting, organizing, and analyzing precipitation data in the municipality of Pinheiro, Maranhão, Brazil. In this sense, the automation of pluviometric data recording enabled the creation of a continuous and reliable database, enhancing data quality and facilitating local-scale climate analyses.

Based on the data systematized by the application, the analysis of daily precipitation revealed a rainfall regime marked by temporal variability, characterized by the concentration of rainfall volumes in a few intense events, especially during the first months of the analyzed period. Thus, the results reinforce the importance of daily monitoring for understanding local climate dynamics and for supporting environmental planning and management actions.

Beyond technical aspects, from an educational perspective, the project has the potential to contribute to the engagement of elementary and high school students in the Baixada Maranhense and Maranhão Coastal Zone regions, promoting active participation in scientific practices, developing technological competencies, and strengthening environmental education. Therefore, the integration of science, technology, and education, combined with the principles of citizen science, constitutes a consistent strategy for training critical, aware citizens prepared to understand and address the challenges associated with climate variability and global climate change.

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