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Regional School of Computation Bahia-Alagoas-Sergipe
Escola Regional de Computação Bahia-Alagoas-Sergipe (ERBASE)

Immersive and Generative Realities
November 5th to November 8th 2024

Anísio Teixeira Institute - Salvador - BA - Brazil

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Volume 7 • Supplement 2 **SUMMARY** *December 2024*

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COVER: VR Lens in the World of Immersive & Generative Realities created by ChatGPT.

EDITORIAL

ERASE
Immersive and Generative Realities

It is with great pleasure that we present this special edition of the *Journal of Bioengineering, Technologies and Health* (JBTH), dedicated to the best papers presented at ERBASE 2024, which focused on the theme "*Immersive and Generative Realities*." The event was held in Salvador, Brazil, from November 5 to 8, 2024.

The *Regional School of Computing Bahia-Alagoas-Sergipe* (ERBASE) is an annual event promoted by the *Brazilian Computer Society* (SBC). It has a long-standing tradition of bringing together students, researchers, and professionals in the field to engage in activities that present and discuss the most current and relevant topics in Computing today. In its 24th edition, ERBASE 2024 provided a valuable showcase of the research and development produced by the Computing community in the Bahia-Alagoas-Sergipe region.

The event was organized by the *Federal University of Bahia* (UFBA, Camaçari Campus), SENAI CIMATEC University Center, and the *State University of Bahia* (UNEB). This year, ERBASE returned to Salvador as a well-established event, integrating federal public universities (such as UFBA, UFAL, UFS, UFRB, UNIVASF, UFOB, and UFSB, among others), state universities (such as UNEB, UESC, UEFS, and UESB), and private institutions (such as UNIFACS and the *Catholic University of Salvador*). It also included a broad network of *Federal Institutes* (offering both higher education and technical education), researchers of various levels (PhD holders, master's graduates, and undergraduate students), market professionals, professors, students, entrepreneurs, and public sector representatives. Additionally, ERBASE 2024 fostered collaboration between different areas of Computing and other fields, such as Education, Health, and Industry, while strengthening connections between the micro-regions of Bahia and the neighboring states of Alagoas and Sergipe.

ERBASE 2024 was centered on the theme "*Immersive and Generative Realities*," offering an in-depth analysis of the significance, impact, and scientific, economic, and social implications of Immersive Technologies and Generative Artificial Intelligence. The event aimed to highlight the specific impact of these technologies in the Bahia-Alagoas-Sergipe region while considering national and international contexts.

The convergence of *virtual, augmented, and mixed reality* with algorithmically generated systems—such as generative models for text and image creation—is profoundly reshaping how we interact with the digital world. This transformation is driving innovation in fields such as education, industry, culture, and entertainment, paving the way for new forms of creativity, communication, and learning. The event emerged as a response to the growing need for a qualified space for knowledge exchange, critical debate, and the formation of collaborative networks across institutions and academic disciplines.

We live in an era where immersive and generative technologies are becoming increasingly integrated into our daily lives, enhancing interactions and optimizing how we work, learn, and create. As paradigms shift at an accelerated pace, it is crucial for the Computing community within the regional innovation ecosystem to engage in a critical and strategic discussion about these technologies, strengthening both the academic and industry sectors.

Immersive realities, such as virtual and augmented reality, offer new layers of perception, expanding the boundaries of human experience. They enable the exploration of simulated environments with a high degree of presence, interactivity, and engagement. These technologies have proven valuable in professional training and the development of safer, more sustainable, and more inclusive industrial solutions. Beyond being a technical advancement, immersion is redefining practices in education, content creation, and production.

On the other hand, generative technologies, driven by artificial intelligence, are establishing a new creative paradigm. By enabling the automatic generation of text, images, sounds, and virtual environments, these tools push the boundaries of computational expressiveness. When combined with immersive technologies, they facilitate the creation of highly responsive, adaptable, and often unprecedented digital worlds.

This intersection between immersive and generative technologies also raises important ethical concerns. How can we ensure the authenticity of digital experiences? How can we mitigate algorithmic biases in content generation? What are the social impacts of these technologies on memory, identity, and reality construction? Addressing these questions requires a multidisciplinary approach, one that is sensitive to human dimensions and committed to principles of inclusion, diversity, and sustainability.

Over four days, emerging trends such as *Artificial Intelligence, Cloud Computing, Cybersecurity, Virtual and Augmented Reality, and the Internet of Things* were explored through national keynote lectures, panel discussions, hands-on workshops, parallel events (including workshops on Digital

Games, Computing in Education, Assistive Technology, and others), and interactive activities such as robotics and programming marathons and hackathons.

The *Organizing Committee* of ERBASE 2024 ensured a comprehensive event focused on professional development and continuing education, addressing the challenges and opportunities shaping the field of Computing. The event fostered connections between key stakeholders in the regional innovation ecosystem, including representatives from academia, industry, and government. Researchers, students, professionals, and policymakers took advantage of this platform to exchange knowledge, showcase research findings and products, and strengthen their professional networks.

ERBASE 2024 saw strong engagement from the regional community, with research contributions from groups and scholars across different parts of Brazil. A total of 96 papers were submitted to the event's workshops (*PesqBASE, WEIBASE, XBASE, and Meninas Digitais*). These papers underwent a rigorous blind review process, with a minimum of two reviewers per submission, leading to the selection of the best research for presentation at the event and publication in the conference proceedings.

In this context, the papers selected for publication in this special issue explore innovative solutions in the fields of *immersive realities, artificial intelligence, and educational technologies*. The research topics covered include:

- Safe route planning for collaborative robots using the *Seam Carving* technique;
- Development of low-cost IoT-based electronic access control systems;
- Creation of affordable *Virtual Reality* hardware focused on inclusion;
- Application of active learning methods for mobile app development with *Django and Flutter*;
- Optimization strategies for *automated trading* systems using reinforcement learning;
- Standardization of educational materials with *Marp* and *CI/CD* workflows;
- Initiatives aimed at empowering women in immersive technologies, such as "*ICT & Elas*" and "*Elas nas Exatas*", which promote training, inclusion, and representation in STEM and computing fields.

These topics reflect the transformative potential of immersive and generative technologies when applied in an ethical, accessible, and socially responsible manner.

We believe that this publication will serve as an important reference for those seeking to understand and follow the technical, scientific, and social developments in immersive and generative realities. We wish all readers an engaging, critical, and inspiring reading experience!

João Soares de Oliveira Neto (*UFBA-Camaçari*) – *General Coordinator of ERBASE 2024*
Ingrid Winkler (*SENAI CIMATEC University*) – *Publications Committee, ERBASE 2024*
Paulo Eduardo Ambrosio (*UESC*) – *Publications Committee, ERBASE 2024*
Luciana Knop (*SENAI CIMATEC University*) – *Managing Editor, JBTH*

Safe Route Planning For Manipulator Robot Using Seam Carving Technique

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Route planning is a critical challenge in ensuring the safe operation of collaborative robotics. Seam Carving, a digital image processing (DIP) technique initially developed for content-aware image resizing, identifies paths of lowest energy within an image. In the context of collaborative robotics, regions with fewer obstacles correspond to lower-energy areas, making this technique a promising tool for determining safe routes. This work explores the application of Seam Carving to generate safe trajectories for robotic manipulators, enabling their operation in diverse environments. Both quantitative and qualitative results demonstrate the effectiveness of this approach, establishing it as an innovative method in the field of collaborative robotics.
Keywords: Seam Carving. Safe Routes. Robotic Manipulator. Collaborative Robotics.

Collaborative robots [1] share workspaces with both machines and humans, performing complex, precise, and dynamic tasks [2]. One of the primary challenges in this context is designing collision-free routes for these robots [3]. Optimizing such routes is crucial, enhancing workplace safety while improving production efficiency. This work presents an alternative approach to addressing this challenge.

Several global methods have been employed for route planning, including tree-based algorithms such as Rapidly-exploring Random Trees (RRT) [4,5], Probabilistic Roadmaps (PRM) [6], Topological Path Planning (TPP) [7], and Generalized Voronoi Diagrams (GVD) [8], a particular case of TPP. However, these approaches often present limitations related to computational efficiency, unnecessary detours, or non-optimal, randomly generated paths.

Generating, evaluating, and validating routes requires real-time image acquisition in dynamic environments. Consequently, leveraging Digital Image Processing (DIP) techniques is viable. This work proposes applying Seam Carving, a technique originally designed for image resizing, to route planning for robotic manipulators.

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Theoretical Foundation

Methods for Route Planning

Various methods have been developed to address the path-finding problem in robotics. One such method is Probabilistic Roadmaps (PRM), proposed by Kavraki and colleagues [9]. PRM generates random samples (or nodes) within the environment and then connects them to form a graph, representing the relationships between the nodes. Search algorithms like A* or Dijkstra are typically applied to find the shortest path. Due to its probabilistic nature, PRM can generate multiple potential routes for a given environment, offering flexibility in route planning.

Another widely used approach is the Generalized Voronoi Diagram (GVD), introduced by Takahashi and Schilling [8]. This technique processes an environment's free space by creating a simplified representation emphasizing its key structural features. By doing so, it becomes possible to generate collision-free trajectories for the robot. However, the skeletonization process involved in GVD can be computationally expensive, particularly in large-scale or complex environments.

The method proposed by Lavalle [10], called Rapidly-exploring Random Trees (RRT), is based on creating an exploration tree that rapidly and randomly expands from the initial point. However, the solution generated by RRT can be influenced by the distribution of random nodes and the strategy used to grow the tree. As a random approach, RRT often produces different routes for the same scenario, which can hinder its application in tasks that require repeatability and consistency, especially when ensuring safety is a priority.

A more recent and efficient approach for route planning is the Topological Path Planning (TPP) method, proposed by Batista and colleagues [7]. TPP identifies topologically constrained connected points within the environment's free space, enabling homotopic and non-homotopic topological paths [11]. To determine the best possible route, a shortest path algorithm is applied to find the optimal connected points, which results in smoother trajectories and minimizes unnecessary detours.

Seam Carving

The Seam Carving method presented by Avidan and Shamir [12] is a technique that brought a significant change in image processing, providing an innovative approach to image resizing that goes beyond conventional techniques. Its primary objective is to adjust image dimensions, preserving visually important areas of interest while reducing or expanding the image size. The energy map represents the importance of each pixel in the image. Techniques such as gradients are used to create this map, which calculates changes in intensity between nearby pixels. Areas with high pixel intensity variations or containing multiple objects have higher energy values, indicating that they are visually important and, therefore, unsuitable for removal.

Equation (1) shows the concept of the energy function described by e, where I is the image:

$$e(I) = \left|\frac{\partial I}{\partial x}\right| + \left|\frac{\partial I}{\partial y}\right| \quad (1)$$

The image I present in Equation (1) is a matrix n x m, where n represents the number of rows and m is the number of columns.

The ideal seam can be obtained using dynamic programming. Calculating the minimum energy M for all the seams connected to each input (i,j), as demonstrated in Equation (2), returns the chosen ideal seam.

$$M(i,j) = e(i,j) + \min(M(i-1,j-1), M(i-1,j), M(i-1,j+1)) \quad (2)$$

Materials and Methods

Scenarios

Table 1 presents the parameters used in creating the scenarios used for testing. For comparison and conclusion, all methods use the exact specifications of the scenarios.

Metrics

Quantitative evaluation is an essential step in comparing and validating these approaches. The

Table 1. Scenario parameters.

Parameter	Definition
Scenario	100 random scenarios with the presence of obstacles in varying shapes, positions and quantities.
q_{start}	Defined in x = 15 cm, y = 15 cm.
q_{goal}	andom position, defined within the manipulator's working space and away from obstacles.
RGrid	The workspace and obstacles are presented in a grid of 60cm x 60 cm, divided into 1cm x 1cm for the methods.
Safety Margin	A safety margin of 4cm is used for the diameter of the manipulator in relation to the proximity of obstacles.

proposed metrics play a key role in the outcome, providing objective measurements to compare different methods and techniques. They are derived from the joints' manipulator angular displacement (θ). The following metrics were used in this work: path distance (in centimeters), number of points, standard deviation of joint acceleration (θ), maximum jerk (θ), and processing time (in seconds).

Proposed Method

The approach used in this research acts on the lowest energy present, whether horizontal or vertical. Some mathematical transformations are used to align the points. First, the distance between the points must be verified to define the direction of the rotation performed, as seen in Equation 3.

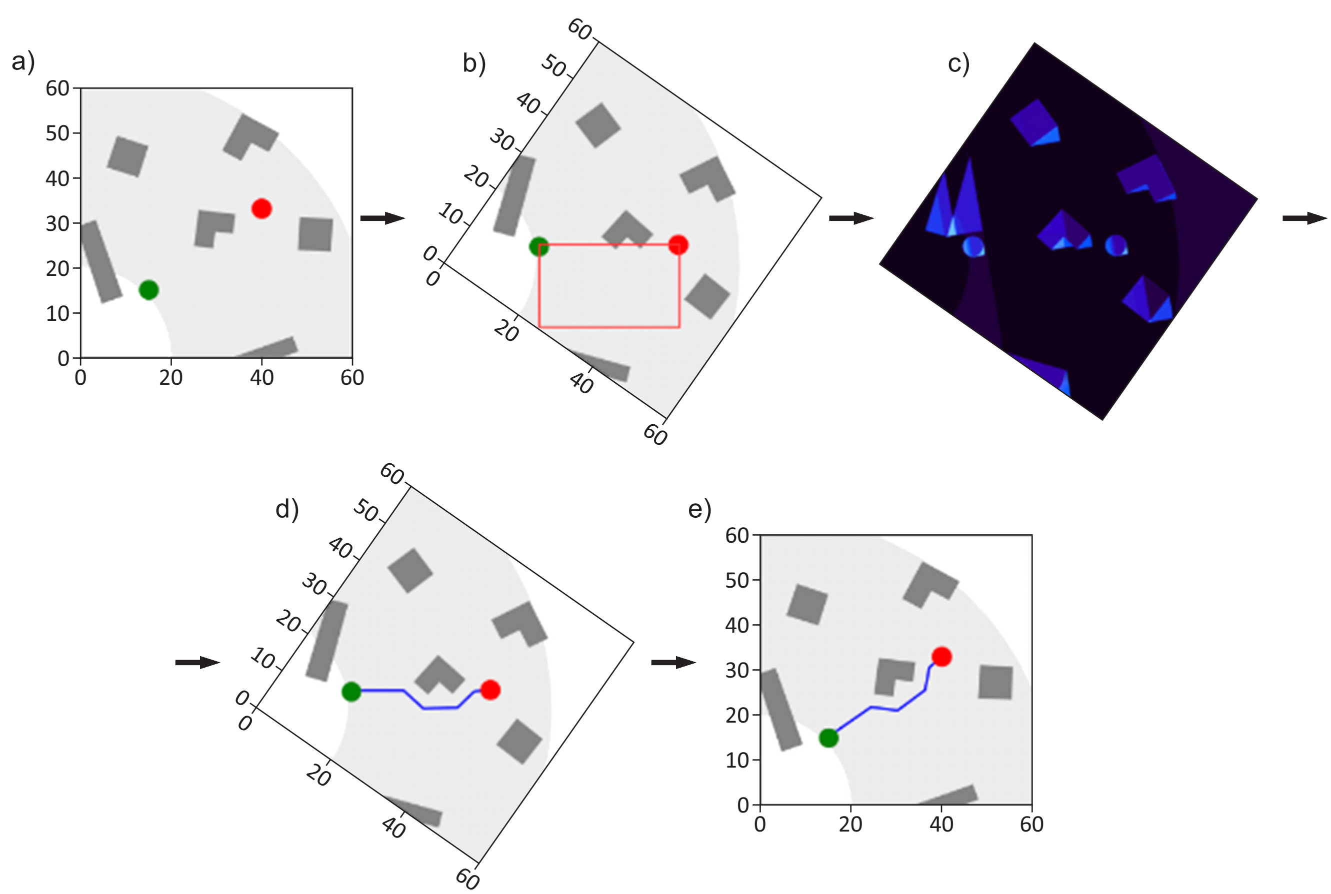
$$D_{AB} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (3)$$

After this step, the direction of the rotation performed can be determined. The next step is to calculate the necessary rotation angle to align the points. Equation 4 shows the calculation used to define the rotation angle.

$$a^2 = b^2 + c^2 - 2.x.y.\cos\alpha \quad (4)$$

With the points aligned, the use of the technique becomes simpler. A region of interest is used to apply Seam Carving, as seen in Figure 1b. By calculating the energy map shown in Figure 1c, it is possible to identify the areas with lower energy in the image.

Figure 1. Proposed method. a. Input image with the starting point (green), end point (red), and obstacles (dark gray). b. Space transformation and selecting the region of interest for use with Seam Carving. c. Energy map of the scenario. d. Route drawn on the rotated image. e. Image in the original space with the path drawn.



Using Equation 2, we return to the positions used to trace the route (seam), as shown in Figure 1d. Finally, Figure 1e uses an inverse mathematical transformation to return the workspace and the traced route to the original position.

Results and Discussion

This section presents the results of the proposed method and compares them with those of other methods in the literature. In Table 2, we compare the classical methods in the literature, such as PRM, TPP*, TPP, and RRT, using quantitative metrics to evaluate and compare them to the proposed method (PM) in this work.

Table 2 shows that based on the Seam Carving technique, the proposed method stood out in reducing the distance traveled compared to the classical methods mentioned. This result suggests that the route returned by the proposed method, on average, provides shorter trajectories, minimizing the robot's travel time. Another important analysis is the number of points needed to trace the path. It is worth noting that a more significant number of points allows for smoothing out the movements, influencing the acceleration and jerk values, as the movements made are more precise. When analyzing metrics related to movement dynamics, such as acceleration and jerk, the values demonstrated by the proposed method were low compared to classic methods, such as PRM and RRT.

With values in this range, the traced path presents smooth movements with slight variations in acceleration and jerk.

Furthermore, when considering the execution time to create the best route, it was observed that the proposed method presented values comparable to classical methods, such as PRM and TPP*, while outperforming techniques such as TPP. This implies that the proposed method approach offers a balanced solution between fast route feedback and computational accuracy, making it a viable option for practical applications in collaborative robotics.Figure 2a presents a case where there are no obstacles between the starting and ending points of the route. In this scenario, the proposed method traces a more direct route without unnecessary detours, indicating that the proposed method minimizes the distance traveled. Compared to other methods, these tend to trace longer paths and unnecessary detours. A more in-depth analysis of these results reveals the effectiveness of the proposed method in simple scenarios where there is no need to bypass obstacles.

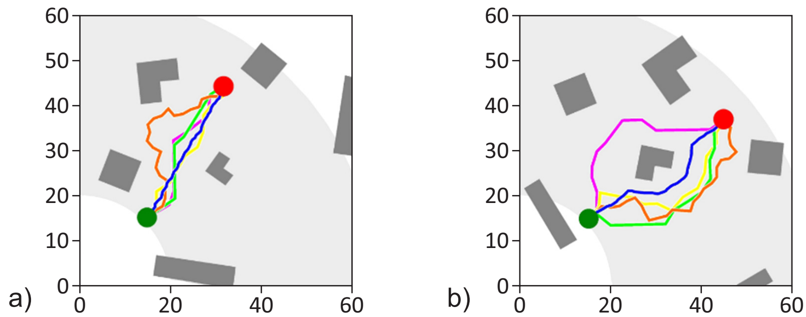
In Figure 2b), the proposed method demonstrates its effectiveness in tracing a route close to the obstacle, generating a minimum deviation and consistent results in the search for efficient trajectories. On the other hand, the RRT method presents trajectories with unnecessary deviations, consequently generating longer paths.

When observing PRM and TPP's behavior, we see trajectories with some deviations, such as the one presented by RRT. Finally, the TPP* method presents an alternative behavior by returning a longer and less smooth path. This behavior results in less optimized trajectories in terms of distance and smoothness.

Table 2. Comparative metrics between methods.

Method	Distance (cm)	Points	Std_Acc	Max Jerk	Time (s)
PRM	42.83 ± 6.71	13.71 ± 2.12	3.28 ± 0.61	10.94 ± 2.84	2.31 ± 0.75
TPP*	45.42 ± 6.83	14.45 ± 1.88	2.91 ± 0.57	9.01 ± 4.06	2.68 ± 0.50
TPP	43.02 ± 6.07	13.47 ± 1.79	2.62 ± 0.56	7.97 ± 3.21	5.28 ± 1.87
RRT	48.78 ± 6.42	25.30 ± 3.28	2.35 ± 0.31	10.04 ± 1.98	0.81 ± 0.48
PM	35.83 ± 2.80	39.8 ± 4.06	0.62 ± 0.11	3.09 ± 0.41	2.03 ± 1.01

Figure 2. The PRM method is in yellow, TPP* in magenta, TPP in green, RRT in orange, and the proposed method in Blue.



Conclusion

The proposed method, with a resolution of 1cm x 1cm, presents an alternative approach to safe route planning in collaborative robotics. Observing the data from the different methods presented in Table 2 and qualitatively analyzing the routes traced by all methods, we can conclude that the proposed method based on the Seam Carving technique proved to be an alternative approach for tracing routes for collaborative robotics, returning smoother paths with more minor deviations towards the goal. Finally, the approach proposed in this work does not require parameter adjustments for different scenarios, does not require the use of shortest-path search algorithms, and guarantees path repeatability for the same scenario. Since it acts on the lowest energy, it will always return the same path, demonstrating an advantage in guaranteeing the path's reliability, which random approach methods cannot guarantee. This method shows great promise for modifying a technique created for image processing and applying it to collaborative robotics.

Acknowledgments

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Development of a Modular and Low-Cost Electronic Lock System for the Academic Environment

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Security in educational institutions is paramount, and electronic access control solutions play a crucial role in enhancing the protection of these environments. However, commercially available systems often lack cost-effectiveness for large-scale deployment in public institutions. This article presents the development of a modular, adaptable, and low-cost electronic lock prototype designed for access control in academic settings. The prototype leverages microcontrollers and simple electronic components to deliver an efficient and affordable solution. Key features include remote control, multiple authorization methods, and seamless integration with other systems, making it a practical option for schools with limited budgets.
Keywords: IoT. Smart Campus. Electronic Lock. Security.

Security is a sensitive topic, addressed in various aspects ranging from cybersecurity, also known as logical security, to the physical security of people, environments, and equipment. Ensuring security is a challenge in many scenarios. However, with the notable expansion of technologies aligned with the Internet of Things (IoT) paradigm, numerous network-connected devices, such as surveillance cameras, motion sensors, and electronic locks, have been employed for security purposes. However, limited financial resources can be a significant obstacle to achieving such an innovative scenario in public organizations, where budgets for these matters are often restricted.

Flexible and modular authorization systems for environments are uncommon; however, they offer various applications in shared spaces. The availability of multiple authorization methods is also crucial, particularly in organizations with a diverse range of individuals who may or should have access to a given environment, depending on schedules and contextual needs. This is often the case in universities, institutes of education, science and technology, and schools, which comprise students, faculty members, laboratory technicians, administrative staff, and other occasional academic community members. In different situations, these individuals may or may not be granted access to classrooms, laboratories, offices, and other environments, each of which may have specific access rules.

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Microcontrollers with Wi-Fi connectivity integrated into a management system can ensure efficient access control for various environments. To achieve this, it is also essential to guarantee the logical security of the systems involved in such physical access control mechanisms. Encryption of network communications and protection schemes against attacks such as "man-in-the-middle," among others, should be incorporated into the design of such systems, even those with limited computational resources.

This article presents a prototype developed for a door access control system using typical IoT technologies. The main benefits of this approach include (1) Flexible Access Control, (2) Low Cost, (3) Detailed Reports, (4) Solution Modularity with Multiple Authorization Methods, and (5) Protection Against Cyber Attacks. This system was specifically designed for public educational institutions due to its low cost and high adaptability to their unique requirements. However, it can also be adapted for other types of organizations.

Theoretical Foundation

According to Geepalla (2013) [1], digital access control models are often inadequate for representing the specifications of physical access control. It is crucial to consider the unique characteristics of real-world environments to adapt the corresponding digital strategies. According Bindra and colleagues [2] and Kaur and colleagues [3] provide examples of studies that explore the characteristics of modern access control systems for smart buildings and their various possibilities. Encryption is essential for protecting data and ensuring information confidentiality in an increasingly digital world. According to Kaur and colleagues [3], it uses mathematical algorithms to transform readable data into an encrypted format, making it accessible only to those with the correct decryption key. This technique has been employed since ancient times but has evolved significantly in the digital era. Its primary goal is to secure communication against unauthorized access, ensuring that information remains protected.

The lack of encryption has led to numerous significant data breaches, exposing sensitive information from both companies and individuals. A recent example is the Tangerine Telecom breach 2024, where over 200,000 customer access records were exposed due to inadequate database security [4]. Another case involved Spoutible, which had a vulnerability in its API exploited [5], allowing access to users' personal information and encrypted passwords. These incidents highlight the direct risks of the absence of encryption and robust security measures. Reports like the one from the OAIC (Office of the Australian Information Commissioner) have also exposed severe security flaws in Australian government agencies, such as misconfigured security settings and the lack of proper encryption. In 2024 alone, the Australian government reported 63 data breaches in the first half of the year, leaving personal information vulnerable to unauthorized access [6].

These examples represent just a fraction of what is happening globally. A 2024 study by IBM revealed that 60% of organizations that suffered cyberattacks attributed the root cause to the lack of encryption in their systems [7]. Furthermore, the IBM report indicated that the average cost of a data breach without encryption could reach $4.35 million, factoring in reputational damage, financial losses, and mitigation costs.

These figures reinforce the need for proper encryption as a best practice and a critical factor for business continuity and security.

Therefore, implementing encryption should be considered an essential component for any company or organization. In addition to preventing data breaches and protecting sensitive information, encryption is also necessary for compliance with data protection regulations such as the GDPR (General Data Protection Regulation) in Europe [8] and the LGPD (Lei Geral de Proteção de Dados) in Brazil [9]. Failing to invest in proper data protection exposes organizations to cyberattacks and severe regulatory penalties, highlighting the need for a proactive and integrated approach to information security.

Materials and Methods

The proposed solution is built on the ESP-32 NodeMCU development platform, which enables Wi-Fi integration and connectivity with components such as an RFID reader. For device and permission management, a web application was developed using Django, a Python-based framework for building full-featured web applications. This system manages users, devices, and permissions, allowing for the seamless integration of the involved technologies and providing a robust solution to the proposed problem.

The device includes a relay connected to an embedded electric lock, as shown in Figure 1. This electric lock allows device integration without rendering the original door system unusable. As a result, the remote access control system can be used without losing the traditional key-based access option. Additionally, this solution ensures system security in cases of power outages or device connectivity issues.

To ensure secure requests from the device to the server, authentication is performed using the device's MAC address and IP address, assigning a temporary

Figure 1. Electric lock used in the device.

token to each device at the time of authentication. On its first use, the device remains in standby mode until a system administrator authorizes it, allowing it to make requests to the system. The assigned tokens are based on the UUID4 standard, ensuring system security. Additionally, all requests are made using the HTTPS method, guaranteeing that all packets are encrypted. Once authorized, the device must include the token in all subsequent requests. Every device authentication is logged, including its MAC address, IP, ID, and authentication timestamp. The web platform enables user registration with specific permissions, allowing administrators to manage which environments each user can access. Furthermore, every user's access attempt to an environment is recorded, including details such as user ID, environment, and timestamp.

There are multiple ways to access environments through the platform:

Direct Application Access: The user logs into the application, selects the device and sends a request to unlock the environment.

QR Code Authentication: A QR Code associated with the device can be scanned, which opens an application page and verifies the user's permissions before granting or denying access.

Temporary PIN Access: A 4-digit temporary password with a customizable expiration time can be generated. This PIN is linked to the device and allows non-registered users to access the environment via an authorization page in the application. All accesses using temporary passwords are logged with the user who generated the PIN. An RFID module can also be connected to the device, enabling quick access through an RFID tag scan. Before using RFID tags, they must be registered in the web application, which stores the hexadecimal tag code. The tag is then linked to the user's account, allowing access management and deactivation. The RFID tag's permissions are directly tied to the account permissions of its owner.

Results

The final device measures 84x79x42mm in external dimensions, as shown in Figure 2. The enclosure housing all prototype components was designed and 3D-printed, ensuring durability and meeting the necessary resistance requirements for the device.

The device was assembled as shown in Figure 3 and is powered by a 12V power supply, which provides energy to both the electric lock and a 12V-to-5V voltage converter. This setup allows the remaining system components to function properly.

The final model also features a human-machine interface (HMI) separate from the main device. This interface includes three LEDs:

Figure 2. Device assembly diagram.

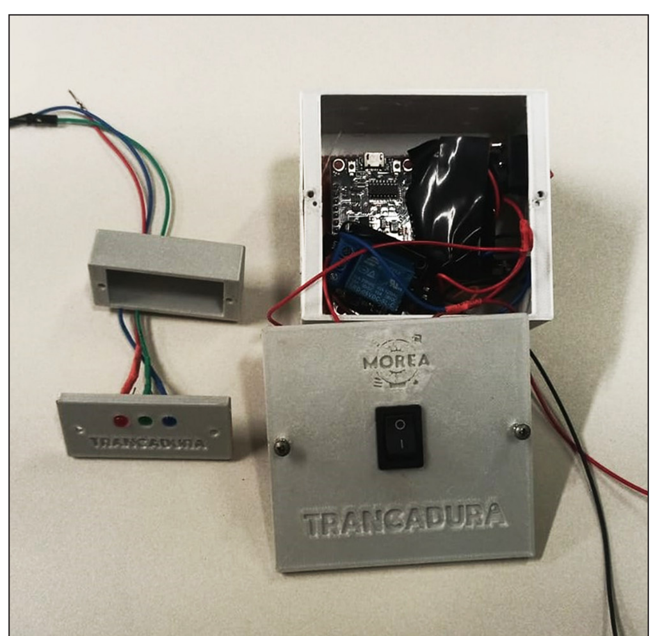
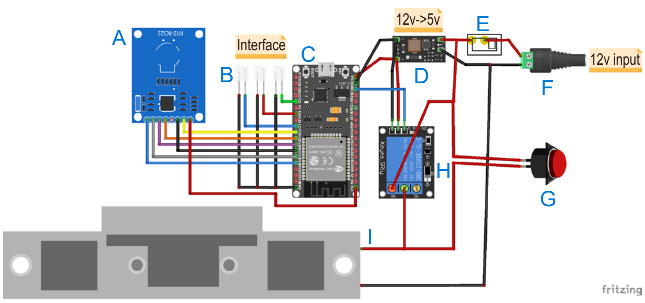


Figure 3. Device Wiring Diagram.



Blue LED: Indicates internet connection status.
Green LED: Signals that entry is unlocked.
Red LED: Signals that entry is locked.

This interface is designed to be installed outside the controlled environment. It allows users to verify the device's operational status before use and connects to the main system via a 4-pin connector. Since the RFID sensor is an optional module, it can be connected via a 6-pin connector. Additionally, the device includes a physical button directly linked to the power supply, serving the same function as the relay in the circuit. This allows users to manually unlock the door from inside the environment without requiring access to the web application, enabling a quick exit when necessary.

Web Application Development

The web application includes the following main sections:

- User and Permission Management
- Device Management
- RFID Tag Management

Each section provides basic CRUD (Create, Read, Update, Delete) operations and specific functionalities.

For example, user management includes permission control, while device management includes authentication approval.QR Codes, one of the authentication methods, are generated using external applications. These QR codes direct users to the device-specific page, allowing access authorization based on the user's account permissions or an active temporary password for that environment.

Conclusion

The electronic lock prototype passed all tests, demonstrating its effectiveness in access control for research laboratories within a federal institution.

- Future developments include:
- New authentication modules, such as numeric keypads and fingerprint sensors.
- Size reduction of the prototype for improved integration.
- Enhancing security features to strengthen protection against cyber threats.

To maximize impact, the project has been released as an open-source solution on GitHub: https://github.com/Morea-IFS. This enables the community to collaborate, improve, and expand its functionalities, fostering more competent environment management.

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Development of Accessible Virtual Reality Technology for User Inclusion

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This research aimed to develop accessible hardware technology for virtual reality (VR), enabling its use across diverse environments and by a broader range of users. This approach aims to bridge the gap where technological advancements often become social barriers.We analyzed existing market technologies through an applied research method and designed a cost-effective, sustainable VR headset. The developed technology has been successfully validated, offering immersive interaction with VR environments while fostering innovation and creativity. However, particular challenges remain and present opportunities for further exploration. Future research will focus on optimizing the user experience, enhancing accessibility, and refining technological aspects to ensure a more inclusive and seamless VR interaction.
Keywords: Accessibility. Assistive Technology. Virtual Reality.

Virtual Reality (VR) is a technology that simulates three-dimensional environments, allowing users to interact with these spaces in an immersive way. According to Tori and Hounsell (2018), VR creates experiences that transcend the physical world's limitations, offering new perspectives and interaction possibilities. This immersive capability makes VR a powerful tool, not only for entertainment but also for various fields. VR can be understood as follows:

The meaning of "virtual" is "potential" (from the Latin virtus, meaning strength, energy, power), meaning that a virtual element has the potential to become that element. (…) A digital file is both a real and a virtual object or virtual image [1].

Virtual Reality (VR) is an "advanced user interface" for accessing applications running on a computer. Its characteristics include real-time visualization, movement within three-dimensional environments, and interaction with elements in these spaces. Beyond visualization, the VR user experience can be enriched by stimulating other senses, such as touch and hearing [2].

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Virtual reality is a computer-generated digital environment that can be interactively experienced as if honest [3].

Virtual reality (VR) has vast and impactful applications. In education, for example, VR enables the simulation of historical or scientific environments, allowing students to experience simulated or real-life situations for learning purposes. In medicine, the technology is used for training in complex surgeries, increasing the safety and efficiency of procedures.

However, as virtual reality becomes more integrated into our daily lives, discussing issues of inclusion and social sustainability is essential. According to Tori and Hounsell (2018) [1], today's technology enables access to synthetic, immersive, and high-definition environments that can cheaply transport users to alternative realities. Although it can potentially democratize experiences and knowledge, it risks widening inequalities if inaccessible. Digital inclusion must be a priority to ensure that technology benefits a more significant segment of the population rather than just a privileged group. Thus, VR implementation initiatives must consider access to tools—whether high-end equipment such as smartphones, headsets, and computers or technologies that users can develop, such as cardboard VR glasses.Ultimately, virtual reality's relevance in the future is intrinsically linked to its ability to promote sustainable and inclusive development

Discussions about the technology must go beyond its immediate applications and incorporate ethical and social considerations. Building a future where virtual reality can be used equitably will depend on collective actions prioritizing inclusion and social responsibility. Only through a critical and committed approach can we ensure that technology serves as a driver of social transformation rather than exclusion.

This research aimed to develop accessible hardware technology for virtual reality in various environments and by a more significant number of people, helping to mitigate the risk of technological advancement becoming a social barrier.

Additionally, an overview of available technologies and VR platforms will be presented. It is important to highlight that this research is an extension of the ICTI e Elas project, which focuses on encouraging girls to complete digital technology courses. As part of this initiative, workshops and experiments with the developed technology were conducted for testing.

Available Technologies

The concept of immersion in Virtual Reality (VR) is linked to creating a haptic illusion for the user through the somesthetic system, which includes human senses within a purposefully designed environment. In other words, the illusion of reality can be perceived through physical devices that "trick" the human nervous system and promote interaction. The environment is designed to emit visual, tactile, and auditory stimuli, which engage the user's sensory receptors. In response, the user reacts emotionally and expresses bodily behavior in a continuous cycle of perception and reaction.

Beyond the virtual environment, which is meticulously developed by designers, engineers, computer scientists, and Human-Computer Interaction (HCI) professionals, physical devices complete the interactive experience. These devices transmit information from the virtual environment to the users, enabling them to "feel" and engage with it. According to Jerald (2015) [3], there are four types of presence illusions in VR:

- Spatial illusion is where the user feels like they are in a specific location.
- Body illusion, where the user perceives themselves as having a virtual body.
- Physical illusion, where the user can interact with elements within the environment.
- Social illusion, where the user can communicate with virtual characters or other users.

Biocca and Levy, cited in Tori and Hounsell [1] highlight that the term Virtual Reality was coined in the late 1980s by Jaron Lanier, an artist and computer scientist who successfully merged two seemingly opposing concepts into a new and dynamic idea—capturing the essence of this technology: the fusion of the real with the virtual. However, the origins of interactive virtual technology date back even earlier. In the 1960s, Ivan Sutherland developed the first VR interaction device—the VR headset (Figure 1), which he named the "Ultimate Display" (Sutherland, 1965) (Packer & Jordan, 2002).

Today, VR hardware consists of various input and output devices that enable immersive interaction with virtual environments. Among the input devices, trackers, electronic gloves, 3D mice, and joysticks stand out, allowing users to communicate intuitively with the system. Displays (Figure 2), in turn, are essential as sensory output elements, covering not only vision but also audio and haptic feedback, which enhances the user experience. The evolution of leading and supporting processors, such as graphics and sound cards, has been crucial in supporting complex three-dimensional applications, reflecting technological advances influenced by the gaming market. Among the displays, VR headsets can be mentioned.

In the research, a survey was conducted on the market's most widely used and available VR headset models, as presented in the Table 1.

The virtual environment is typically modeled in 3D modeling software and integrated into

Figure 1. First VR helmet (produced in the late 1960s). Source: Tori and Hounsell (2018).

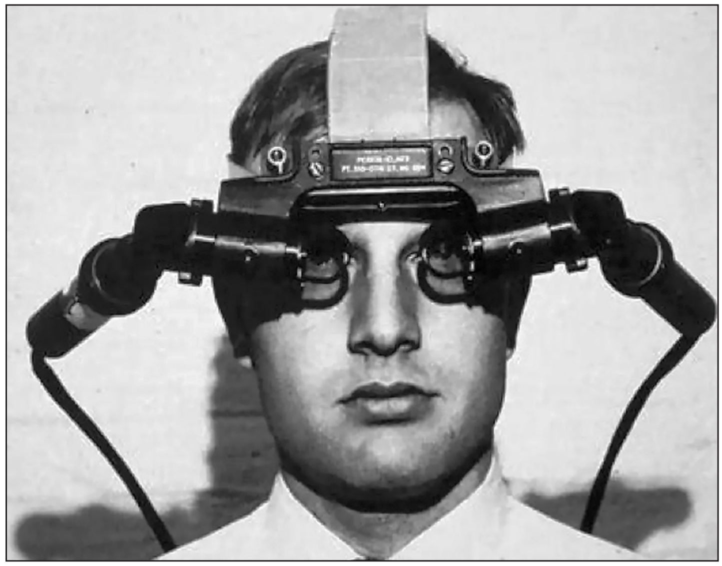


Figure 2. Displays for VR interaction.

platforms that allow user interaction. Platforms for integrating and visualizing the VR environment were researched (Table 2).

Development of Accessible and Sustainable Headsets

Löbach (2001) [4] defines design as realizing an idea into products or models through a constructive process, resulting in a feasible product for mass production. In this regard, it is understood that the product requires techniques that allow for reproducibility—methods that underpin the formal properties, which constitute the configuration, and mainly the technical, operational, ergonomic, and communicative functions [5]. Therefore, the development of a new product, in its complex and interdisciplinary design process, as Mike Baxter states, "*... requires research, careful planning, meticulous control, and, most importantly, systematic methods. Systematic design methods require an interdisciplinary approach, encompassing marketing methods, engineering methods, and applying knowledge in aesthetics and style*" [6].

The principle of the methodological foundations of design and the modeling of its creative journey lies in defining the scope of a problem through both unsystematic and systematic observations [7], with an empathetic focus on understanding the problem and the actors involved. In this problematizing context, the need for the inclusion of all people in the realm of emerging technologies is acknowledged. Considering the advancement of VR worldwide, designing a cheap and efficient product for future professionals becomes essential to technological progress.

The second phase involves data collection and analysis of similar products. Google's cardboard (Figure 3) was tested as a reference for low-cost headsets, as presented in Table 1. However, the proposed model became problematic due to the complexity of its layout, requiring specific cuts that are difficult to reproduce manually in series. The cardboard consists of three separate structures that are cut out individually and then assembled.

Preliminary formal studies were conducted using cardboard with the conceptual proposal of reducing cut areas, simplifying the cuts, minimizing glue points, and incorporating interlocking points to ensure proper assembly. In this regard, the layout shown in Figure 4 was developed. The proposed headset consists of 4 pieces, which, after being cut, are assembled according to the indicated letter markers and glued together using hot glue.

The production of sustainable lenses was also investigated. Given the complexity of producing lenses from PET bottles and water, which is commonly suggested on maker websites, the manual production of sustainable lenses proved imprecise, hindering the final visualization of the VR environment. Therefore, considering the cost of acquiring 25mm biconvex lenses without flanges, it was decided to purchase them for R$19.50 per pair of glasses.

In the prototyping phase, the glasses were assembled and tested with users – girls from the Colégio Estadual Polivalente de Camaçari (Figure 5). The most significant difficulty they encountered was adjusting the distance between the screen and their eyes and ensuring the smartphone's stability during use so that when they moved their heads, the smartphone remained fixed within the headset. The test was conducted with users who experienced the homemade cardboard headset and the Quest 2. After adjustments, the user experience with the developed cardboard headset showed satisfactory results compared to the Quest 2.

Development of Accessible and Sustainable Headsets

The research concludes that the goal was achieved through the development of a paper VR headset with biconvex lenses and the use of smartphones for environment transmission. This represents accessible hardware technology for VR use, potentially reaching a larger and more diverse audience. However, it is still necessary to understand the challenges and the potential for innovation and creativity in the product.

Table 1. Description and cost of VR headsets.

Headset	Description	Cost
Quest 2	The Oculus Quest is a standalone VR headset developed by Facebook. It features a high-resolution display of 1832x1920 pixels per eye, a 90Hz refresh rate, and a Snapdragon XR2 processor. The motion controllers provide precise tracking, and the device is available in storage variants.	R$ 3,480.00
Quest 3	The Meta Quest 3 is a standalone VR and augmented reality headset developed by Meta. Equipped with a Snapdragon XR2 Gen 2 processor, 8 GB of RAM, and available in 128 GB and 512 GB storage versions, it offers an immersive experience without the need for a computer or console connection. It includes RGB cameras for external world view, infrared sensors for gesture reading, and depth adjustment.	R$ 4,089.90
HoloLens 2	The HoloLens 2 is an augmented reality (AR) headset developed by Microsoft. Released in 2019, it offers an advanced AR experience with a 2K display. Powered by a Qualcomm Snapdragon 850 processor, it includes eye and gesture tracking for natural interactions. Its field of view is wider than its predecessor, designed for prolonged use with a lighter, more comfortable frame. It is mainly intended for business applications such as training, design, and remote collaboration.	R$ 35,800.00
Valve Index	The Valve Index is a VR headset developed by Valve Corporation and launched in 2019. It features an LCD with a refresh rate of up to 144Hz, providing an immersive visual experience. The field of view is about 130 degrees, offering a wide and engaging view. Motion controllers provide precise tracking and a variety of interactions while the audio system is integrated.	R$ 10,498.00
PlayStation VR	The PlayStation VR is a VR headset developed by Sony. Released in 2016 for PlayStation 4, it offers a VR experience with a 1920x1080 pixel OLED display and a refresh rate of up to 120Hz, delivering sharp graphics and an engaging visual experience. It uses PlayStation Move motion tracking technology and the PlayStation Camera to detect player movements.	R$ 4,599.90
HTC Vive Pro 2	The HTC Vive Pro 2 is a VR headset developed by HTC. It features a 5K display (2448 x 2448 pixels per eye) with a refresh rate of up to 120Hz. The field of view is about 120 degrees. It is compatible with SteamVR motion tracking and is primarily designed for gaming, simulation, design, training, and entertainment applications.	R$ 12,899.00
HTC Vive Cosmos	The HTC Vive Cosmos is a VR headset released by HTC. It has a screen resolution of 2880 x 1700 pixels combined (or 1440 x 1700 pixels per eye) and a refresh rate of 90Hz. The field of view is about 110 degrees. The Vive Cosmos uses inside-out tracking, meaning the sensors are embedded in the headset, eliminating the need for external sensors.	R$ 9,689.00
Vive Cosmos Elite	The HTC Vive Cosmos Elite is a VR headset designed by HTC. It offers a screen resolution of 2880 x 1700 pixels combined (or 1440 x 1700 pixels per eye) and a refresh rate of 90Hz. The field of view is about 110 degrees. The Cosmos Elite uses external sensor-based tracking, providing enhanced precision and a more robust tracking experience, which is ideal for intensive gaming and simulations.	R$ 9,698.00
Google Cardboard 3D VR Glasses	Developed by Google for use with smartphones, Google Cardboard is made of cardboard and has a simple design. It is compatible with most smartphones up to 6 inches in size, provided the device has an embedded gyroscope (present in most newer smartphones). Users can use specific apps to watch 360° videos, play VR games, take virtual tours, and participate in various interactive experiences.	R$ 14.90

Table 2. VR Environment integration and visualization platform.

Platform	Link	System	Description
Resonite	resonite.com	PC Steam	A social VR platform (also available in desktop mode) where users can create interactive objects, avatars, and maps using a visual programming system.
Frame	learn.framevr.io	Web	This platform is a web-based platform that allows users to create their own 3D virtual spaces and avatars to interact with others in a metaverse environment. It can be accessed from a computer, tablet, smartphone, or VR headset.
Spatial	spatial.io	Web	It is a web-based platform that allows users to create their own 3D virtual spaces and avatars to interact with others in a metaverse environment. It is accessible from a computer, tablet, smartphone, or VR headset.
Third Room	thirdroom.io	Web	It is a web-based platform where users can create their own 3D virtual spaces and avatars to interact with others in a metaverse environment. It can be accessed from a computer, tablet, smartphone, or VR headset.
Overte	overte.org	PC	An open-source social VR platform (also available in desktop mode) where users can create interactive objects, avatars, and maps using JavaScript programming.
Aframe js	aframe.io	Web	A JavaScript framework for creating 3D experiences on the web, with the ability to access in VR.
Godot Engine	godotengine.org	PC + Quest/ Pico	An open-source game engine that can be used to create VR games.
Unity	unity.com	PC	A platform for creating 3D and 360-degree games, models, and VR experiences.

One of the main challenges is related to the durability and robustness of the material used. Although cardboard is an accessible and sustainable solution, it is susceptible to wear, especially when exposed to prolonged use or environments with high humidity. Additionally, the ergonomics of the headset is another limiting factor. Due to its rigid material and lack of precise adjustments, user comfort is often compromised, particularly during longer immersion sessions. From a technical perspective, one of the challenges is the imprecision in the distance between the lenses and the smartphone screen, which can affect the quality of the visual experience and cause eye strain.

Several solutions and improvements can be implemented, such as using more durable materials like treated cardboard or more resilient recyclable composites, increasing the device's lifespan without compromising its low cost. Adjustable supports or padding in areas that contact the face could make the headset more ergonomic for a

Figure 3. Google cardboard mockup.

Figure 4. Layout of the developed headset.

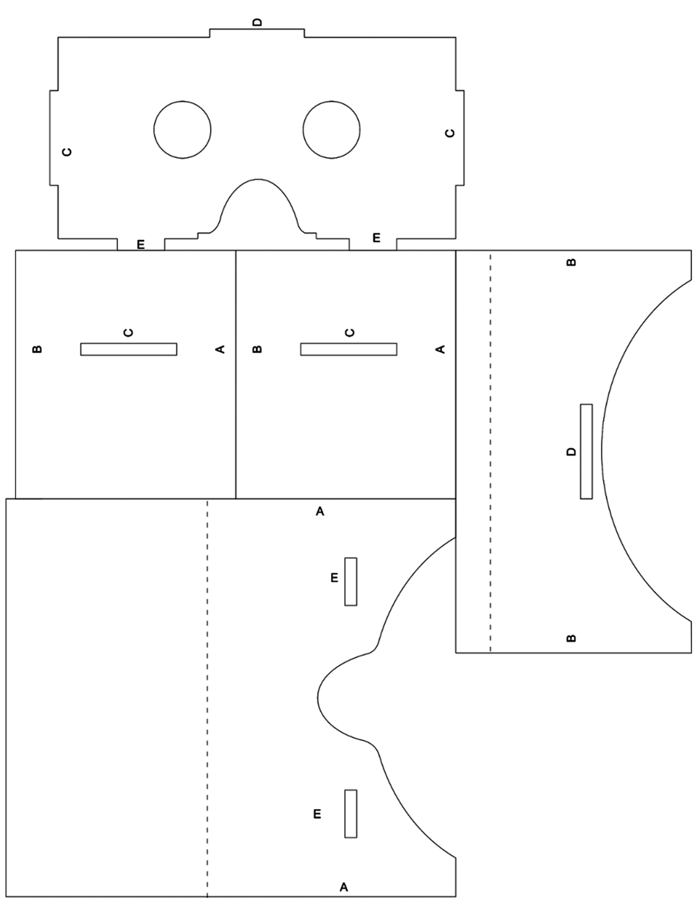
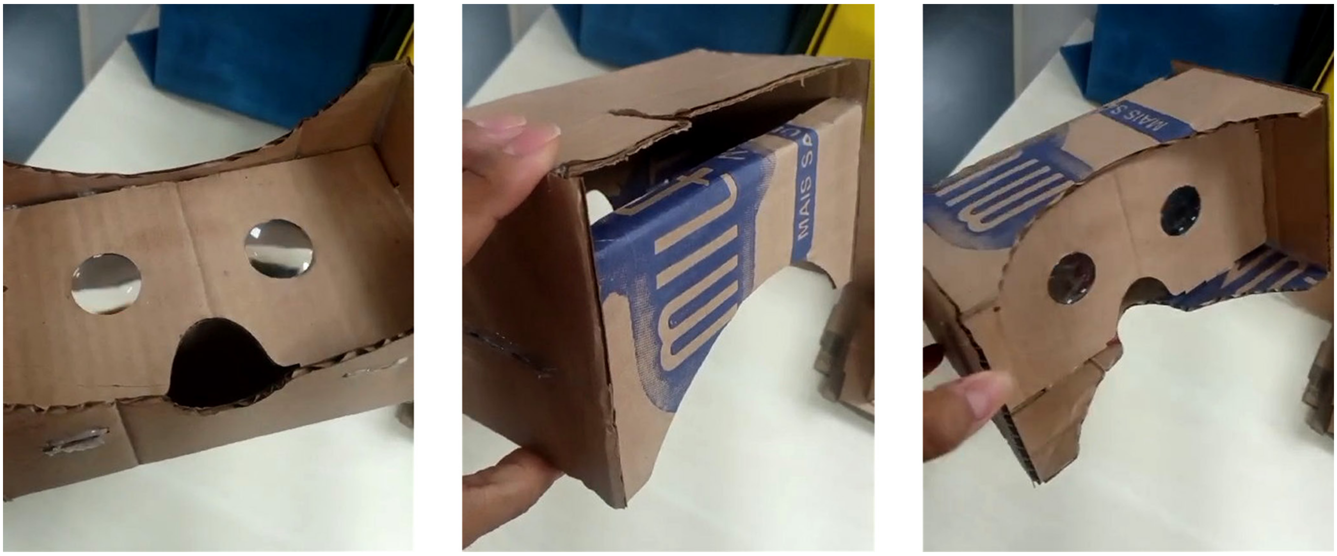


Figure 5. Prototype of the developed and tested headset.



broader range of users. Regarding the technical aspect, developing a smartphone fixation system that ensures stability during use, even with more intense head movements, is crucial.

In the field of design, despite its structural simplicity, the device allows designers to explore new ways to develop accessible and sustainable products. The fact that the cardboard headset can be assembled manually or on a small scale opens up opportunities for customization and adaptation, serving various audiences from students, researchers, and professionals in the field. This promotes accessibility and democratization of VR access in a scenario where cutting-edge technology is financially unfeasible for many people. This means more individuals, schools, and communities can access VR, using it as a learning, experimentation, and innovation tool.

The developed prototype was delivered to the Colégio Estadual Polivalente de Camaçari, becoming an example of how this technology can be practically applied in the educational context. It serves as an immersive experience and a means to encourage creativity and innovation in the learning process. Students could create content and adapt the headset for different needs, fostering a continuously innovative environment.

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Active Methods in Teaching Frameworks for Mobile Application Development: An Experience with High School Students

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This article reports an experience focused on applying active methods in teaching frameworks for mobile application development involving high school students from the metropolitan region of Feira de Santana. The project was divided into four modules, and the Django and Flutter frameworks were utilized to create an application for an environmental preservation NGO. The active approach combined video lessons with collaborative practices, challenging students to apply concepts of system modeling and user interface development. Periodic questionnaires were administered to measure the method's impact on learning progress and technical and social skills development. The results highlight the effectiveness of active methods in fostering greater engagement, autonomy, and creativity in the learning process, as well as significantly improving students' technical competencies in software development.
Keywords: Active Methods. Technology Education. Computer Science Education. Educational Engagement.

Integrating active methods into teaching Information and Communication Technologies (ICT) has proven to be an effective approach for developing practical and cognitive skills in educational contexts. Since the early discussions by Papert [1], who advocated for using computers as teaching tools and as mediums to promote active learning, Computational Thinking has emerged as an essential 21st-century skill for problem-solving and creativity. Papert emphasizes that learning with technologies should be a creative process rather than mere passive absorption of information. Today, Computational Thinking is formally incorporated into Brazilian educational guidelines through the National Common Curricular Base (BNCC) [2], underscoring the need to develop students' digital and technological skills in basic education. However, despite these directives, implementing these practices in classrooms remains challenging. According to the ICT Education Report [3], 61% of teachers in Brazil reported difficulties in using digital technologies for pedagogical activities, highlighting a significant gap between curricular needs and educators' technical capabilities.

In response to this scenario, we developed an outreach program utilizing active methods to teach programming to high school students from public schools, offering two courses. For the vocational course on application development, the program was structured around the Django (https://www.djangoproject.com) and Flutter (https://flutter.dev) frameworks, aiming to teach topics ranging from object-oriented programming concepts to mobile interface development. To consolidate their learning, students were challenged to develop an actual application for an NGO, applying acquired concepts in a collaborative, problem-based project.This article examines the impact of this method, investigating how active learning and the development of a real-world project contributed to the student's technical and social formation.

Additionally, we present the main challenges encountered during the course and the strategies adopted to promote student persistence and academic success.

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Materials and Methods

The course initially involved 32 students, offering a hands-on experience aimed at developing technical skills and fostering social and teamwork abilities, which are crucial for professional growth in the technology field. Throughout the project, periodic questionnaires were administered to assess learning progress and the impact of active methods—particularly Problem-Based Learning (PBL), a method already utilized in the Computer Engineering program at UEFS [4]—on student engagement and motivation.

The problem posed to the students was to develop a mobile application for the Eco da Mata Institute (IEM). Using the requirements provided, we applied PBL to address a real-world challenge with the following functionalities:

- **Event Management**: Centralizing the creation and dissemination of events related to ecological tourism and community fairs;
- **Project and Partner Promotion**: Showcasing sustainable services and products from traditional communities;
- **Geolocation of Map Points**: Highlighting tourist spots along the northern coast of Bahia;
- **Community Interaction**: Facilitating local community engagement and strengthening the connection between environmental preservation and tourism.

Active methodos, such as flipped classrooms, have gained prominence in recent years as a way to foster greater student engagement and active learning [5]. By reversing the traditional logic of knowledge transmission, this method allows students to study the material in advance and use classroom time for practical and collaborative activities, promoting the construction of new knowledge and its application to real-world situations [6]. In this context, in addition to problem-based learning, we employed the flipped classroom method for activity development. Educational materials were made available through recorded lessons (https://sites.google.com/view/jeditemple/desenvolvimento-mobile), and students were required to watch these asynchronous lessons before synchronous classes. This approach made the sessions more interactive and focused on clarifying doubts and engaging in collaborative discussions rather than mere content delivery. These meetings, held via videoconference, facilitated direct interaction between participants and the instructor, eliminating the need for physical travel, particularly for students from the Feira de Santana region.

The course was divided into four modules and spanned 34 weeks. Each module was designed to balance theoretical foundations with practical activities, promoting knowledge construction progressively and collaboratively. Accordingly, evaluation was conducted continuously and practically, with each team developing specific functionalities of the requested application.

<u>Module 1: Object-Oriented Programming (OOP) and Introduction to Software Engineering Concepts</u>

The course required prior knowledge of structured programming in Python, which we also taught to high school students from public schools through another course: Algorithms and Programming in Python (https://sites.google.com/view/jeditemple/algoritmos-e-programação). Accordingly, the first module, spanning 10 weeks, focused on Object-Oriented Programming (OOP) concepts, Design Patterns, and UML Diagrams.

During this period, students conducted seminars on the topics covered and completed practical Python activities to reinforce their understanding of the concepts. Assessment was based on their participation in the seminars and weekly practical activities.

<u>Module 2: Understanding Requirements and Introduction to System Development</u>

The second module, lasting six weeks, introduced students to more specific software development concepts. The PBL problem was presented, and students began working on the planning and design of the mobile application. The main activities and approaches adopted in Module 2 were as follows:

Theoretical Classes: Video lessons covered Project Architecture, Database Modeling, Version Control Concepts, and the distinctions between back-end and front-end. Additionally, the Django and Flutter frameworks—used in system development—were introduced.

PBL Problem: Starting with this module, students began working on solving the proposed problem, organized into teams responsible for different application functionalities (event management, partners, community, and projects).

Synchronous Meetings: Synchronous sessions were increased to two weekly, each lasting two hours. One session focused on resolving questions related to theoretical content, while the other was dedicated to practical team-based work.

Team Activities: Students were divided into groups, with each team responsible for developing a specific part of the application, strengthening collaborative learning among participants [7]. Teams worked together to ensure the integration of functionalities and the system's overall functioning. During practical sessions, students created class diagrams, use case diagrams, and prototypes for the application based on the identified requirements. The project supervisor and coordinator provided the requirements specification.

<u>Module 3: Back-End Development and API Creation</u>

The third module, lasting eight weeks, focused on building the back-end and creating the API using the Django and Django REST frameworks. The goal of this module was to enable students to apply concepts such as data modeling, the MVC (Model-View-Controller) architectural pattern adapted in Django as MTV (Model-Template-View), and the development of RESTful APIs. The core features of Module 3 included:

Theoretical Classes: Students studied pre-recorded video lessons covering advanced topics such as data modeling, Object-Relational Mapping (ORM), and using the Django REST Framework to create APIs. Additionally, they were introduced to concepts like authentication, access control, and best practices for API security.

Synchronous Meetings: Following the structure established in the previous module, students participated in two weekly meetings, each lasting two hours. The first session addressed questions related to the video lessons, organized team progress, and set weekly goals. During these discussions, students structured their ideas, identified issues and facts, and defined short-term objectives, adhering to the "divide and conquer" principle [8].

Practical Activities: During the second weekly session, students worked in teams to implement the application's back-end. Using Django, they modeled the database, created functionality for managing events, projects, communities, and NGO partners, and developed a RESTful API to enable interaction with the front end. By the end of this module, a functional and well-documented API was delivered.

<u>Module 4: Prototyping and Graphical User Interface Development</u>

The fourth and final module, lasting 10 weeks, focused on prototyping the application and implementing the graphical user interface using the Flutter framework. This module aimed to consolidate the knowledge acquired throughout the course and provide practical experience integrating the front-end and back-end.

The key features of Module 4 included:

Theoretical Lessons: Students watched video lessons on interface prototyping using Figma and mobile development with Flutter. Key concepts covered included reactivity in Flutter, using widgets to build modular and reusable interfaces, and integrating the front end with the API developed in the previous module.

Synchronous Meetings: As in Module 3, students participated in two weekly meetings of two hours each. The first meeting was dedicated to reviewing the concepts presented in the video lessons and planning interface development. The second meeting focused on practical implementation. Teams discussed short-term goals, aligned interface functionalities with the back end, and engaged in collaborative programming.

Practical Activities: During practical sessions, students used Figma to create application interface prototypes, simulating the user experience. They then implemented these prototypes in Flutter, connecting the front-end functionalities to the previously developed API.

Integration and Project Completion

By the end of the course, all established goals were achieved. The final project was presented to the NGO, delivering a comprehensive solution with a robust back-end, a well-structured API, and a responsive, intuitive graphical user interface. The PBL method, including fli, piped classrooms, and collaborative learning, provided a practical and enriching educational experience. This approach culminated in delivering a real product that met the NGO's needs and engaged the students in all stages of software system development.

Results and Discussions

The results from the final questionnaire applied to the students provide a comprehensive view of the impact of the active methods used in the course. They address aspects such as the participants' technical development, the course's influence on motivation to pursue a career in software, and an analysis of the attrition rates. Below, we discuss in detail each of these aspects based on the students' responses.

Analysis of Results on the Effectiveness of Active Methods

To understand the impact of active methods on the student's learning process, a questionnaire assessed different aspects of the educational experience. The responses comprehensively show how Active Learning has influenced academic progress and student motivation.

Among the questions asked, the one that stands out is: "On a scale of 1 to 5, how much do you think Active Learning has benefited you in achieving the course goals?" Most students (12 out of 19) gave the highest rating (5), indicating a significant positive impact. However, one student gave the lowest rating (2) and explained that Active Learning was not as beneficial for them. They mentioned: "I searched for solutions in many different places, which were often contradictory, and I got confused". Also, "I understand of certain topics was quite shallow." Therefore, while most students found value in the approach, not all could overcome difficulties interpreting varied information, failing to achieve autonomy in their studies. To make Active Learning more inclusive, it is advisable to provide clear guidelines and diverse learning resources (video lessons, manuals, synchronous classes, guided practical activities), adjusting the method to better meet the needs of all students.

Regarding the learning encouragement provided by the course, 13 students rated it a 5, 4 gave it a 4, and only one gave a lower rating (2). These data suggest that the course effectively encouraged students to seek knowledge autonomously, reflecting the effectiveness of active methods in maintaining student motivation. Additionally, the students highly valued the practical challenges. Most participants (13 out of 19) gave a 5 for the impact of using challenges on learning, and 15 considered the course challenging. The fact that no student gave a rating below 3 indicates that practical challenges were widely accepted as a fundamental tool for learning and engagement, reinforcing the relevance of active methodos in the educational process.

The pre-recorded lessons received an average score of 3.8 regarding their contribution to the course content, with ratings ranging from 2 to 5. Six students gave the maximum rating, another six gave a 4, four chose a 3, and three gave a 2. The responses revealed that some students preferred to search for information online due to time constraints or the convenience of finding specific content rather than watching lengthy videos. One student mentioned that the theoretical lessons became less valuable as the course progressed. To improve, it is important to make the recorded lessons more accessible and adaptable to students' needs. For future classes, there are plans to break the lessons into subtopics and introduce a reference manual to facilitate access to information.

Based on the responses to the questionnaire, the course method, grounded in Active Learning practices, practical challenges, and recorded lessons, was well received by most students. The encouragement for learning and the relevance of the practical challenges were particularly praised. In contrast, the recorded lessons and the level of challenge in the course may be areas that require adjustments to better address the diverse needs and expectations of the students. This analysis reflects the importance of flexible methods, which promote autonomy and practice and can be adjusted to meet the different profiles of students.

Impact on Technical Development and Challenges Faced

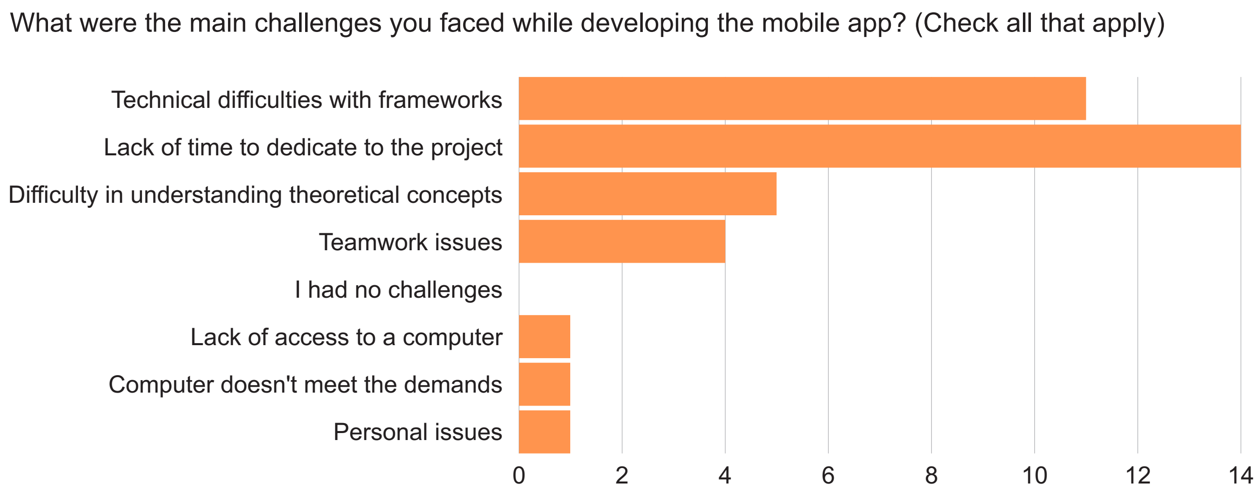
The results of the questionnaire on the use of the Django and Flutter frameworks and the development of a mobile application show that the course positively impacted the participants' technical knowledge. When asked about their understanding of these frameworks before and after the course, most participants (78.9%) stated that their understanding increased significantly. In comparison, 15.8% said their understanding increased moderately, and 5.3% reported a slight increase in knowledge. No student indicated that there was no change in their understanding, demonstrating that the course fulfilled its role in providing a solid foundation of technical knowledge.

Applying theoretical concepts was also highlighted as an important learning process. The question, "Did you manage to apply the theoretical concepts learned (such as object-oriented programming and system modeling) in the development of the application?" revealed that 31.6% of students were able to fully apply these concepts, while 52.6% applied them broadly. Only 10.5% said they applied them to a small extent, and 5.3% stated they applied them partially. These data suggest that the course provided an effective practical integration of theoretical concepts and the actual development of applications, which is crucial for the student's training.

However, when asked about the main challenges faced during application development, it became evident that technical and personal difficulties also influenced the process (Figure 1). 57.9% of the students mentioned technical difficulties with the frameworks, while 73.7% of participants identified the lack of time to dedicate to the project as the most significant obstacle. In addition, 26.3% of students mentioned difficulties in understanding theoretical concepts, and 21.1% reported problems with teamwork. No student stated that they did not face any challenges.

Two students also highlighted other factors that hindered their progress on the project: one mentioned the lack of access to a computer, and another reported that their equipment did not meet the minimum requirements necessary for application development. While the EAD modality has the advantage of opening opportunities for students who live far from the university, it simultaneously exposes social inequalities that could only be overcome with adequate infrastructure in computer labs in all public schools, accessible to students throughout the day, just like school libraries.

Figure 1. The main challenges encountered by the students.



Impact of the Course on Motivation for Careers in Technology

The survey results highlight the significant impact of the Mobile Development course on students' motivation to pursue careers in software development and, more broadly, in the technology field. The question "Did the development of this project increase your motivation to pursue a career in software development?" received overwhelmingly positive responses, with 16 students answering yes and 3 responding "maybe." No students expressed a lack of motivation.

Additionally, the question about the motivation of high school students who had not yet started higher education revealed that 87.5% expressed interest in pursuing a technology degree, while 12.5% answered "maybe." Several students provided detailed justifications for why they felt motivated to enter higher education in technology. One student stated that "the course sparked a desire to learn more about the field," mentioning plans to enroll in the Computer Engineering program at the State University of Feira de Santana (UEFS). Furthermore, the hands-on experiences provided by the course were highlighted as essential in shaping the students' aspirations. One participant commented, "The course made me realize that it is possible to acquire the necessary knowledge by practicing and studying, which motivated me to enter university."

In summary, the course developed technical skills and significantly influenced students' academic and professional aspirations. Exposure to real-world software development challenges and the collaborative resolution of problems motivated many students to consider continuing their studies in technology-related fields. These results highlight the effectiveness of vocational courses in inspiring young people to pursue higher education, further emphasizing the importance of practical learning experiences in shaping their careers.

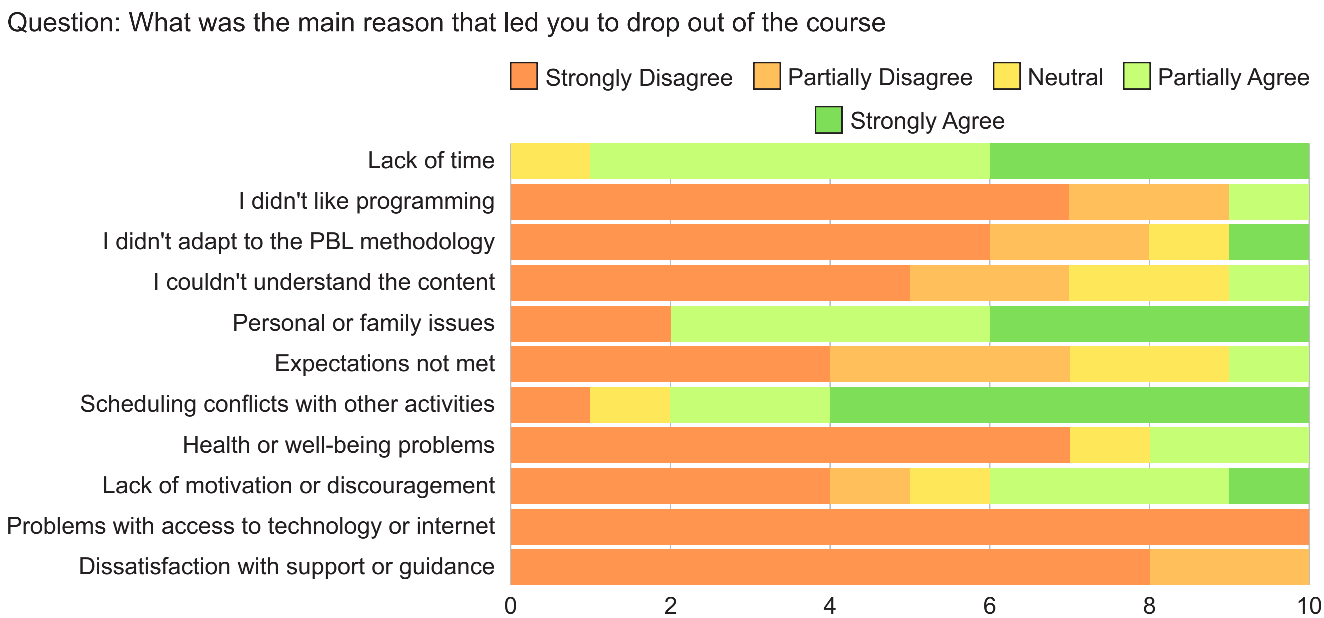
Contributing Factors to Course Dropout

The analysis of the responses from the questionnaire applied to students who dropped out of the programming course revealed a series of factors that contributed to their decision.

The primary reason identified was lack of time, mentioned by 90% of the participants, who agreed partially or entirely with this reason, as illustrated in Figure 2. Many students reported that professional and personal responsibilities, such as work and family commitments, made participating regularly in the course meetings and activities difficult.

In addition to the lack of time, difficulty understanding the content was another significant

Figure 2. Reasons for dropping out of the course.



factor for the dropout. Some students mentioned that they could not keep up with the course's pace, with one commenting that "it felt like everyone was already ahead." This sense of inadequacy may have been exacerbated by the active learning method, which requires greater autonomy from students and may not have been well-received by those with little prior experience in programming.

Another recurring factor was schedule incompatibility. One student reported that, although the meeting times were collectively defined, "changes in personal life" made it difficult to participate in synchronous activities. The lack of flexibility in the schedule was seen as an obstacle for those facing unforeseen circumstances or external commitments, suggesting the need to offer more scheduling options or alternative meetings. Despite the challenges, some students praised the course structure, describing it as "great" or "very good." This indicates that the dropouts were more related to external and contextual factors than dissatisfaction with the course content or method.

Some strategies could be implemented to address these issues and reduce dropout rates. Creating more accessible initial modules aimed at leveling students' knowledge with varying levels of experience could help improve course engagement. Offering alternative synchronous meetings or flexible schedules could better accommodate students' external demands. Additionally, more monitors could provide personalized support, addressing students' diverse needs and learning paces. These measures could significantly increase retention and student success in the course.

Conclusion

This paper presented the results of an educational experiment focused on applying active methods in teaching frameworks for mobile app development, emphasizing the use of Django and Flutter. The initiative involved high school students from the metropolitan area of Feira de Santana, aiming to develop technical skills and promote greater engagement with the technology field. The experiment also evaluated the impact of these methods on students' motivation toward higher education.

The results demonstrated that the adopted approach effectively enhanced the students' technical knowledge. They reported significant improvement in understanding the frameworks and their practical application in software development. Furthermore, the surveys indicated that the course stimulated motivation for careers in the technology sector, with many students considering pursuing higher education at local institutions such as UEFS and UFBA.

However, technical difficulties, lack of time to dedicate to the project, personal issues, and lack of access to adequate equipment were mentioned. These factors highlight the need for more robust infrastructure and technical guidance support to ensure that all students can fully participate in the learning process.

We concluded that applying active methods, such as project-based learning and integrating video lessons and practical activities, is beneficial in the context of technological education. The course not only improved the students' technical knowledge but also fostered interest in careers in the software field, demonstrating the potential of these initiatives to train and guide young talent. Finally, it is recommended that future projects consider expanding technical support and flexibility schedules to better accommodate students' needs, ensuring that all can overcome the identified challenges and make the most of the opportunities offered by the course.

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Optimizing Automated Trading Systems Portfolios with Reinforcement Learning for Risk Control

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This work proposes an innovative method for optimizing Automated Trading Systems (ATS) portfolios with advanced Deep Reinforcement Learning (DRL) techniques. The algorithms A2C, DDPG, PPO, SAC, and TD3 are assessed for their ability to learn and adapt in volatile market conditions. The main goal is to enhance ATS's risk control and operational efficiency using data from the Brazilian stock market. DRL models outperformed traditional benchmarks by offering better risk management and risk-adjusted returns. The findings demonstrate the potential of DRL algorithms in complex financial scenarios and lay the groundwork for future research on integrating machine learning in quantitative finance.
Keywords: Computational Finance. Machine Learning. Reinforcement Learning.

Reinforcement Learning (RL) has emerged as a powerful tool for tackling challenges in various areas, including real-time decision-making and stock market predictions. In RL, an agent learns to maximize rewards by interacting with the environment, making it promising for financial applications, such as automated trading [1]. ATS (Automated Trading Systems) uses algorithms to make buy-and-sell decisions based on real-time market data. However, volatile markets present risks, requiring constantly optimizing these systems [2]. The application of RL in these models offers an adaptive approach, allowing greater flexibility and efficiency in trading.

Moreover, RL stands out by eliminating the need for intermediate predictions and dynamically adapting to market changes. Recent studies demonstrate that RL outperforms traditional approaches in profitability and effectiveness, proving to be a robust technique in areas such as high-frequency trading and portfolio management [3]. Studies show that these strategies surpass traditional approaches regarding profitability and effectiveness [1,4,5].

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This study aims to explore the optimization of RL models in an ATS portfolio, comparing them with the traditional approach without optimization and market indices to verify the advantages and limitations of RL in risk control.

Materials and Methods

This section outlines the methods employed in the study to thoroughly evaluate and compare the performance of different trading strategies. It includes a detailed description of the dataset, the preprocessing steps, the approach to portfolio optimization using RL, the proposed environment for trading simulations, and the training process of the DRL (Deep Reinforcement Learning) agents.

Dataset

The algorithms are applied using the FinRL library, which specializes in DRL for automated stock trading [6]. For optimization, backtests are performed, which consist of simulations based on historical data of how a proposed portfolio would have behaved if it had been implemented over a past period. Based on this, backtests comprise historical strategy data and daily returns of the Brazilian Stock Index, IBOVESPA.

Each trade involves two mini contracts of the IBOVESPA index (WIN) or USDBRL (WDO), with the historical data covering 20,644 trades.

In total, 26 strategies are considered, with 18 applied to WIN contracts and 8 to WDO contracts. These strategies include both trend-following techniques and oscillators, and except for one strategy, all trades belong to the day trade category. These day trade strategies use 15 and 20-minute timeframes, allowing granular analysis and rapid execution of operations throughout the day. Using short timeframes is fundamental to capturing intraday price movements and taking advantage of profit opportunities in periods of high volatility [7].

The finance library is used to obtain data from the main Brazilian stock market index, IBOVESPA, through the Exchange Traded Fund (ETF) BOVA11, which aims to replicate the performance of the IBOVESPA, representing the other dataset to be used as a backtest of trading performance. The data is accessed from June 6, 2018, to November 11, 2019.

The diversity of metrics allows the application of technical analysis techniques and the simulation of backtests to evaluate the historical performance of the proposed strategies.

Data Preprocessing

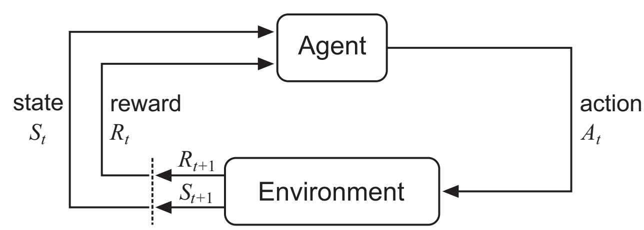
The initial historical dataset consists of detailed records of operations, including the type of operation (buy or sell), dates, entry and exit prices, results in terms of profit or loss, traded volumes, and the identification of the ATS involved. After the entire process, the generated dataset includes the date, strategy name, and daily operation profit (or loss) expressed in financial amounts. The column "data" is renamed to "date" to standardize the column names. Next, a transformation is performed via DataFrame to convert its wide format to a long format, where each row represents the profit for a specific date and ATS, indicated by the columns "close" and "tic," respectively. In addition, technical indicators are calculated to enhance analyses and assist in making trading decisions.

Portfolio Optimization using RL

One approach to solving the portfolio optimization problem is using a RL agent. In this method, the agent develops a policy by interacting directly with an environment. At each time interval, the environment provides observations that define the system's state. Based on this state, the agent decides which action to take. After the action is executed, the environment returns a reward, allowing the agent to evaluate the effectiveness of the chosen action. The goal of the RL agent is to develop a policy that maximizes the expected sum of rewards over time [8]. Figure 1 illustrates the training cycle of an RL agent interacting with the environment.

However, the RL agent needs to handle complex state spaces to be effective in portfolio optimization tasks. A portfolio consists of multiple assets, each with its series of prices, resulting in a highly dimensional state space. Using function approximations, such as neural networks (NN), has shown notable results in various complex tasks [8]. Thus, DRL algorithms are the most suitable for this purpose.

Figure 1. Elements of RL [9].



Proposed Environment

Thus, it is necessary to design an automated trading solution for portfolio allocation. Stock trading is modeled as a Markov Decision Process (MDP), involving the observation of changes in stock prices, taking actions, and calculating rewards to adjust the agent's trading strategy [8]. All preprocessing is performed to ensure that the ATS trading data aligns with this environment, where the agent can interact and learn, considering crucial elements such as historical stock prices and technical indicators [6].

To train a trading agent with DRL, an environment simulates real-world trading using OpenAI Gym [10]. The environment initializes by loading market data for the current day and configuring the initial state, which includes the covariance matrix and technical indicators. At each step, the agent makes allocation decisions, which are normalized and applied to calculate the weight of each ATS in the portfolio. The portfolio value is updated according to this balancing, and the reward is defined as the new value. If the episode ends, accumulated and daily reward graphs are saved, and statistics such as the sharpe ratio are calculated and displayed. The environment is then reset for a new episode.

Training the DRL Agent

The implementation of the following DRL algorithms is based on Stable Baselines. Stable Baselines is a fork of OpenAI Baselines, with significant structural refactoring and code cleanup [9]. From this library, all DRL algorithms, A2C, DDPG, PPO, SAC, and TD3, are implemented due to their widespread use in finance [6,11,12].

The selection of these algorithms for an RL agent is based on their ability to handle continuous action spaces, sample efficiency, training stability, and robust performance. Each of these algorithms brings unique characteristics that can be explored to develop effective and adaptive trading strategies, allowing agents to learn and optimize their policies efficiently and robustly [13].

This splits the ATS trading data by date, with the training period covering September 1, 2014, to June 5, 2018. For testing, the period from June 6, 2018, to November 11, 2019, is used, totaling 18,486 trades for training and 10,218 for testing, with an approximate ratio of 65% and 35%, respectively. To generate the DRL models using the FinRL library [6], the training parameters for all agents must be imported and configured. The Optuna[14] library optimizes the hyperparameters to improve the DRL agents' performance.

After training, each model is used to predict the performance of the ATS portfolio in the defined environment using the ATS dataset, specifically between June 6, 2018, and November 11, 2019. This generates two sets of results: daily returns and actions taken by the models. These results help evaluate the effectiveness of each model's strategy in terms of maximizing returns and risk management in a portfolio optimization environment.

Min-Variance

This model seeks the allocation of assets that results in the lowest possible volatility, given an expected level of return [15]. This method relies on the principles of modern portfolio theory, which promotes diversifying investments across various asset categories to minimize risk [16].

In this work, the Min-Variance model is implemented using the PyPortfolioOpt library [17], which offers robust tools for financial portfolio optimization based on financial theories.

Using Min-Variance as a benchmark is crucial because it establishes a performance reference in terms of minimum risk for a given level of return. This allows for evaluating how practical other portfolio optimization approaches are compared to a well-established model. A new approach that achieves superior performance to Min-Variance in metrics such as the Sharpe ratio can be considered more efficient.

Results and Discussion

Three distinct experiments are conducted to analyze the results. In the first experiment, the evaluation focuses exclusively on WIN contracts. In the second experiment, the analysis is dedicated to WDO contracts. Finally, in the third experiment, the dataset is evaluated considering both WIN and WDO contracts. Each experiment aims to explore the effectiveness of the applied strategies in different trading contexts.

In each experiment, the performance of each DRL strategy is assessed using the performance metrics mentioned earlier. Comparisons are also made with a baseline, represented by the non-optimized portfolio. The choice of the DRL strategy is based on the highest sharpe ratio, as this index evaluates the relationship between accumulated return and the volatility of returns, providing a risk-adjusted measure.

Subsequently, the selected DRL strategy is compared with established benchmarks to contextualize the results achieved. In the experiment, the benchmarks used are IBOVESPA and minimum variance in all comparisons.

Performance Evaluation of DRL Strategies

As mentioned, the five DRL algorithms are trained to find the best parameter configuration using the hyperparameter optimization technique with 50 trials. The tables present the agents with the best configuration obtained for each experiment, showing their cumulative results from June 6, 2018, to November 11, 2019.

Performance of Strategies in the WIN Contract

In Table 1, the annual returns ranged from 17.2% to 19.1%, indicating robust performance in a relatively stable period. DDPG stood out with the highest annual return of 19.1%, while TD3 presented the lowest, with 17.2%. The annual volatility of these strategies is consistently low, ranging between 4.1% and 4.8%, suggesting considerable stability in daily operations, with PPO being the method with the lowest volatility.

At the same time, the baseline maintained a volatility close to the group's average, at 4.2%. Regarding the sharpe ratio, which measures the relationship between return and risk, all strategies presented values above 3.5. The baseline had an excellent performance, with a sharp ratio equal to 3.9, just slightly below SAC, which obtained the highest value of 4.0. These values indicate excellent risk-adjusted efficiency. The maximum drawdown, which indicates the most significant drop in portfolio value before a new high, remained below 1.4% for all strategies and the baseline. PPO showed the lowest maximum drawdown of only 1.3%. This demonstrates the notable resilience of the DRL models against potential market drops. Among the analyzed DRL models, SAC is selected as the most efficient due to its highest Sharpe ratio, which demonstrates its superiority in risk control.

Performance of Strategies in the WIN Contract

Observing Table 2, the annual returns varied significantly among the strategies, with DDPG presenting the highest return of 14.6% and PPO the lowest, at 11%. The annual volatilities of these strategies also showed variations, ranging from 6.7% to 7.6%, with SAC presenting the highest volatility and the baseline matching the lowest observed volatility at 6.7%. This suggests that the baseline managed to maintain stability comparable to that of the more complex strategies. Regarding the sharpe ratio, which measures the risk-adjusted return, the values ranged between 1.6 and 1.9. DDPG led with the highest sharpe ratio, indicating superior efficiency in managing risk relative to the returns obtained. The baseline, with a sharpe ratio of 1.6, offered reasonable efficiency, surpassing PPO and TD3. The analysis of the maximum drawdown

Table 1. Performance comparison between DRL Strategies - WIN Contract.

Metrics	A2C	DDPG	PPO	SAC	TD3	Baseline
Annual Return	17.4%	19.1%	17.7%	18.7%	17.2%	17.7%
Annual Volatility	4.6%	4.8%	4.1%	4.3%	4.3%	4.2%
Sharpe Ratio	3.5	3.7	3.9	4.0	3.7	3.9
Max. Drawdown	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%

Table 2. Performance comparison between DRL Strategies - WDO Contract.

Metrics	A2C	DDPG	PPO	SAC	TD3	Baseline
Annual Return	12.2%	14.6%	11.0%	14.4%	11.3%	11.2%
Annual Volatility	7.1%	7.2%	6.7%	7.6%	6.9%	6.7%
Sharpe Ratio	1.7	1.9	1.6	1.8	1.6	1.6
Max. Drawdown	3.7%	4.1%v	5.0%	4.7%	5.1%	3.7%

shows a maximum loss in portfolio value, ranging between 3.7% and 5.1%, with PPO and TD3 exhibiting the highest drawdown.

DDPG is selected as the most efficient among the evaluated strategies due to its superior sharpe ratio, which indicates an excellent capacity for risk management.

Performance of Strategies in Combined WIN and WDO Contracts

Table 3 shows that the annual returns of the strategies ranged from 13.5% to 17.6%. SAC achieved the highest annual return, while A2C presented the lowest annual return. The baseline obtained a return of 15.7%, surpassing A2C and positioning itself competitively among the other DRL strategies. Regarding annual volatility, the values ranged between 3.8% and 4.4%, with SAC again presenting the lowest value, where lower volatility implies lower risk.

The sharpe ratio of the strategies varied from 2.9 to 4.2, indicating the effectiveness of SAC, which recorded the highest value, in maximizing return per unit of risk. The baseline achieved a ratio of 3.7, showing robust performance, just slightly below PPO and TD3. In terms of maximum drawdown, all strategies, including the baseline, demonstrated significant resilience with a maximum drawdown between 1.2% and 1.4%, indicating their ability to significantly minimize potential losses during the evaluated period.

Comparison with Benchmarks

This section presents the results of applying the DRL methods compared to their respective benchmarks involving the WIN, WDO, and combined contracts.

Comparison in the WIN Contract Experiment

As presented in Table 4, SAC recorded an annual return of 18.7%, positioning itself below IBOVESPA, which had a return of 28%, and Min-Variance, with 22.8%. The annual volatility is considerably lower for SAC and Min-Variance than IBOVESPA, which presented a high volatility of 21.2%. The sharpe ratio is superior for Min-Variance, achieving a value of 5.2, indicative of exceptionally efficient risk management. SAC also showed efficiency with a ratio of 4.0, while IBOVESPA

Table 3. Performance comparison between DRL Strategies - WIN and WDO Contract.

Metrics	A2C	DDPG	PPO	SAC	TD3	Baseline
Annual Return	13.5%	15.5%	16.0%	17.6%	16.9%	15.7%
Annual Volatility	4.3%	4.4%	4.0%	3.8%	4.3%	4.0%
Sharpe Ratio	2.9	3.3	3.7	4.2	3.7	3.7
Max. Drawdown	1.2%	1.4%	1.2%	1.2%	1.3%	1.3%

Table 4. The Best Agent: IBOVESPA and Min-Variance - WIN Contract.

06/06/2018 to 11/11/2019	SAC	IBOV	Min-Variance
Annual Return	18.7%	28%	22.8%
Annual Volatility	4.3%	21.2%	3.9%
Sharpe Ratio	4.0	1.3	5.2
Max. Drawdown	1.3%	11.4%	1.1%

had the lowest value of 1.3, reflecting higher relative risk to the returns generated. The maximum drawdown is considerably lower for SAC and Min-Variance than IBOVESPA, which experienced a significant maximum drawdown of 11.4%. Regarding annual return, expressed as a percentage, IBOVESPA led with 28%, followed by Min-Variance with 22.8% and SAC with 18.7%. As shown in Table 4, these results highlight the differences in investment strategies, where IBOVESPA provides higher total returns but with considerably higher risks.

Comparison in the WDO Contract Experiment

According to the data in Table 5, DDPG presented an annual return of 14.6%, positioning itself among the lowest return values when compared with IBOVESPA, which had a significant return of 28%, and Min-Variance, with returns of 11.3%. The annual volatility of DDPG is 7.2%, demonstrating more excellent stability compared to IBOVESPA and comparable to Min-Variance with 7.3%. Regarding sharpe ratio, DDPG achieved 1.9, superior to IBOVESPA with 1.3, but inferior to Min-Variance with 1.5. The maximum drawdown analysis revealed that DDPG had a drawdown of 4.1%, significantly lower than IBOVESPA and comparable to Min-Variance with 4.5%. This highlights the ability of DDPG and Min-Variance to limit potential losses more effectively than the more volatile market indices. The analysis of the results in Table 5 evidences the efficiency of DDPG, even when compared with IBOVESPA, highlighting its ability to capitalize on market opportunities compared to traditional benchmarks and minimum variance.

Comparison in the Combined WIN and WDO Contracts Experiment

Table 6 shows that SAC achieved an annual return of 17.6%, lower than IBOVESPA, which registered 28%, and slightly below Min-Variance with 21.1%. Despite the lower annual return, SAC demonstrated an extremely low annual volatility of 3.8%, equivalent to Min-Variance and much below IBOVESPA's 21.2%. This low volatility indicates more excellent stability of SAC and Min-Variance compared to the more volatile IBOVESPA. The sharpe ratio of SAC is 4.2, reflecting high efficiency in adjusting return for the risk taken, although Min-Variance presented a still higher ratio of 5.

Table 5. The Best Agent: IBOVESPA and Min-Variance - WDO Contract.

06/06/2018 to 11/11/2019	SAC	IBOV	Min-Variance
Annual Return	14.6%	28%	11.3%
Annual Volatility	7.2%	21.2%	7.3%
Sharpe Ratio	1.9	1.3	1.5
Max. Drawdown	4.1%	11.4%	4.5%

On the other hand, IBOVESPA, with a sharpe ratio of 1.3, showed lower efficiency under the same metric. The maximum drawdown, which measures the most significant drop in portfolio value before a new high, is only 1.2% for SAC and 1.1% for Min-Variance, significantly lower than IBOVESPA's 11.4%. This result emphasizes the robustness of SAC and Min-Variance in terms of risk management and loss limitation.

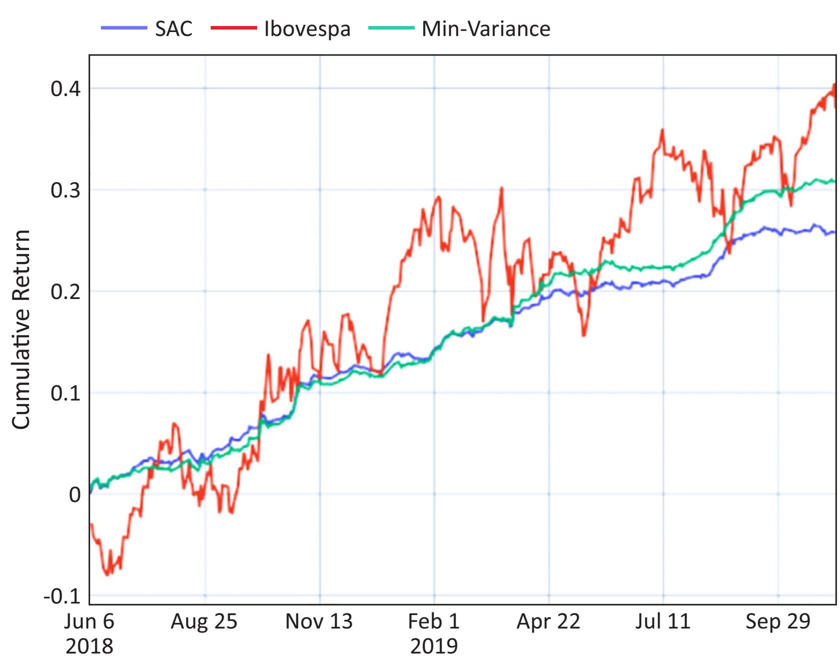
According to Table 6, regarding the final accumulated portfolio value, SAC increased 26.6%, compared to 41.8% of IBOVESPA and 31.1% of Min-Variance. Although IBOVESPA offered a higher total return, it came with considerably higher risks. Notably, the IBOVESPA index shows a significant recovery from mid-2019, surpassing the other strategies in the last quarter of the observed period, highlighting its capacity for recovery after downturns. The graph in Figure 2 shows that the SAC strategy achieved a significant sharpe ratio with low volatility, as desired.

The results illustrate the diversity of performance between different investment strategies, especially in volatile contexts. RL-based strategies show the potential to outperform traditional benchmarks like IBOVESPA in certain periods, although there are significant variations among them in terms of return and risk. Min-Variance, while offering the lowest volatility, also provides the lowest returns, confirming its suitability for investors who prioritize capital preservation over growth.

Table 6. The Best Agent: IBOVESPA and Min-Variance - WDO Contract.

06/06/2018 to 11/11/2019	SAC	IBOV	Min-Variance
Annual Return	17.6%	28%	21.1%
Annual Volatility	3.8%	21.2%	3.8%
Sharpe Ratio	4.2	1.3	5.0
Max. Drawdown	1.2%	11.4%	1.1%
Acc. Portfolio Value	26.6%	41.8%	31.1%

Figure 2. Cumulative results of SAC, Min-Variance, and IBOVESPA.



Conclusion

This study presented an innovative approach to optimizing ATS system portfolios with DRL algorithms, with a specific focus on risk control in highly volatile market environments. The DRL techniques, particularly the DDPG and SAC algorithms, demonstrated a notable ability to learn and adapt trading strategies in real-time, optimizing returns while efficiently managing the associated risks and outperforming the baseline in several aspects.

The results indicate that DRL can significantly surpass traditional trading methods, such as heuristic-based or even other quantitative models that do not incorporate continuous learning and adaptation. The ability to process and react to market conditions in real time, learning from past interactions without explicit predictions, makes DRL-based systems promising tools for modernizing financial trading practices.

This work demonstrates the effectiveness of DRL models in reducing risks and optimizing portfolio performance and points to the potential of applying these techniques in other financial areas, indicating a promising field. Future research could explore integrating RL techniques with other data types, such as macroeconomic signals or sentiment analysis, to develop even more robust and adaptive systems. Therefore, applying advanced RL techniques, such as DRL in finance, represents a promising and innovative direction with substantial implications for the theory and practice of investment management and market operations.

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Standardization of Teaching Materials with Marp and CI/CD: A Study at the Federal Institute of Sergipe

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This article presents an approach for developing simple, flexible, and multi-format educational materials using Marp, a Markdown-based presentation creation tool combined with Continuous Integration (CI) and Continuous Delivery (CD) techniques. The integration of these technologies automated the process of creating, updating, and distributing educational content in slide format. To this end, a custom theme was developed following the visual standards of the Federal Institute of Sergipe (IFS). This workflow optimized the authors' time, standardized, and improved the visual appeal and structure of the slides, enhancing the creation of high-quality educational content for the teaching and learning process.
Keywords: Marp. Educational Tools. CI/CD. Template.

Technological advancements have contributed to the current teaching model by providing tools that enhance knowledge transmission and learning. In both in-person and distance learning environments, teachers deliver educational content through presentations.

It is common for educators to use Microsoft PowerPoint, OpenOffice Impress, and Apple Keynote for content presentation [1], although alternatives exist, such as Marp.

Marp is an open-source presentation framework that enables the creation of elegant and customized slides through the simplicity and versatility of Markdown. This is because Markdown allows users to access a robust software ecosystem for rendering text into various document formats. Thus, content creators can focus on the message, eliminating the complexity of formatting and design [2]. Its lightweight and structured syntax, combined with flexible output options, allows exporting to formats such as PDF [3].

Extensions for the Command Line Interface (CLI) and Visual Studio Code further expand its capabilities, enabling presentations to be exported in multiple formats, including Hypertext Markup Language (HTML), Portable Document Format (PDF), and PowerPoint Open XML Presentation (PPTX) [2].

Marp offers various customization options, allowing authors to reflect their style and preferences by simply writing content in plain text using Markdown syntax.

Recent studies [4-7] have explored new methods for developing teaching materials focusing on simplicity and flexibility. The study by Brilhaus and colleagues [4] suggests a modular approach to creating interactive presentations in Markdown format, where users benefit from a balance between reuse and specialization without requiring complex training.

Other relevant study is by Oelen and Auer [5], which aims to make online teaching materials accessible to blind or visually impaired individuals through this markup language (Markdown).

Recent research from Grayson and colleagues [6] utilizes the R Markdown interface to create interactive classroom modules with R Markdown files. According to the study, these resources enable the creation of modules that guide students through concepts while providing areas for coding. Following a similar line of reasoning, the study by Hofert and Kohm [7] presents using LaTeX for creating scientific presentations. According to the research, the main advantage of this approach is

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that LaTeX presentation slides allow easy copying and pasting of content from other documents

According to a UNESCO study on Open Educational Resources (OER), the application of open licenses in creating educational materials offers valuable opportunities for creating, reusing, adapting, and redistributing these materials, promoting greater accessibility and inclusion [8]. By making the Markdown code openly available on GitHub, authors ensure the ease of access and adaptation of materials by other educators and follow UNESCO's guidelines for encouraging the use of open-source tools to create and share educational materials.

Given this context, the present study focuses on the application of Marp with Continuous Integration (CI) and Continuous Delivery (CD) tools to create, maintain, and share educational content in a simple, flexible, automated, and consistent manner through a system developed as part of a capstone project [9].

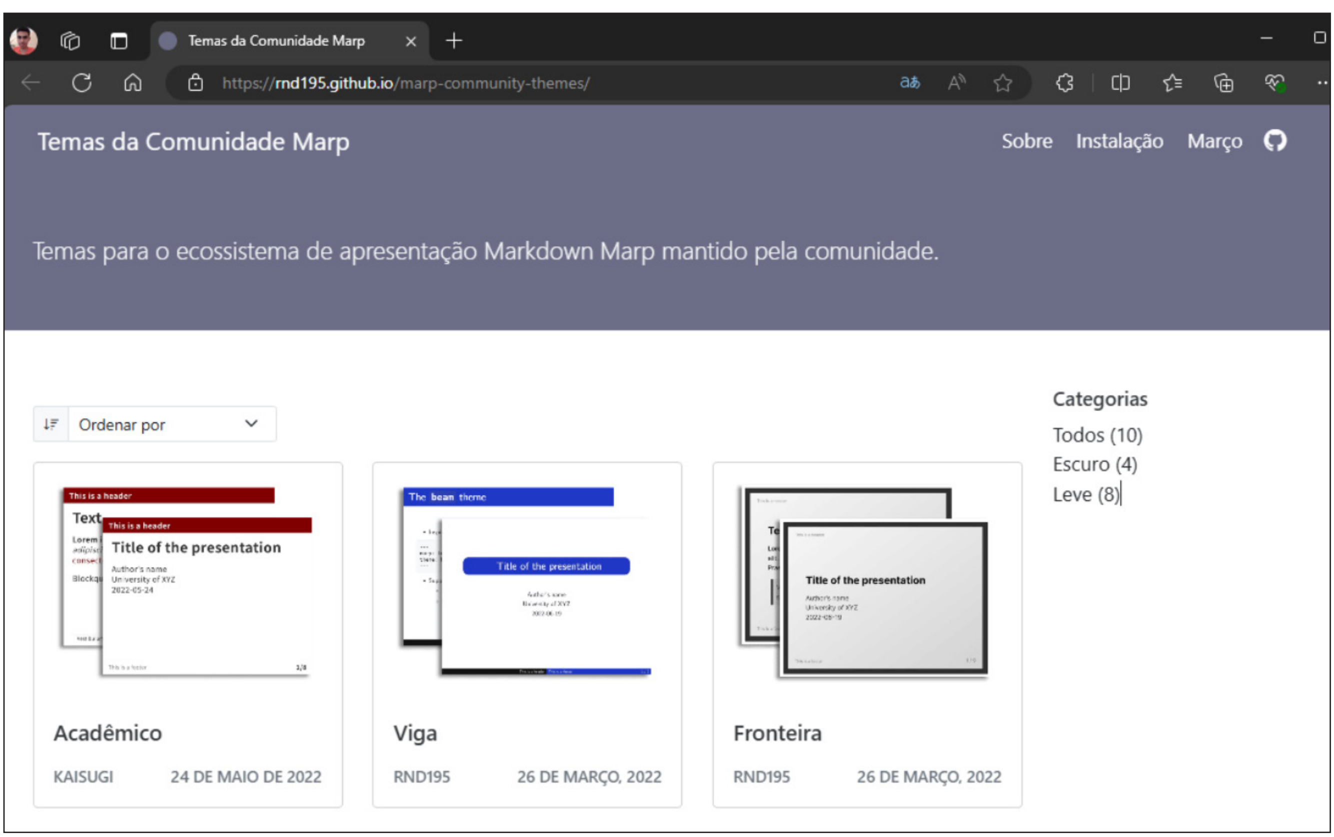
A customized theme was created as a case study to meet the formatting requirements of the Bachelor's Degree in Information Systems (BSI) at the Federal Institute of Sergipe (IFS).

Creation of the IFS Marp Academic Theme

The Marp community provides themes that can inspire or serve as a starting point for customizations and new designs. To achieve this, it is essential to familiarize oneself with the documentation to learn how to style presentations [2]. Figure 1 illustrates a community-maintained repository for sharing predefined themes for Marp presentations.

Despite the variety of themes available in the community, they often do not conform to institutional standards. For this reason, a study was conducted on the presentations used by faculty and students of the BSI program at IFS Campus Lagarto to identify the authors' visual standards and replicate them using the Marp tool.

Figure 1. Marp theme repository.



The analysis included observations of presentations made available by professors on the Integrated Academic Activities Management System (SIGAA) and thesis defenses conducted by students, both in person at IFS and via platforms such as Google Meet. During the study, common visual elements were identified in the presentations, particularly in design, including predominant colors, font size and spacing, and element alignment.

In Figure 2, we present two presentations where the color green is dominant, reflecting the visual identity of IFS. The presentation follows a consistent spacing and alignment pattern focused on clarity and readability, along with the institutional logo to indicate its origin. These visual characteristics were designed to create a harmonious and professional experience that aids students in content assimilation. Additionally, the consistent use of institutional identity reinforces the recognition of IFS in educational materials, promoting more excellent uniformity and professionalism.

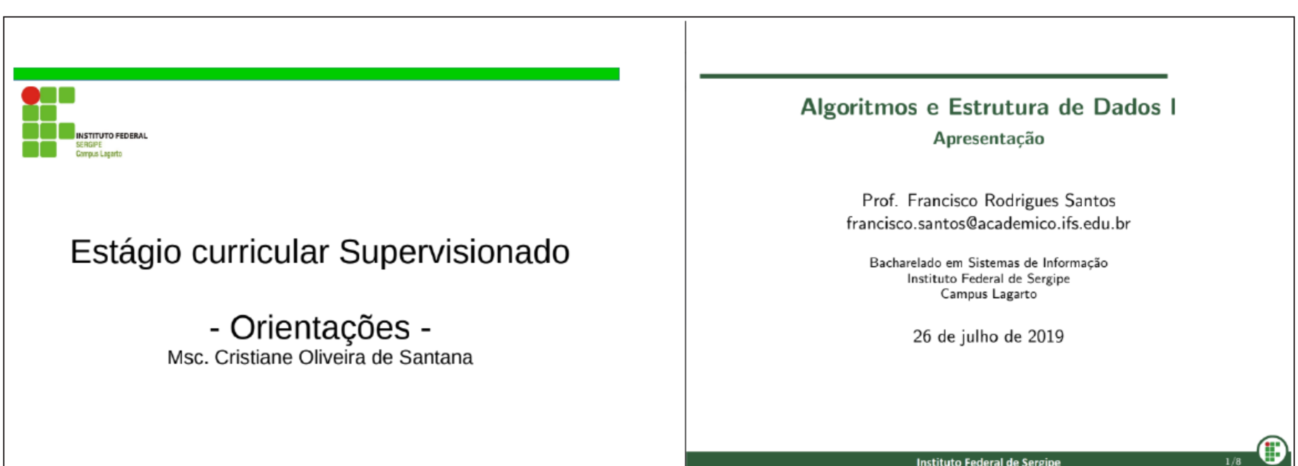
Typically, slide backgrounds have soft and neutral colors, while text colors provide strong contrast—for example, a white background with black text to ensure optimal readability. Additionally, slides should contain only essential information, allowing the presenter to effectively explain concepts, methodology, and results [10].

Another example of standardization, as seen in Figure 2, is using visual elements (such as the logo and color scheme) to create a visual identity consistent with the institutional standard. While these characteristics are not strict rules, the analysis revealed that these visual elements are recurring in the evaluated presentations. Furthermore, the study highlighted legible font sizes, typically between 14 and 16 points. Fonts that are too small hinder readability, reduce accessibility, and cause discomfort for the audience, while huge fonts may limit the space available for important content [10]. Based on these findings, the map-theme-academic theme from Marp was customized to align with the IFS visual standard, as this template includes many of the elements observed in the study. To achieve this, a fork of this theme was created on GitHub.

Figure 3 illustrates the GitHub repository created from the original theme. This repository contains the necessary customizations for IFS slide presentations. By centralizing the style rules, any modifications made to the repository will automatically apply to all projects using this theme.

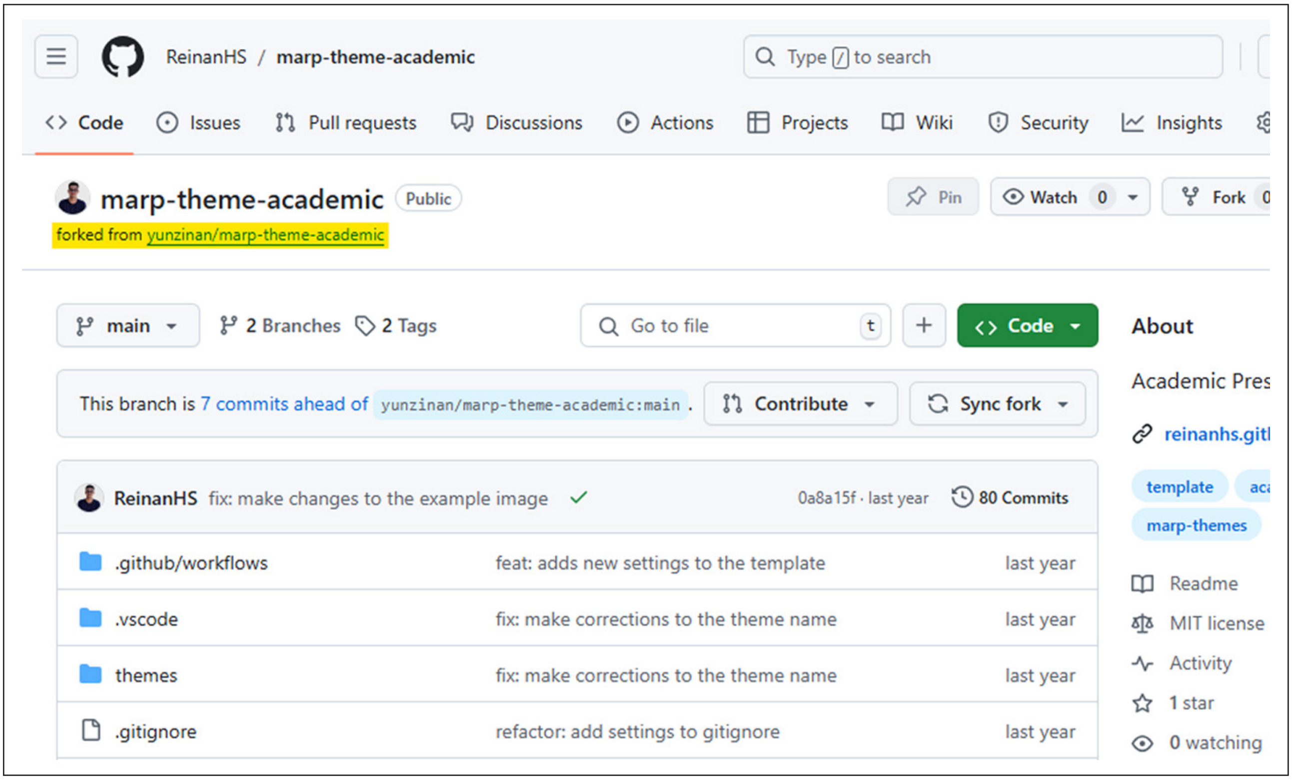
The main configuration file in this repository is themes/academic.css. This file contains all the style rules for the slides, including font size, colors, and other settings that define the theme used by

Figure 2. Examples of slides at IFS.



a) Supervised internship b) Data structure I

Figure 3. IFS Marp template repository.



the authors. It plays a crucial role, allowing Marp to identify and apply the defined configurations when generating slides. A white background was the default within this configuration file, avoiding intense colors. Additionally, only two shades were used for the text.

The development of the academic theme for Marp follows the same principles used in creating Limarka, a solution designed to standardize the formatting of academic papers according to the norms of the Brazilian Association of Technical Standards (ABNT). Similarly, the Marp academic theme was developed to ensure that presentations align with IFS institutional guidelines. This approach facilitates and streamlines the creation of slides following academic standards while promoting consistency and professionalism in materials presented by students and faculty [9].

Educational Materials with IFS Marp

The process begins with writing slide content in Markdown format using Marp. The content is then versioned locally using Git and pushed to the project's repository on GitHub. At this stage, a Pull Request is created for review, allowing for analysis and validation by other collaborators. Once approved, these modifications are merged into the principal repository, automatically triggering the CI/CD pipeline. This pipeline compiles the slides into HTML, PDF, and PPTX formats.

To complement the standardized and automated workflow described above, a GitHub repository was created containing the entire structure necessary to facilitate the adoption of the customized Marp theme. This repository includes an initial file called slide-deck.md, located in the project's root directory. This file is a base template, giving users a starting structure for developing their presentations.

The slide-deck.md incorporates IFS institutional guidelines for visual standardization. The process is intuitive: users write content in Markdown format, and Marp automatically converts the text into a visually consistent presentation. This approach reduces the technical complexity involved in creating educational materials and ensures that presentations meet the quality and uniformity requirements established by the institution.

Figure 4 illustrates how an instructor can write their presentation using the structure provided in the slide deck file. With this configuration, changes are displayed in real-time. To enable this feature, users must activate the Markdown preview in the upper right corner of the file editing tab. Images, charts, code snippets, and even mathematical formulas are possible to include in academic presentations. To demonstrate how to utilize these resources effectively, a YouTube video has been published: [https://youtu.be/sPbBDXfdofA]. This material provides a practical demonstration of integrating these elements into Marp presentations, showcasing real-world application examples.

Additionally, the video guides users on best practices for creating visually impactful presentations and explains how to streamline the process by using CI/CD automation.

It is necessary to add a configuration in the .vscode/settings.json file so that the tool recognizes the repository link and applies the settings to the slides. This ensures that Marp correctly imports the theme customizations.

Figure 5 illustrates the configuration added to the file. It is important to note that the setup references the reinanhs/marp-theme-academic repository, which contains the entire fundamental structure required to format the slides according to the defined standards.

Slide Compilation and Publication via CI/CD

An automated pipeline was configured to compile the slides whenever changes are pushed to the main branch of the GitHub repository. This pipeline compiles the presentation into three formats: HTML, PDF, and PPTX. These formats cater to user needs and preferences, allowing the material to be viewed in browsers, printed, or edited in presentation software such as Microsoft PowerPoint.

The automated compilation process uses Marp CLI, a specialized tool for converting Markdown files into presentations. The pipeline configuration ensures that the files are generated in the desired formats. With every push to the main branch, the pipeline executes the following steps:

Figure 4. Example of using IFS Marp.

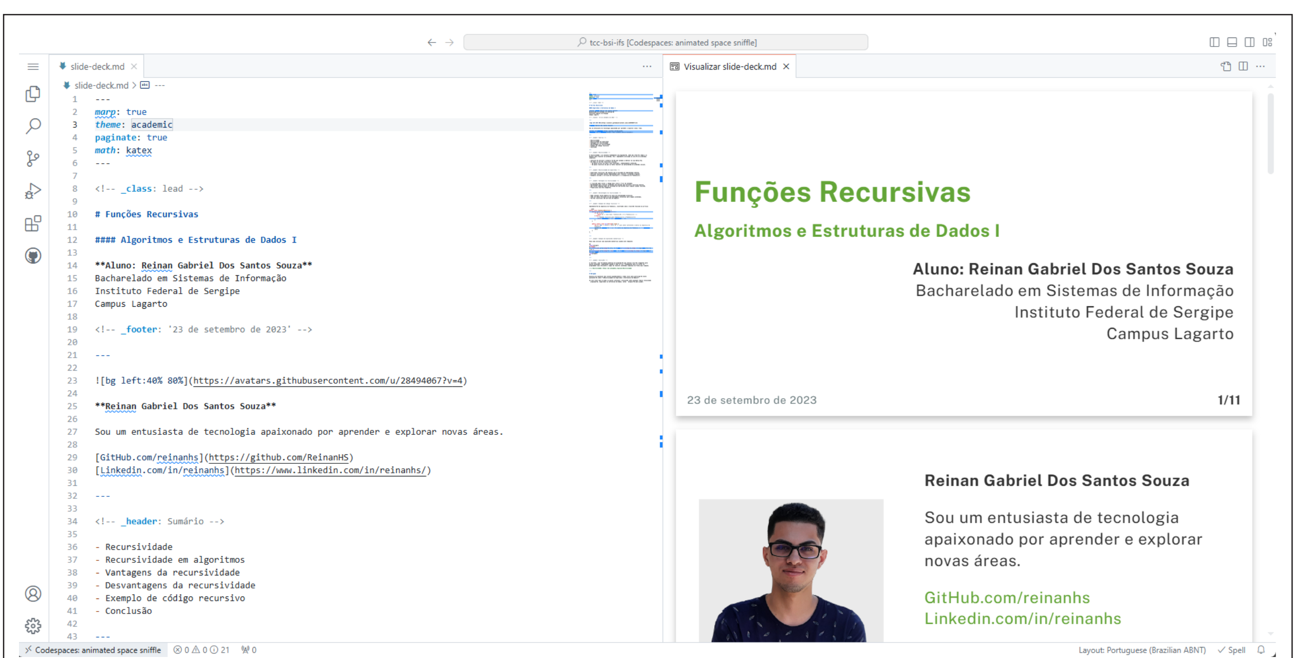


Figure 5. Configuration for IFS Marp.

```
    "cSpell.ignorePaths": [
      ".vscode",
      "templates",
      "configuracao.yaml"
    ],
    "markdown.marp.themes": [
      "https://raw.githubusercontent.com/reinanhs/marp-theme-academic/main/themes/academic.css"
    ],
    "markdown.marp.enableHtml": true
  }
```

- **Code Checkout**: The pipeline begins by checking out the latest code from the main branch, ensuring that all recent changes are available for compilation.
- **Creation of the dist-slide Directory**: A directory named dist-slide is created to store the compiled files.
- **Theme Download**: The custom theme is automatically downloaded to ensure the slides follow the desired visual standard.
- **Compilation to HTML**: The first compilation step converts the Markdown file (slide-deck.md) into an HTML presentation.
- **Compilation to PDF**: The pipeline generates a PDF version of the presentation, which is recommended for printing or easy sharing. Compilation to PPTX: The slide is converted into a PPTX format, which makes it compatible with Microsoft PowerPoint and allows interactive editing.
- **Publishing of Artifacts**: All generated files are stored and available for download in the repository after compilation. The files are retained for one day, ensuring students have access to the generated materials while optimizing storage usage in the repository.

Collaborative Workflow via GitHub

In addition to enabling process automation, such as the compilation and publication of slides through CI/CD pipelines, this study also proposes an optimized workflow for the collaborative creation of educational materials. Drawing on best practices in software development, the proposed workflow leverages GitHub features to ensure that collaborators can edit and contribute in an organized and efficient manner. In this model, all proposed modifications to the materials go through a structured discussion and review process, ensuring that only thoroughly evaluated contributions are integrated into the final document. This approach enhances the quality of the produced content and fosters a controlled and transparent collaboration environment.

In the context of the proposed collaborative workflow, GitHub plays a key role in the organization and shared editing of documents. The platform offers features like Issues and Pull Requests, which can manage the development of educational materials or academic projects. For example, when discussing the choice of a title for an educational material, the student can open a specific Issue, encouraging structured interaction with their advisor. This space allows for sharing ideas and arguments and clarifying doubts until a consensus is reached. Once a decision is made, a Pull Request can be created to formalize the change and linked to the corresponding Issue, allowing it to be closed in a documented and transparent manner.

Figure 6 illustrates this dynamic between student and advisor regarding the project title selection. During the process, both parties can leave comments and suggestions, with automatic notifications for every update. This approach promotes collaborative interaction and creates a detailed and auditable history of decisions made, fostering an efficient and organized workflow.

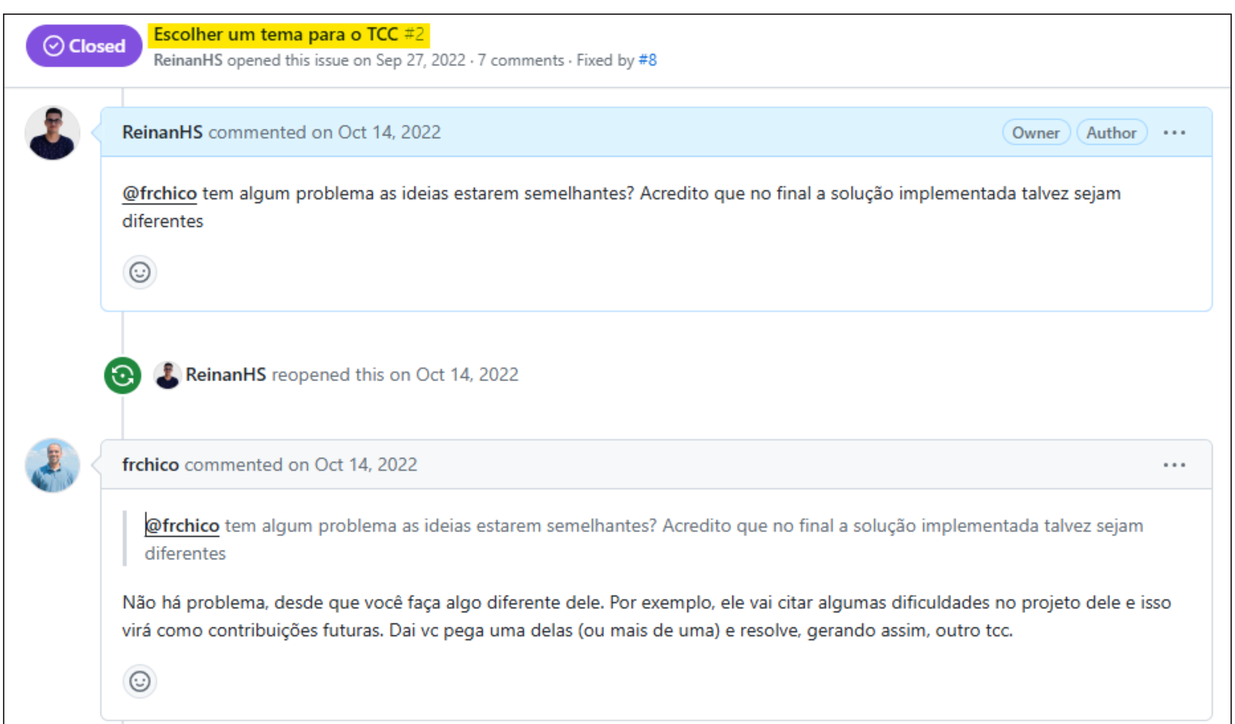
When dealing with software development, whether in an individual project or within a team, managing a complex scope of tasks to be implemented is a common challenge. In this context, GitHub Issues is a handy feature that provides visibility and efficiency in communication between team members. Issues can be used to track bugs, enhancements, or other project demands [11].

The proposed method enables active participation from all involved in the discussion and review of relevant information, ensuring that each decision is well-founded. One feature that enhances this process is the visualization of Issues through a Kanban board, which makes it easier to track the progress of tasks related to academic work in a clear and organized manner.

The student and the advisor can access a structured view of task management through the Kanban board integrated into GitHub. This board allows them to monitor the status of tasks in real time, with cards being moved between columns to represent the progress of activities. Additionally, the history of changes is automatically recorded, providing complete traceability of the actions taken. This approach not only promotes transparency and control over the project's development but also offers a powerful visual tool for organizing and prioritizing tasks, helping efficiently manage the academic work.

The GitHub Kanban Board is a powerful tool that significantly contributes to the organization of projects, allowing for visual and efficient workflow monitoring. With the Kanban Board, columns can be created to represent different stages of the workflow process, and cards can be moved to indicate the progress of each task.Using this tool makes it easier to visualize which tasks are waiting to be started, which are in progress, and which have been completed. This clarity

Figure 6. Discussion via GitHub issue.



helps identify bottlenecks and increases team productivity, giving all participants an overview of the current project status [12].

GitHub also offers robust version control, another key element for the success of collaborative projects. In this process, the student forks the official version of the educational material, creating an independent repository where changes can be made freely. During the creation or review of files, modifications are systematically recorded in commits, documenting the progress of the changes made.

When the changes are ready for review, the student can submit it as a Pull Request (PR), automatically notifying the advisor or other collaborators with review permissions. GitHub's review interface is designed to facilitate the analysis of these changes, allowing for detailed comments on specific lines of code and the overall context of the Pull Request. This functionality fosters clear and objective communication and enables cross-references between Pull Requests, Issues, and Authors, enhancing interconnection and traceability within the project. Once all requested modifications have been made, the repository maintainers, who have elevated permissions on GitHub, approve the Pull Request and merge the changes into the official version of the material. This writing and review process can be entirely conducted through GitHub using a web browser. Adopting this strategy shows efficiency in the writing process by providing unrestricted but structured editing, intelligently limiting which authors or sections can be edited. Additionally, each commit is associated with a specific author, making it easier for collaborators to recognize individual contributions [13].

Managing Updates with Changelog and Releases

Building on the collaborative version control and review practices discussed earlier, it is crucial to adopt strategies that ensure the traceability and organization of the changes made throughout the project. Maintaining a changelog and using the Releases feature on GitHub is essential in this context. These tools document the changes made and structure communication among the contributors, ensuring clarity and accessibility regarding the progress of the material's development. The changelog is a detailed and systematic record of all significant changes made to the project, such as the development of new features, performance improvements, bug fixes, and other relevant modifications [14]. This documented history provides an overview of the project's progress and directly connects to previously discussed version control and collaboration features like Pull Requests and Kanban boards.

The integration of Marp with platforms and tools that enable CI/CD offers educational content creators a quick, flexible, standardized, simple, and maintainable way to create educational materials while providing access to different formats. The workflow presented in this article enables an automation process that transforms the creation and distribution of educational materials, offering greater efficiency and consistency in content publication. Using Marp in conjunction with CI/CD tools has significantly enhanced the process of creating slides for lessons.

Analysis and Conclusions

The integration with CI/CD allowed slides to be created, viewed, and automatically published on platforms like GitHub Pages. This ensures that any modification made to the materials is immediately reflected in the various versions made available to readers. This automated process eliminates the need for manual updates, reducing human error and saving time for the authors.

Moreover, using Markdown syntax significantly simplifies the creation of slides, allowing editors to focus on the pedagogical content. At the same time, the formatting and publishing stages are managed automatically through CI/CD pipelines. This approach removes the need for advanced technical skills in creating professional presentations, making the process more accessible and efficient. Additionally, Marp's compatibility with formats like HTML, PDF, and PPTX offers essential flexibility for distributing materials across various platforms and devices, broadening the reach and promoting inclusivity for students with different access needs and preferences

Figure 7 presents a practical example of educational material on the Java coding of the Fibonacci sequence automatically published on a GitHub Pages HTML page. This example demonstrates the tool's potential and possibilities. This approach not only demonstrates the tool's flexibility but also its ability to integrate technical programming concepts into visual and didactic materials, offering a richer and more engaging learning experience. By making the content available quickly and organized, the tool promotes more effective interaction between teachers and students, strengthening the educational process.

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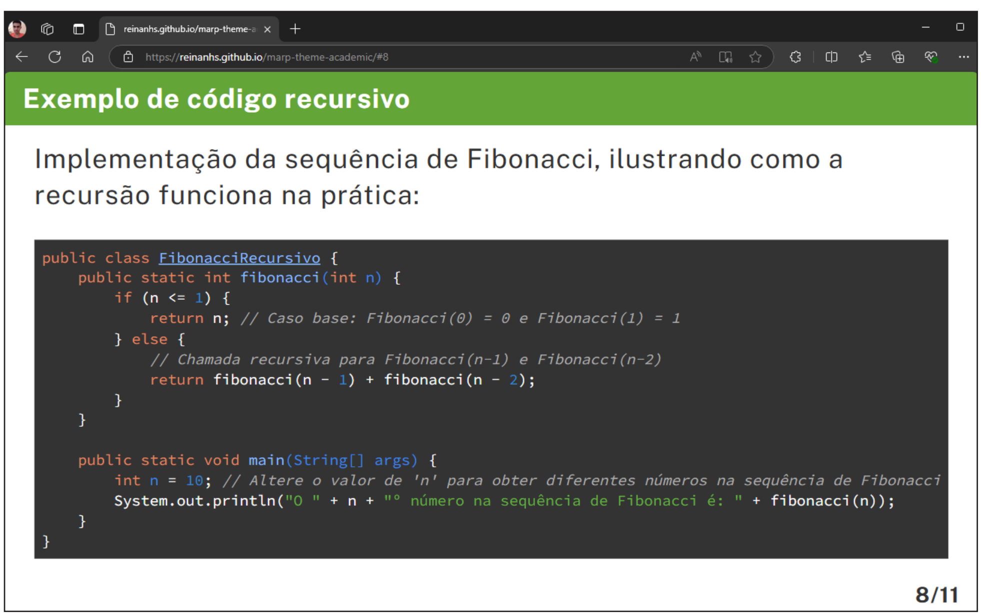
We would like to thank IFS for their institutional support and the BSI professors from IFS, Campus Lagarto, for their valuable contributions, guidance, and discussions that enriched the development of this research. Finally, we would like to thank Marcelo Castro and MOVA for their support and for allowing us to participate and present this work at ERBASE 2024, contributing to the exchange of knowledge and strengthening the field.

Figure 7. Educational material on GitHub Pages.



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ICT & ELAS: Training and Women's Empowerment in the Exploration of Augmented Reality and Virtual Reality, Building Bridges Between Gender and Technology

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The "ICT & ELAS" project aims to train girls in high school and elementary school II from public schools in the metropolitan region of Salvador in augmented reality (AR) and virtual reality (VR) technologies. The project aims to transform the approach to social challenges by integrating these tools, promoting female empowerment and gender equality. Through AR and VR, the project aims to raise awareness, educate and engage students, encourage awareness and collective action on gender and ethnicity issues, and expand the dialogue with socio-educational initiatives in the capital of Bahia. As research that aims to generate knowledge, it is methodologically categorized as applied. This article concludes by presenting the results achieved.
Keywords: Augmented Reality (AR). Virtual Reality (VR). Female Empowerment. Gender Equality. Socio-Educational Initiatives.

Augmented Reality (AR) and Virtual Reality (VR) combine knowledge abstraction with cognitive recognition of the results of practical technological applications. These technologies can provide 3D visualizations and simulations without needing real-world experimentation, demonstrating their effective educational potential. Through sensory immersion, they enhance user experience and facilitate meaningful student learning. Additionally, they are perceived as innovative and highly engaging tools.

With the increasing availability of technological innovations and the dissemination of knowledge, learning platforms, collaborative spaces, open educational resources, and learning objects have emerged, increasing the demand for training in digital technologies. The market inclusion of future professionals will depend on their mastery of technology and its application as a problem-solving tool. AR and VR in teaching practices can help address specific content or facilitate laboratory experiences that cannot be conducted within the traditional classroom setting of public institutions.Moreover, these technologies can be easily replicated and reused in various contexts, enhancing the user experience.

The historically exclusionary nature of education in Brazil is gradually giving way to opportunities for economically and culturally vulnerable communities to access quality education. This represents a modest but significant advancement in promoting inclusion and social equality.

The project aligns with the three pillars of the university—teaching, research, and outreach—which are often inseparable. The outcomes obtained contribute to education and research, providing expertise in science, technology, and innovation. This culminates in the execution of workshops, documentation of participant experiences, and scientific publication. Additionally, the project aspires to collaborate with schools to train new multipliers who can further disseminate its impact.

Contextualization of the Theme

Gender inequality in technology and exact sciences remains a persistent issue in many societies worldwide. Despite significant progress in increasing female participation across various sectors, the technology landscape reflects deep disparities. Historically, women have been underrepresented in technology-related

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professions, often due to social and cultural barriers that discourage their participation.

These barriers start early, with a lack of encouragement in school environments, gender stereotypes that associate technology and science with predominantly male professions, and a scarcity of successful female role models in these fields. Studies show that when girls are exposed to the world of technology and encouraged to participate, they perform just as well as, or even better than, boys. However, many abandon pursuing technological careers due to a lack of representation and institutional support.

According to UNESCO, as of 2020, only 30% of scientists worldwide are women [1]. In Brazil, female researchers make up 40.3% of the total. Women in vulnerable situations often face multipl6. e challenges, including limited access to education, gender-based violence, financial constraints, labor market discrimination, healthcare access difficulties, and a lack of political representation. Additionally, according to the Atlas of Social Vulnerability in Brazilian Municipalities [2], the country's Northeast region presents high Social Vulnerability Index (IVS) figures, directly impacting the education available to the population.

Projects like ICT & ELAS aim to mitigate gender barriers in the technological field by encouraging young girls to reflect on the discussed social context and apply AR (Augmented Reality) and VR (Virtual Reality) technologies. By training girls in emerging technologies, the project provides an opportunity to engage and empower them in traditionally male-dominated areas. The primary goal is not only to offer technical training but also to foster confidence and self-efficacy, allowing participants to see themselves as capable of contributing to and thriving in high-tech fields. Additionally, the project seeks to challenge the cultural barriers students face, empowering them to become agents of change within their communities.

AR, VR, and UX in Education: Broadening Perspectives

Augmented Reality (AR) and Virtual Reality (VR) in educational settings can be applied in various ways. One of the main benefits is the ability to provide real-time three-dimensional simulations, enabling the exploration of complex concepts such as anatomical structures, chemical reactions, or even abstract mathematical ideas. These technologies allow students to manipulate virtual objects and interact with them in real-time, enriching comprehension and facilitating learning subjects that traditionally require expensive or inaccessible physical equipment.

Additionally, the interactivity provided by these technologies transforms the learning environment into a more dynamic and engaging experience. According to Tori and Hounsell (2018) [3], immersion and presence are key elements in defining the success of a virtual environment. Immersion refers to the system's ability to engage the user's senses, while presence is the psychological sensation of "being inside" that environment. This reinforces AR and VR's ability to capture students' attention, fostering active learning that resembles real-life experiences. Tori and Hounsell (2018) [3] point out that "*VR systems already allow for response times of less than 10 ms*," enabling high-quality interactions applicable in various contexts.

The impact of these technologies on education is directly linked to promoting experiences that engage multiple senses, providing a deeper understanding of content, which contributes to meaningful learning. Cybis and colleagues (2010) [4] state that "*user experience (UX) emerges from the interaction between humans and technology*," incorporating emotional aspects. According to the authors, UX arises from this interaction, offering a comprehensive perspective that integrates aesthetic, functional, and interactive properties, shaping how people respond physically and cognitively.

As Hekkert (apud Mont'Alvão and Damazio) [5] defines the experience with a product as "*a set of effects triggered by the interaction between a person and a product, including the degree to which all our senses are gratified (aesthetic experience), the meanings attributed to the products (experience of meaning), and the feelings and emotions that are evoked (emotional experience)*."

The design of AR and VR environments is anchored in understanding the desired user experiences. Thus, AR and VR are powerful tools for promoting UX, especially in increasing technological integration within the educational landscape.

AR and VR Environments: Hedonistic and Functionalist Interactions

AR and VR environments should provide both hedonistic and functionalist interactions, ensuring that students feel a sense of belonging in the experiences associated with the presented content.This ultimately leads to an improvement in education quality and a reduction in the vulnerability of affected populations. Jordan (2000) [6] understands that human beings constantly pursue pleasure, often obtained through direct interaction with products. Emotional, hedonic, and practical benefits drive this pursuit. Practical benefits result from completing specific tasks using the product.

Emotional benefits stem from how a product affects a person's mood. Hedonic benefits relate to the sensory and aesthetic pleasures associated with a product. From this perspective, the design of AR and VR environments is guided by emotion. From Baxter's (2000) [7] perspective, subject-object interaction can occur through attractiveness, which fosters engagement. An attractive product captures attention and pleases the user, and this attraction can take four distinct forms:

- **Familiarity** – Attraction to what is already known.
- **Functional or Semantic Attraction** – Based on usefulness and meaning.
- **Symbolic Attraction** – Related to cultural and social significance.
- **Inherent Visual Attraction** – Based on aesthetic appeal.

Thus, the visual appearance of AR and VR environments acts as a gateway to interaction, facilitating an exchange of information with users within a dialogical interaction context (which includes experiences, social and cultural backgrounds, attention, and interest). Through this dialogue, meaningful interaction emerges. It can be maintained in two ways:

- **Holistically** – A broad perspective of the environment.
- **Detailed Observation** – Systematic analysis based on defined criteria guided by aesthetic perception.

The study by Ricca (2019) [8] encourages critical reflection on the unrestricted use of digital interactive artifacts in mediating experiences. The author questions the assumption that "*simply using such artifacts automatically results in a satisfactory experience.*" Ricca emphasizes that the digital media production market in Brazil is growing. However, responsive interfaces, such as lights, projections, buttons, sounds, and screens, may be an essential tool for knowledge mediation and visitor engagement.

VR headsets, such as the Quest 2 (Figure 1), represent a revolution in education. They offer an immersive experience that goes beyond traditional teaching methods. This technology enables the creation of interactive three-dimensional environments, deeply engaging students and transforming abstract concepts into visual and tangible experiences.

Materials and Methods

According to Fonseca (2002) [9], research enables an approximation and an understanding of the reality under investigation as a continuous and unfinished process. The author also states that scientific research

Figure 1. Quest 2 VR headset.

results from a detailed inquiry or examination to solve a problem using scientific procedures.

A scientific investigation examines a person or a qualified group (the subject of the investigation) while addressing an aspect of reality (the object of the investigation) to:

- Experimentally confirm hypotheses (experimental research),
- Describe phenomena (descriptive research), or
- Explore new aspects (exploratory research).

Due to its nature, the proposed project is classified as applied research, which, according to Silva (2005) [10], aims to generate practical knowledge for solving specific problems. This research is designed to develop a model to be integrated into science education practices through technological inclusion for girls.

In this context, the research was developed through the following stages:

- Mapping and selecting participants
- Planning qualification instruments
- Designing and producing content
- Executing planned activities
  Evaluating and validating activities.

Development: Planned and Executed Activities with Schoolgirls

Initially, schools in the surrounding area were mapped based on the accessibility for girls and the availability of physical facilities. Two schools were identified, and contact was established with teachers. Teachers were asked to form groups of girls (between 5 and 10 participants) for the activities. These girls were expected to act as multipliers within and outside the selected schools.The selection also considered their availability, interest in participating, and social vulnerability criteria.

During phases 2 (planning of qualification instruments) and 3 (content planning and production), the project team and school teachers brainstormed the best approach, considering the students' profiles. It was decided that workshops would be offered to introduce fundamental concepts of AR and VR, culminating in a discussion circle about contemporary issues, including the application and ethics of these technologies. The following key challenges were established for the planning phase:

- Provide training on AR and VR principles and applications, offering theoretical and practical knowledge to spark interest and build confidence in these technologies.
- Encourage the creation of support networks among participants, fostering knowledge sharing and experience exchange
- Inspire creativity and innovation in the use and development of these technologies.

To execute the planned activities, the university laboratory and dedicated spaces within the participating schools were used for school visits. The workshops (Figure 2) were conducted by a student scholarship holder from the project and mediated by the supervising professor and the fundamental education teacher.

In the first phase, the girls were introduced to the content about these technologies. In the second phase, they were encouraged to use VR headsets, including the Quest 2 model, Warrior model, and cardboard VR viewers (the latter two using smartphones). Finally, the discussion circle served as a culminating moment, allowing for an evaluation and validation of the activity.

The workshops conducted with Colégio Estadual Polivalente de Camaçari students

Figure 2. Participants of one of the workshops: Teachers and students.

marked a milestone in training young girls. The participants had the opportunity to interact with technologies that previously seemed distant from their daily lives—all reported never having had contact with the presented content and equipment. The use of VR headsets sparked interest and curiosity, leading to enriching discussions about the potential of these technologies. From their very first experience with the VR headsets, the girls exhibited enthusiasm and curiosity. While experimenting with the immersion provided by Quest 2, many reported feeling "transported" to new worlds—an experience that inspired reflections on how this technology could be applied to their lives and careers. Some participants commented that they had never imagined interacting with a virtual environment, which led to debates on VR's endless possibilities in fields such as education, healthcare, and entertainment.

The interaction with technology sparked questions among them about the future of professions. "*How far can this technology go*?" was a recurring question. The discussions revolved around the possibilities of applying AR and VR in various fields, such as teaching history—through the recreation of historical moments—or in medicine with virtual surgery training. The girls began envisioning scenarios where they could be creators of these experiences rather than just consumers. In this sense, the workshop introduced the technology and opened up a new horizon for these young women, now considering careers in science and technology.

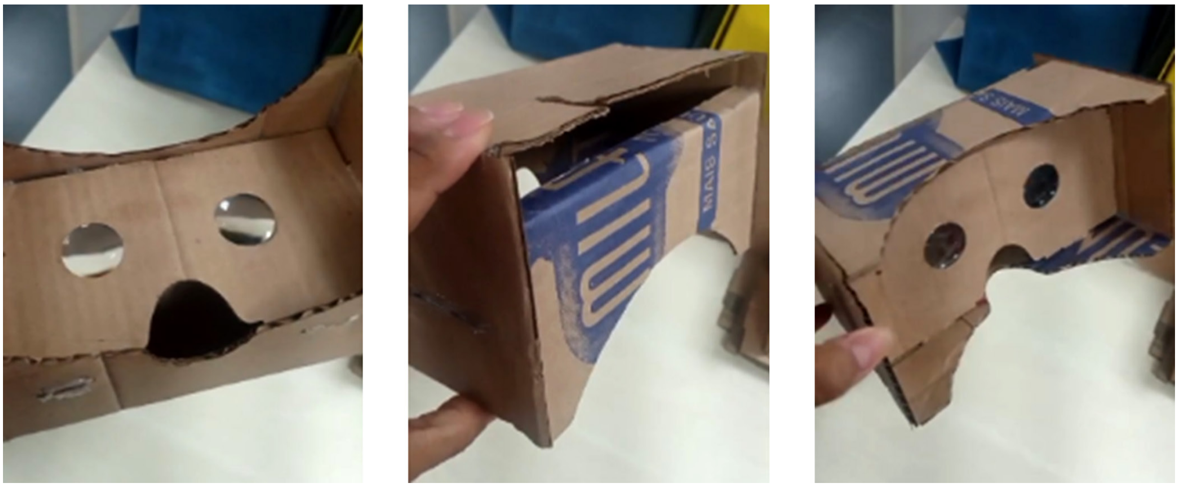
The use of the Quest 2 headset, one of the most advanced VR devices, was a highlight of the workshop. The girls experienced high-quality graphics, immersion, and interaction provided by the device. Some described the experience as "incredible" and "unforgettable," emphasizing the sensation of being in another place, interacting with virtual elements as if they were real. This experience was essential for them to understand the impact of VR on their daily lives and future career choices.

Other key aspect of the workshop was using VR headsets made from accessible materials, such as cardboard (Figure 3). This exercise showed the girls that technology does not have to be inaccessible or expensive. They could build their own VR headsets using low-cost materials, utilizing smartphones as screens. The cardboard headset was donated to the school.

Conclusion

AR and VR technologies have emerged as innovative and transformative tools in the

Figure 3. Prototype of the developed and tested VR headset.



educational field, providing new forms of student engagement and promoting a more interactive and meaningful learning experience. These immersive environments facilitate the understanding of complex concepts and broaden access to quality education, positively impacting the teaching process and including historically underrepresented groups, notably women in science and technology.

Initiatives such as the ICT & ELAS project highlight the potential of AR and VR technologies in promoting equal opportunities and strengthening the empowerment of girls in contexts of social vulnerability. The 25 participants in the workshops showed high engagement levels as they interacted with these emerging technologies. The immersion provided by VR devices such as the Quest 2 sparked a genuine interest in technology, fostering discussions about the future of professions and the possibilities these tools offer. The hands-on experience and the construction of VR headsets using low-cost materials demonstrated the potential for democratizing access to the technological world, inspiring these young women to explore new educational and professional opportunities.

The adoption of AR and VR in the educational context not only enhances the learning experience but also contributes to building a more inclusive education. Demystifying access to digital tools promotes the inclusion of young people in innovative and technological job markets. By empowering individuals and expanding their digital competencies, these tools play a crucial role in building a fairer, more innovative society ready to face the challenges of the 21st century

It is recommended that the project continue expanding activities to include lectures and debates with recognized women in the field so they can share their experiences, create an open space for discussions about challenges and opportunities, and inspire the students. The target audience should be expanded to include elementary and high school girls. Practical workshops should be held on creating accessible VR headsets, designing VR environments, and developing 3D models in AR. Additionally, mentorship and personalized guidance should be offered to assist participants in developing their projects and enhancing their technical skills while encouraging network formation.

The use of AR and VR in a problematizing context can transform how we approach and solve social challenges. These technologies offer new ways to raise awareness, educate, and engage students, promoting awareness, empathy, and collective action to address issues related to gender and ethnic belonging.

It is also worth emphasizing the social strengthening of this action through the involvement of university extension projects as a space for dialogue with the community, promoting knowledge transfer, co-creation of knowledge, exchange of experiences, and formation of collaborative networks. The project provided a space for direct interaction between the university and society, demonstrating its commitment to the training and development of women in science and technology. It also facilitated the exchange and encouragement of knowledge through co-creation alongside teachers from the schools.

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"Elas nas Exatas" Project: An Evolving Trajectory

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The "Elas nas Exatas" project addresses the underrepresentation of women in Science, Technology, Engineering, and Mathematics (STEM) fields in Brazil by leveraging Research, University Extension, and social media to inspire and empower young girls and women. The project includes mini-courses, workshops, and a YouTube channel featuring stories of women in STEM. Results indicate increased self-efficacy and broadened career perspectives among participants despite ongoing structural challenges. The diversity of interviewees and the visibility provided by the project have been crucial in promoting female inclusion in STEM.

Keywords: Underrepresentation of Women in STEM. Empowerment of Young Girls and Women. Self-Efficacy. Encouragement of Women into STEM Careers. Evolving Trajectory.

Fields of Science, Technology, Engineering, and Mathematics (STEM) face significant challenges in terms of gender and racial inequality, both in Brazil and globally. This scenario is concerning as these fields remain male-dominated, with a notable underrepresentation of women resulting from a combination of complex factors. Several initiatives have been created to promote women's contributions to STEM and encourage girls and women to pursue careers in these areas. However, progress remains limited, highlighting the need for continuous efforts.

In the Brazilian context, the situation remains challenging. According to the National Institute for Educational Studies and Research Anísio Teixeira (INEP), even though women make up the majority of participants in the National High School Exam (ENEM) in all editions and in the university context (Pedagogical Reports - INEP, 1998 - 2012 and in Statistical Synopses of the National High School Exam, INEP, 2013 – 2020) [1,2], they are underrepresented in exact sciences fields. This discrepancy is concerning because performance in exact science subjects can significantly impact young women's academic and professional opportunities, considering we live in a digital and digitized world in many aspects.

Since 2014, various actions have been implemented globally, involving governmental and institutional efforts and university research and extension projects to minimize these inequalities, as exemplified by the "Elas nas Exatas" Project presented here. This project arose from concerns during research for a doctorate completed in 2013. Among many readings, we were troubled by the discussion of whether science is masculine, deepening with authors such as Dr. Áttico Chassot (2003) [3]. Thus, the project emerged to understand this disparity within the university environment and stimulate high school students to choose careers in Earth and Exact Sciences.

Therefore, our intention is to show a bit of the project's journey, its origin, challenges, achievements, and perspectives throughout this article.

Theoretical Bases

The underrepresentation of women in STEM has been a topic of discussion for some time (OECD, 2015 [4]; UNESCO, 2017, 2018 [5,6]; NSF, 2019 [7]; GENEVA, 2020 [8]) because, since the 19th century, women have faced barriers to entering and

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excelling in these fields. Factors such as gender bias, the lack of female role models, and cultural stereotypes contribute to the perpetuation of this inequality, resulting in the invisibility of their achievements in STEM areas. Additionally, the lack of adequate public policies and institutional support further exacerbates the situation, making it difficult for women to access and remain in scientific and technological careers.

It is important to highlight that women's participation in STEM fields is essential and has been discussed by authors such as Chassot (2003) [3] in his book "Is Science Masculine? Yes, Madam." He bases his work on the understanding that patriarchal societies did not emerge by chance. Thus, he examines three influences that have shaped us as human beings in the Western world: Greek traditions with their myths and philosophy, Judaic traditions starting from cosmology and the Torah, and Christian traditions using biblical texts from the apostle Paul and other doctors of the Christian Church. He explores whether the contributions and gaps of these three roots have shaped us with this patriarchal perspective.

Although it is challenging to understand why science is considered a male domain, it is evident that its structure has predominantly been associated with men. However, some women have overcome this established norm, which erroneously assumes women lack the aptitude or competence for the sciences, particularly in the exact sciences. In his work, Chassot seeks to highlight the remarkable contributions of women to the development of scientific knowledge. These accomplishments occurred despite the numerous obstacles that women have faced and continue to face in the scientific field.

In other words, this author is dedicated to highlighting the important contributions that women have made to the development of scientific knowledge. Despite this, they have had to overcome numerous barriers that have been and continue to be systematically imposed.

One of the barriers faced is the underrepresentation of women in the fields of Science, Technology, Engineering, and Mathematics (STEM). As highlighted by Olinto (2011) [9], this phenomenon not only reflects persistent gender inequalities but also represents a significant loss of human potential and innovation for scientific and technological progress. In this context, Research and University Extension, through projects like Elas nas Exatas, emerge as essential means to address this disparity, aiming to understand and seek to minimize it. Extension initiatives that encourage and support the participation of girls and young women in STEM fields are crucial. When these actions are aligned with the principles of University Extension, they can create a more conducive environment for the inclusion of women in the scientific realm of STEM fields. By integrating the objectives and goals of extension programs with the evaluation of the impact of student participation on social issues, as advocated by FORPROEX (2012) [10], these initiatives can effectively contribute to reducing the gender disparity in STEM.

The project is based on essential concepts, such as Deci and Ryan's self-determination theory (1985) [11], which emphasizes the role of intrinsic motivation in personal and professional development. These theoretical bases provide a solid framework that helps the project effectively influence the choices and aspirations of the young participants.

In this way, the Elas nas Exatas project aims to give visibility to women and their contributions to scientific and technological development. Thus, the project has built its trajectory around this purpose through Extension and Research activities.

Materials and Methods

Since its inception, the Elas nas Exatas project has employed various means and methods to achieve its objectives, such as conducting mini-courses, workshops, and interviews with women from STEM fields.

It was launched as a research project in 2017, and in 2018, the extension branch was incorporated. This led to several discussion panels with students from various courses within the Department participating.

In 2019, the extension project continued under the coordination of two faculty members with degrees in Mathematics and two scholarship holders, one from the Civil Production Engineering course and the other from the Chemistry Teaching course.

Since then, a scientific day has been held in the fourth week of March, titled "Workshop in Honor of the Female Presence in Scientific and Technological Development," which features discussion panels, mini-courses, workshops, and conversation circles, led by women in the fields of Exact and Earth Sciences. The first edition took place in March 2019. This year, as a strategy to engage with the young audience (the focus of our work) and to make the Project more well-known, the Instagram account @elasnasexatas_ssa was created. This account publishes the actions carried out by the project in a more direct language, which has enabled the development of other actions aligned with the project's proposal, engaging students both inside and outside the University.

In 2020, with the onset of the COVID-19 pandemic, it became necessary to suspend all activities that were planned to be conducted in person (with nearly 300 participants registered), and the project needed to reinvent itself. Thus, in June of that year, the YouTube channel Elas nas Exatas (www.youtube.com) was created, and live sessions began to be held weekly using streaming platforms.

In 2023, the fifth edition of the Workshop in Honor of the Female Presence in Scientific and Technological Development was held, along with other activities such as discussion panels, lectures, and school visits, always to promote the presence of women and their contributions in the scientific and technological world, as well as encouraging girls and women to become part of this universe. In 2023, the project had the active participation of five scholarship students and five volunteer monitors (four students and one university staff member). The students involved are from the Bachelor's degree courses in Information Systems (three students), Design (one student), Chemistry Teaching (four students), Civil Engineering (one student), and Law (one – department staff member). The project includes four faculty members and 17 students from the aforementioned fields. In 2024, with the team restructured and the addition of new faculty members and scholarship students, the Project held the VI Workshop, featuring Dr. Julieta Palmeira from Funding Agency for Studies and Projects (Agência Financiadora de Estudos e Projetos) (FINEP) as the opening speaker, along with three discussion panels.

Results and Discussion

The project team has submitted proposals to the University's internal calls and, as a result, continues the actions it has developed over the past years. 2017 - Research Project – Elas nas Exatas – highlighting the contribution of women to scientific development; 2018 - Extension Project – Elas nas Exatas: encouraging girls to pursue careers in sciences – partnership with schools in Cabula; 2019 - I Workshop on Female Presence in Exact and Earth Sciences – March 29 (Sônia Guimarães – Aeronautics Institute of Technology (Instituto Tecnológico de Aeronáutica) (ITA); 2019 – The project coordinators were honored during the I Brazilian Meeting of Women in Mathematics at the Institute for Pure and Applied Mathematics; 2020 – II Workshop on Female Presence in Exact and Earth Sciences – March 17 (transformed into live sessions from June to November); In 2021 – III Workshop on Female Presence in Exact and Earth Sciences – remote – March 25 (Carolina Araújo – Institute of Pure and Applied Mathematics (Instituto de Matemática Pura e Aplicada - IMPA) (Opening lecture link: https://www.youtube.com/watch?v=J8n9ynaKmWI); In the year 2022, it was carried out IV Workshop on Female Presence in Exact and Earth Sciences – remote – March 24 (Christina Brech – University of São Paulo (Universidade de São Paulo - USP) (Opening lecture link: &t=46s); The following year, the fifth edition of the workshop was held – in-person –

March 29 (Carolina Brito - Federal University of Rio Grande do Sul (Universidade Federal do Rio Grande do Sul - UFRGS) – The event was hybrid and had support and participation from Bahia Department of Science, Technology and Innovation (Secretaria de Ciência, Tecnologia e Inovação - SECTI) and Secretariat of Education and Culture of the State of Bahia[1] (Secretaria da Educação e Cultura – SEC). (Opening lecture link: https://www.youtube.com/watch?v=dUCs8QBdpDE&t=338s)

In the year 2023, the Elas nas Exatas Project Connecting Knowledge (aligns with the objectives of the Elas nas Exatas Project in connection with the bicentennial of July 2) was launched, and Elas nas Exatas Project Goal 2030 (aligns with the objectives of the Elas nas Exatas Project in the perspective of the United Nations' 2030 Agenda – UN). Both projects won internal university calls. 2023 – Participation on July 2, honoring the women from Bahia who fought during the struggles for Brazil's independence. This was one of the reasons for launching Connecting Knowledge that year. In the same year, we created a panel for the entrance hall of the Department titled "Women in Sciences.Women in History," featuring women who participated in interviews on the project's channel, some significant in the history of exact sciences in Brazil and abroad, as well as historical women from the struggles of July 2. Continuing, in the first semester of 2023, the Elas nas Exatas project submitted a Technical Note for the University's consideration to create a Program for Women in Sciences aimed at including existing or future Teaching, Extension, and Research projects, actions, and activities, aligned with themes/objectives addressed by the Elas nas Exatas Project. We are awaiting developments. In 2024, with a restructured team and the inclusion of new faculty and scholarship students, the Project held the VI Workshop, and we are resuming the live sessions starting in October.

[1]In the Brazilian governmental system, a "Secretaria" (Secretariat) at the state level is equivalent to a Ministry at the federal level, being a high-level executive body led by a State Secretary.

The project's methodology, centered on content creation and dissemination through a YouTube channel, deserves an in-depth analysis. With over 100 hours of interviews involving more than 60 educators, researchers, and professionals in STEM fields from both Brazil and abroad, the project has built a valuable repository of experiences and knowledge. The number of accesses and views indicates a significant reach and great interest in the content produced.

The interviews for the project's channel began in June 2020. From the sixth interview onward, it was decided that each conversation would have a specific theme to guide the discussion. However, in each virtual meeting, the interviewer asks the interviewees to share their journey before entering higher education, identify influences on their career choices, and present their future projects. In 2020, the first thirty-eight interviews for Project Elas nas Exatas were conducted. Since then, the channel has hosted 102 videos featuring the academic trajectories of women, stories of women from the past, and girls who already excel in STEM fields, even at such a young age.

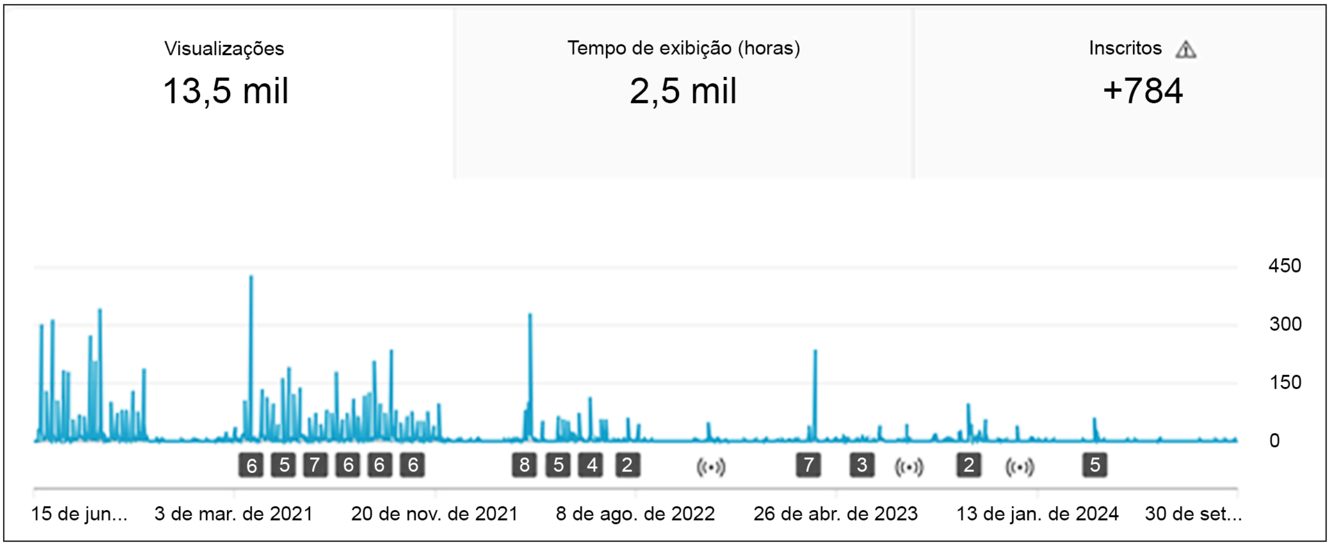
The channel has 784 subscribers who follow the content that has already been published, generating 13.5 thousand views and 2.5 thousand hours of watch time. These are significant metrics for a channel focused on encouraging girls and young women in STEM fields by showcasing interviews that discuss women's journeys in these areas. This is important, as it indicates we are on the right path in disseminating quality material.

Figure 1 shows the fluctuation observed in channel access, which is declining. However, as mentioned before, we resumed live sessions with bi-weekly interviews between October and December 2024.

In summary, the results obtained from the statistics of the Elas nas Exatas Project channel on YouTube are as follows:

- Nearly 13,500 views;
- 2,500 hours of watch time;
- 120,000 impressions;
- More than 100 hours of original content;

Figure 1. Project channel statistics on YouTube.



- Viewers are mainly from Brazil but also from Colombia and Portugal;
- The predominant age group among viewers is 18 to 24 years old, accounting for 43%;
- The channel's audience is primarily female, with 74% of subscribers;
- The use of English subtitles is minimal (0.1%), but it indicates the presence of viewers from English-speaking countries, which broadens the channel's potential reach.

These data demonstrate a significant reach, especially given the specificity of the content. The high number of accesses compared to views suggests that the channel generates initial interest, but there is room to improve audience retention. This can be achieved through content optimization strategies and more targeted engagement, which we are already initiating.

The diversity of interviewees, which includes over 60 interviews with women and men from various STEM fields, career stages, and geographical backgrounds, has contributed to creating a rich and varied panorama of experiences in these areas. This approach aligns with Ausubel's principle of meaningful learning (1968) [12], providing multiple points of connection for a diverse audience. Providing a summary of what was discussed and presented during the interviews, specific patterns can be observed in the experiences of women in STEM, namely:

1. **Importance of Family Support**: Many interviewees highlighted the crucial role of family support in their career choices, which resonates with Deci and Ryan's self-determination theory (1985) [11], emphasizing the importance of relatedness and social support in intrinsic motivation.
2. **Challenges of Representativity**: Most interviewees reported being part of a gender minority group in their classes and work environments, with a predominance of male teachers and colleagues, corroborating Chassot's (2003) [3] observations on the historical masculinization of science.
3. **Barriers in the Workforce**: Experiences of near exclusion from job opportunities and invisibility in male-dominated discussions were reported, aligning with the horizontal and vertical segregation mechanisms described by Olinto (2011) [9].
4. **Perception of Positive Change**: Many interviewees noted a gradual improvement in the situation for women in STEM, indicating an upbeat, albeit slow, trend.
5. **Awareness of the Importance of Representation**: Participants recognized the importance of their visibility in inspiring

other girls, demonstrating a positive cycle of empowerment.

In addition to these aspects, impressions collected from a sample of female viewers revealed positive impacts of the project, the results of which are listed below:

- **Increase in Self-Efficacy**: Many young women reported feeling more confident in their ability to pursue careers in STEM after watching the videos.
- **Broadened Perspectives:** Viewers mentioned discovering careers and opportunities in STEM they were previously unaware of.
- **Identification with Role Models**: The diversity of interviewees allowed many viewers to find role models with whom they could identify, reinforcing the importance of representation.
- **Overcoming Strategies**: Young women value the practical advice and strategies interviewees share to overcome career challenges.
- **Awakening of Teachers to Address the Theme**: Some teachers who watched the channel showed enthusiasm for the topics discussed. They began incorporating these subjects into their classrooms, developing projects with basic education students.

However, we still face challenges:

- **Limited Reach**: Although significant, the project's reach is still limited compared to the potential target population.
- **Sustained Engagement**: Maintaining continuous audience engagement in a saturated digital environment is challenging.
- **Measurement of Long-term Impact**: Evaluating the project's long-term impact on viewers' career choices requires longitudinal follow-up, which has not yet been conducted.
- **Structural Barriers**: The project alone cannot address all structural and institutional barriers hindering female participation in STEM.
- **Low Perception of the Importance of Extension**: Universities need to actively commit to Extension, recognize and value the work of teachers in this area, expand the implementation of incentive policies, allocate adequate resources, and define evaluation metrics that reflect the importance of Extension.
- **Recognition of Extension as a Space for Research and Teaching**: Extension is where academic research translates into social impact, and teaching becomes a two-way street, allowing the University to engage with the community, share knowledge, and learn from its demands.

The potential demonstrated by the results of the "Elas nas Exatas" project, both through the channel and other activities, indicates that it is a tool we should continue to use to promote female participation in STEM. The innovative use of social media, combined with an approach based on established educational and psychological theories, has created a space of visibility and inspiration for women in these fields.

The diverse experiences shared by the interviewees provide a realistic overview of the challenges faced by women in STEM while also offering inspiring examples of overcoming these obstacles. This is particularly important in light of Chassot's (2003) [3] observations on the historical masculinization of science and the segregation mechanisms described by Olinto (2011) [9].

The positive impressions of the viewers, especially in terms of increased 5self-efficacy and broadened perspectives, suggest that the project is fulfilling its objective of empowering and inspiring girls and young women, aligning with the principles of self-determination theory (Deci & Ryan, 1985) [11], by promoting a sense of competence and autonomy in career choices.

Nevertheless, the project's challenges, particularly in terms of reach and sustained engagement, indicate the need for ongoing optimization and expansion strategies. Furthermore, the persistence of structural barriers highlights the importance of complementing initiatives like this with broader political and institutional changes.

Conclusion

The "Elas nas Exatas" project presents a methodology capable of addressing the underrepresentation of women in STEM fields.

The project demonstrates the potential to inspire and empower girls and young women to consider and pursue careers in these areas by combining research and university outreach, strategic use of social media, and strong educational theories. The diversity of the interviewees provided multiple points of identification for the target audience, reinforcing the importance of female visibility in STEM and contributing to increased confidence and broadened career perspectives for the participants. The project's results indicate the significant effectiveness of the digital outreach model, with YouTube as the leading platform, allowing for substantial reach and creating a valuable repository of experiences and knowledge. Nevertheless, the interviewees' accounts confirm the persistence of significant barriers for women in STEM, indicating the need for ongoing and multifaceted efforts. The perception of a gradual improvement in the situation of women in STEM suggests that initiatives like this can contribute to positive cultural change. To maximize impact, higher education institutions need to consider implementing similar projects, leveraging the potential of social media to reach and engage a broader audience. Furthermore, the experiences and reflections generated by the project can be incorporated into STEM curricula, promoting a perspective aimed at a sociocritical, inclusive, and diverse education to increase women's participation in these fields. Cross-sector partnerships and support policies are also crucial for expanding the reach and impact of initiatives like this. Ultimately, the "Elas nas Exatas" project represents an important step towards a future where the talent and potential of all individuals, regardless of gender, can be fully realized in the fields of Science, Technology, Engineering, and Mathematics.

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