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Development of an interactive educational game for early childhood education

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Abstract

The integration of digital technologies into early childhood education has increased the demand for educational tools that are accessible, pedagogically grounded, and aligned with official curricular guidelines. In this context, educational and serious games have emerged as promising resources to support learning through playful and interactive experiences. This paper presents the design, implementation, and exploratory evaluation of a web-based educational game platform aimed at supporting early childhood education in accordance with the Brazilian Base Nacional Comum Curricular (BNCC). The proposed platform integrates pedagogical principles with game-based learning strategies and offers a set of interactive mini-games designed to stimulate fundamental competencies, including motor coordination, language development, emotional recognition, and logical reasoning. The system was developed using open-source technologies and follows a three-layer web architecture composed of frontend, backend, and data persistence layers, ensuring accessibility, scalability, and compatibility with multiple devices without requiring local installation. An exploratory qualitative evaluation was conducted focusing on functional performance, usability, accessibility, and pedagogical coherence. The results indicate that the platform operates reliably across different devices, provides an intuitive and age-appropriate interface, and demonstrates strong alignment between gameplay mechanics and intended learning objectives. The main contributions of this work include the explicit alignment of educational game design with BNCC competencies, the adoption of a modular and accessible web-based architecture, and the presentation of an educational game platform grounded in both pedagogical theory and applied computing. These findings support the viability of web-based serious games as scalable and inclusive tools for early childhood education and provide a foundation for future empirical studies and platform extensions.

Keywords: Serious Games, Early Childhood Education, Gamification, Accessibility, Web-Based Learning, BNCC

1. Introduction

The increasing presence of digital technologies in children's daily lives has significantly influenced contemporary educational practices, particularly in early childhood education. When appropriately designed, digital tools can complement traditional teaching approaches by fostering engagement, motivation, and active learning processes ^[1, 2]. In this context, educational games have emerged as a promising strategy to support cognitive, motor, and socioemotional development during the early years of schooling.

Game-based learning environments enable children to interact with educational content through playful, exploratory, and experiential activities. Classical theories of child development emphasize that learning in early childhood is closely linked to play, experimentation, and symbolic interaction. Piaget ^[3] highlights play as a fundamental mechanism for cognitive development through processes of assimilation and accommodation, while Vygotsky ^[4] underscores the role of social interaction and mediated activities in learning. These perspectives provide a theoretical foundation for the use of games as structured learning environments rather than purely recreational tools.

Recent studies reinforce the educational potential of digital and serious games in early childhood contexts. Research indicates that well-designed educational games can improve attention, motivation, and basic cognitive skills by integrating ludic elements with pedagogical objectives ^[1, 2]. Moreover, serious games have been shown to promote active participation and meaningful engagement, especially when learning goals are embedded directly within gameplay mechanics ^[5].

Despite these advances, significant challenges remain regarding accessibility, inclusion, and curricular alignment. Many existing educational games rely on proprietary platforms, require local installation, or present limited compatibility with mobile devices, which restricts their adoption in public schools and contexts with heterogeneous technological infrastructure ^[6]. Additionally, several solutions lack explicit alignment with official curricular guidelines, reducing their effectiveness within formal educational systems.

In the Brazilian educational context, the Base Nacional Comum Curricular (BNCC) establishes competencies and skills that guide early childhood education, emphasizing the integral development of children across cognitive, motor, emotional, and social dimensions ^[7]. Educational technologies designed for this stage must therefore align with these curricular principles to ensure that playful activities effectively support learning objectives rather than serving solely as entertainment.

From a technical standpoint, web-based educational platforms offer important advantages for addressing these challenges. Browser-based applications eliminate the need for local installation, support multiple devices, and contribute to digital inclusion, particularly in under-resourced educational environments ^[6]. When combined with open-source technologies, such platforms also promote sustainability, adaptability, and long-term maintenance. However, despite the growing number of educational games, few existing platforms explicitly combine BNCC alignment, accessibility, and web-based deployment in early childhood contexts.

In this context, this paper presents the design, implementation, and exploratory evaluation of a web-based educational game platform aimed at supporting early childhood education in alignment with the BNCC. The platform integrates pedagogical principles with a scalable and accessible technical architecture, employing open-source technologies to ensure compatibility with desktops, tablets, and smartphones. The system incorporates a set of mini-games specifically designed to stimulate fundamental skills such as coordination, language development, emotional recognition, logical reasoning, and social interaction.

The main contributions of this work are threefold: (i) the explicit integration of BNCC-aligned pedagogical objectives into the design of educational mini-games; (ii) the development of a modular, web-based architecture that promotes accessibility and inclusion; and (iii) an exploratory evaluation of the platform's functionality and educational potential. By bridging pedagogical theory and applied computing, this study contributes to the advancement of accessible and curriculum-oriented educational technologies for early childhood education.

2. Related Work

2.1 Educational Games in Early Childhood Education

The use of educational games in early childhood education

has been widely discussed in the literature due to their potential to support learning through play, exploration, and social interaction. Foundational theories in developmental psychology emphasize the central role of play in cognitive and socioemotional growth. Piaget ^[3] conceptualizes play as a mechanism through which children construct knowledge by interacting with their environment, while Vygotsky ^[4] highlights learning as a socially mediated process influenced by cultural and interpersonal contexts.

Within this pedagogical framework, Kishimoto ^[8] reinforces the importance of integrating playful activities into formal educational practices, particularly during early childhood, when imagination and symbolic play a decisive role in learning. These theoretical perspectives support the design of educational games as structured learning environments rather than simple entertainment artifacts.

Digital environments have expanded these concepts by introducing interactive and adaptive learning experiences. Gee ^[5] argues that digital games function as complex learning systems that provide immediate feedback, contextualized challenges, and opportunities for experimentation. In early childhood education, such characteristics are especially relevant, as they encourage autonomy, engagement, and learning through action.

Empirical studies report positive effects of educational games on early learning outcomes, including improvements in attention, motivation, and basic cognitive abilities ^[1]. However, the literature also emphasizes that educational effectiveness depends on the alignment between pedagogical objectives and game mechanics. Games that prioritize entertainment without instructional coherence often fail to produce meaningful learning outcomes ^[2].

Early investigations conducted by our research group also explored the use of computerized games to support early literacy processes, particularly in inclusive and special education contexts. Amate *et al.* ^[10] presented a set of digital games designed to stimulate reading and writing skills through interactive and playful activities, demonstrating that game-based environments can enhance motivation, engagement, and symbolic learning during the early stages of literacy development. These findings reinforce the pedagogical relevance of educational games as structured learning tools rather than purely recreational artifacts.

Building on this perspective, Amate *et al.* ^[11] proposed a structured sequence of computerized games aimed at supporting written language acquisition in children, emphasizing the importance of pedagogical coherence and progression within game-based learning environments. The study highlighted that educational effectiveness increases when gameplay mechanics are explicitly aligned with learning objectives and developmental stages. This approach anticipates contemporary design principles adopted in serious games, in which curricular alignment and intentional instructional design play a central role.

Table 1 summarizes the main theoretical foundations that guided the pedagogical and technical design of the proposed platform.

Table 1: Summary of theoretical foundations and their application in the proposed platform

Author (Year)	Theoretical approach	Main contribution	Application in this work
Piaget (1978)	Genetic epistemology / Constructivism	Learning occurs through processes of assimilation and accommodation during interaction with the environment.	Supports the use of games as tools for active knowledge construction.
Vygotsky (2003)	Sociocultural theory	Learning is mediated by social interaction and cultural context.	Grounds the collaborative and inclusive design of the educational game.
Kishimoto (2001)	Play-based pedagogy	Integration of play and education as a core element of early childhood learning.	Informs the selection of ludic activities and symbolic narratives.
Gee (2003)	Game-based learning	Digital games function as interactive and authentic learning environments.	Supports the use of game mechanics to promote engagement and motivation.
Alotaibi (2024)	Game-based learning	Meta-analysis confirms cognitive, social, and emotional gains in children.	Justifies the effectiveness of educational games in early childhood education.
Chen (2025)	Accessibility and digital inclusion	Low-tech serious games promote inclusive and accessible education.	Supports the adoption of open and accessible technologies.
Liu <i>et al.</i> (2024)	Interactive digital learning	Interactive environments enhance motivation and comprehension in children.	Informs the interactive and visual design of the web-based prototype.

2.2 Serious Games and Digital Learning Environments

Serious games have gained prominence as digital applications explicitly designed to achieve educational objectives through structured gameplay. Unlike traditional educational software, serious games embed learning goals within game mechanics, narratives, and feedback systems. Papastergiou ^[2] demonstrates that serious games can enhance student engagement and learning outcomes when compared to conventional instructional approaches.

From a design perspective, contemporary frameworks emphasize the importance of grounding serious games in evidence-based pedagogical models and curricular standards. Such approaches ensure coherence between learning objectives, gameplay mechanics, and assessment strategies, reinforcing the educational value of digital games ^[5, 9].

Recent review studies further consolidate the role of serious games as effective educational tools across different domains. Tan and Nurul-Asna ^[12] conducted a comprehensive systematic review on serious games in educational contexts, identifying key design features associated with successful learning outcomes, such as meaningful engagement, immersive experiences, learn-by-doing strategies, and alignment between game mechanics and pedagogical objectives. Although their focus includes environmental education, the identified principles are broadly applicable to serious games in early childhood education, reinforcing the importance of intentional instructional design and learner-centered interaction.

Recent systematic reviews and empirical studies further confirm the educational potential of serious games in early childhood contexts. Alotaibi ^[9] reports moderate to high effect sizes in cognitive, social, and motivational domains, indicating that well-designed game-based interventions can support holistic child development. Similarly, Liu *et al.* ^[13] show that interactive and visually rich serious games contribute to sustained attention and improved learning outcomes among young learners.

Beyond cognitive development, contemporary research highlights the role of serious games in promoting socioemotional learning and inclusion. Chen ^[6] argues that low-technology and web-based serious games can reduce digital inequality by providing accessible educational tools that do not rely on advanced hardware or proprietary platforms. This perspective is particularly relevant for

public education systems and schools with limited technological resources.

2.3 Positioning of the Present Work

Although existing research demonstrates the effectiveness of educational and serious games in early childhood education, several gaps remain. Many proposed solutions are limited by platform dependency, restricted accessibility, or lack explicit alignment with official curricular frameworks ^[6]. Furthermore, a significant portion of the literature addresses either pedagogical or technical aspects in isolation, with fewer studies integrating both dimensions within a unified system.

From a technical and architectural perspective, recent research has emphasized the importance of modular and flexible platforms to support serious games in educational settings. Barianos, Papadakis and Vidakis ^[14] propose a content management framework for serious games that enables educators to customize and manage educational content independently of the core game logic. This approach highlights the relevance of adaptable architectures and content modularity for improving scalability, reusability, and pedagogical control. Such principles align with the design choices adopted in the present work, which emphasizes a web-based, modular architecture to facilitate accessibility, maintenance, and future extensions.

In the Brazilian context, few works explicitly align digital educational games with the Base Nacional Comum Curricular (BNCC), despite its central role in guiding early childhood education. Additionally, web-based platforms that combine open-source technologies, curricular alignment, and accessibility across multiple devices remain underexplored.

This work addresses these gaps by proposing a web-based educational game platform explicitly designed according to BNCC competencies. By integrating pedagogical theory, serious game design principles, and an accessible technical architecture, the proposed system contributes to the development of inclusive, curriculum-oriented, and scalable educational technologies for early childhood education.

3. Materials and Methods

This study adopts an applied research approach, integrating pedagogical principles and technological development to design and implement an educational game platform for

early childhood education. The methodology combines curriculum-oriented instructional design with game-based learning strategies, ensuring coherence between educational objectives and interactive mechanics. The methodological process was structured into two complementary dimensions: pedagogical design and game design.

3.1 Pedagogical Design

The pedagogical design of the platform was grounded in the

competencies and learning objectives defined by the Brazilian Base Nacional Comum Curricular (BNCC) for early childhood education. The BNCC emphasizes the integral development of children, encompassing cognitive, motor, emotional, and social dimensions. Based on these guidelines, a set of core competencies was selected to guide the design of the educational activities implemented in the platform, as shown in Table 2.

Table 2: Mapping between BNCC competencies and the implemented mini-games.

Mini Game	Objective	Description
Drag and Fit	Visual perception	An interactive puzzle in which the child drags shapes and fits them into the correct outlines.
Painting Emotions	Identification of primary and secondary colors	The child selects colors to paint faces with different emotions (happy, sad, angry, etc.), promoting empathy and emotional recognition.
Magic Words	Syllable and image matching	The child builds simple words by arranging syllables, with visual and auditory support.
Right Path	Logical reasoning	The child guides a character through a simple maze, solving problems to move forward.

The pedagogical objectives focus on the development of fundamental skills commonly addressed during early childhood education, including: (i) fine and gross motor coordination; (ii) language and visual recognition; (iii) emotional awareness and expression; (iv) logical reasoning and planning; and (v) social interaction and problem-solving in simple contexts. These competencies were chosen due to their relevance to early literacy processes and their suitability for stimulation through interactive and playful activities.

To ensure pedagogical coherence, each competency was explicitly mapped to one or more mini-games, establishing a direct relationship between learning objectives and gameplay mechanics. This mapping process aimed to prevent a common limitation observed in educational games, in which learning goals are weakly connected to game actions. Instead, the proposed design embeds pedagogical intent into the core interactions required to

progress within each game.

In addition, the pedagogical design considered principles of inclusivity and accessibility. Activities were conceived to accommodate different learning rhythms and interaction modalities, incorporating visual, auditory, and kinesthetic stimuli. This multimodal approach supports diverse learning profiles and aligns with inclusive education practices advocated in early childhood pedagogical literature.

3.2 Game Design

The game design process focused on creating simple, intuitive, and age-appropriate interactive experiences for children aged between 4 and 7 years. The platform was structured as a collection of independent mini-games, each designed to address specific pedagogical objectives while maintaining a consistent visual and interaction style across the system. Fig. 1 presents the login and creation screens of the platform.

Figure 1 displays four mobile application screens for the proposed educational game platform, labeled (a) through (d). Each screen features a header with a title and a subtitle, followed by input fields for registration information and buttons for login, registration, and back to login.

- (a) Student Login:** The screen has a header with a title "Student Login" and a subtitle "Enter your registration number and class code". It includes input fields for "Registration Number" and "Class Code", a green "Enter" button, and a link "I am a Teacher" with an "EN" button below it.
- (b) Student Registration:** The screen has a header with a title "Student Registration" and a subtitle "Fill in the information below". It includes input fields for "Full name", "Registration number", and "Class code", a green "Create Account" button, and a link "Back to Login" with an "EN" button below it.
- (c) Teacher Login:** The screen has a header with a title "Teacher Login" and a subtitle "Access your management area". It includes input fields for "E-mail" and "Password", a green "Sign in" button, a link "Create a new account", and a link "Back to Student Login" with an "EN" button below it.
- (d) Teacher Registration:** The screen has a header with a title "Teacher Registration" and a subtitle "Fill in the information below". It includes input fields for "Full name", "E-mail", "Phone (optional)", "Institution (optional)", "Password (min. 6 characters)", and "Confirm password", a green "Create Account" button, and a link "Back to Login" with an "EN" button below it.

Fig 1: Login and registration interfaces of the proposed educational game platform: (a) student login screen, where students access the system using a registration number and class code; (b) student registration interface, allowing the creation of a new student account by providing personal and institutional information; (c) teacher login screen, enabling authenticated access for teachers through email and password; (d) teacher registration interface, used to create a teacher account with institutional and contact details.

Four initial mini-games were implemented as part of the platform, as showed in Table 2. They were designed according to the following principles: (i) simplicity of interaction, prioritizing drag-and-drop, touch, and directional controls; (ii) immediate and positive feedback to reinforce learning and maintain motivation; (iii) gradual progression of difficulty levels to adapt to the child's performance; and (iv) narrative and visual elements that promote engagement without cognitive overload.

The mini-game Drag and Fit focuses on developing visual perception, attention, and fine motor coordination. Children are required to drag shapes or objects to their corresponding outlines, receiving visual and auditory feedback upon correct placement.

Painting Emotions, designed to support emotional recognition and expression, this mini-game allows children to color facial expressions associated with different emotions. The activity promotes emotional awareness and empathy through visual cues and narrated feedback.

The mini-game Magic Words targets early language development and phonological awareness. Children assemble simple words by dragging letters, syllables or words to form meaningful combinations, supported by images and audio pronunciation.

The Right Path is focused on logical reasoning and planning, this mini-game challenges children to guide a character through a simple maze, encouraging anticipation, sequencing, and problem-solving skills.

Each mini-game includes adjustable difficulty levels, allowing progression from simpler tasks to more complex challenges. This adaptive structure supports sustained engagement and accommodates individual differences in learning pace.

Feedback mechanisms play a central role in the game design. Visual indicators, sound effects, and verbal encouragement were incorporated to reinforce correct actions and guide children in cases of error. Importantly, mistakes are treated as learning opportunities, allowing repeated attempts without punitive consequences.

By integrating pedagogical objectives directly into gameplay mechanics, the proposed game design seeks to balance entertainment and learning, ensuring that playful interaction serves as a meaningful vehicle for skill development rather than a superficial layer added to instructional content.

4. System Architecture and Implementation

The proposed educational game platform was implemented as a web-based system following a modular and scalable architecture. The architectural decisions were guided by three main requirements: accessibility across multiple devices, ease of deployment in educational environments, and long-term sustainability through the use of open-source technologies. To address these requirements, a three-layer architecture was adopted, separating presentation, application logic, and data persistence.

4.1 System Architecture

The system architecture follows a classic three-layer model composed of a frontend layer, a backend layer, and a database layer, Fig. 2. This separation of concerns promotes modularity, simplifies maintenance, and enables future

expansion of the platform with additional games or analytical features.

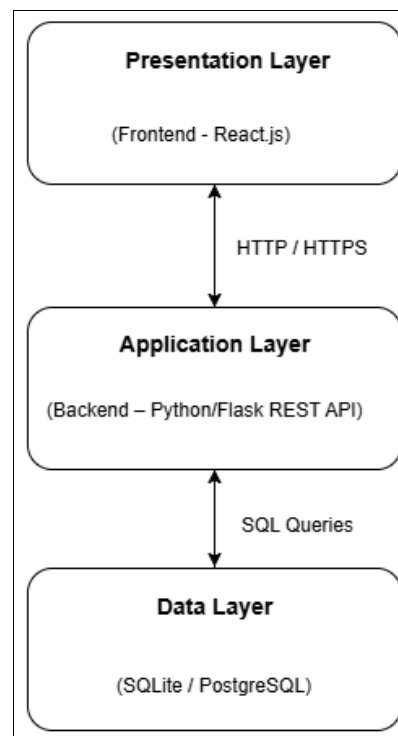


Fig 2: Three-layer architecture of the proposed web-based educational game platform, illustrating the separation between presentation, application, and data layers.

The frontend layer is responsible for user interaction and game execution. It provides the graphical interface, manages navigation between mini-games, and delivers visual and auditory feedback during gameplay. The interface was designed to be responsive, allowing the platform to adapt seamlessly to different screen sizes and input modalities, including mouse, keyboard, and touch-based interactions.

The backend layer handles application logic and data processing. It mediates communication between the frontend and the database, managing user sessions, storing gameplay results, and supporting the generation of basic pedagogical reports. A RESTful API was implemented to ensure loose coupling between the frontend and backend, facilitating future integration with external systems or analytical modules.

The database layer is responsible for persistent data storage. It maintains structured records of users, games, gameplay sessions, and performance indicators, enabling both functional operation and subsequent analysis of learning-related data.

This architecture allows the platform to operate entirely through a web browser, eliminating the need for local installation and reducing technical barriers to adoption in educational settings.

4.2 Frontend Implementation

The frontend was developed using React.js, a widely adopted JavaScript library for building interactive user interfaces. React's component-based architecture supports the modular design of mini-games and interface elements, enabling code reuse and simplifying the development of new activities.

From a usability perspective, the interface was designed to meet the cognitive and motor characteristics of children aged 4 to 7 years. Design choices include large interactive elements, high-contrast color schemes, simple navigation flows, and consistent visual feedback. Fig. 3 presents

examples of the Easy, Medium, and Hard levels of the “Magic Words” mini-game, illustrating the progression of difficulty from syllable-based word construction to short sentence formation.

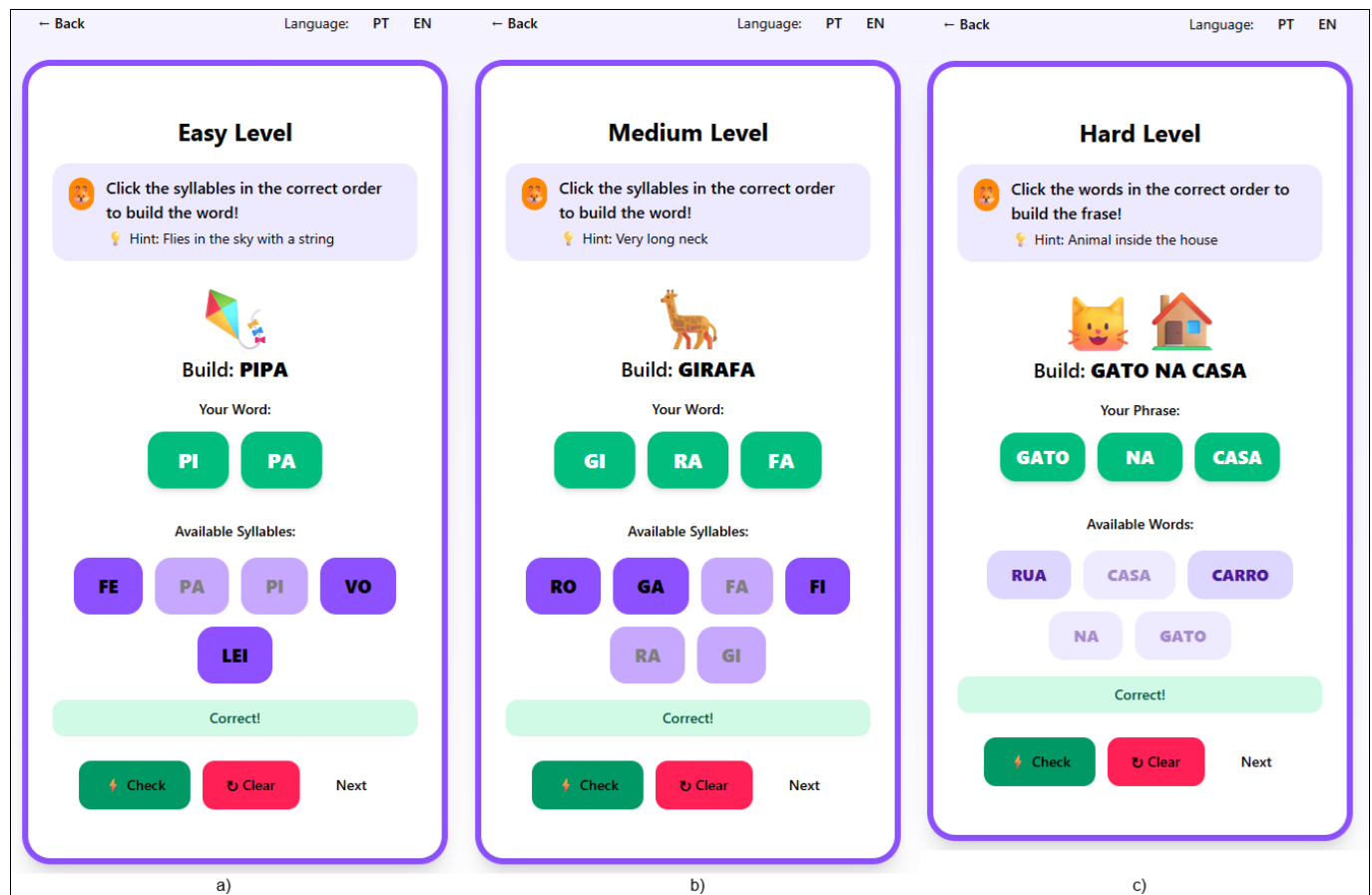


Fig 3: Examples of mini-games “Magic Words” implemented in the proposed platform: a) easy level, b) medium level, and c) hard level.

Responsiveness was a key design criterion. The frontend dynamically adapts to different devices, allowing the platform to be accessed on desktop computers, tablets, and smartphones without functional degradation. This characteristic is particularly relevant for educational institutions with heterogeneous technological infrastructure.

4.3 Backend Implementation

The backend was implemented using Python in conjunction with the Flask framework. Flask was selected due to its lightweight nature, flexibility, and suitability for educational and prototype-oriented applications. The backend exposes a set of RESTful endpoints that support core functionalities, including user management, game session tracking, and performance data storage.

Gameplay data generated in the frontend are transmitted to the backend at the end of each session. These data include information such as time spent on each mini-game, number of attempts, scores, and completion status. The backend processes and stores these records, enabling the monitoring

of individual progress and aggregated usage patterns.

The use of Python facilitates future integration with data analysis and educational analytics tools, creating opportunities for more advanced learning assessment mechanisms in subsequent iterations of the platform.

4.4 Database Design

The data persistence layer was implemented using a relational database model. During the prototyping phase, SQLite was employed due to its simplicity and ease of deployment. For production scenarios, the system is designed to support migration to PostgreSQL, which offers improved scalability, robustness, and concurrency control.

The database schema includes entities representing users (students and teachers), mini-games, gameplay sessions, and achievements, as illustrated in Fig 4. The relationships among these entities allow the system to associate performance data with specific users and activities, supporting both functional requirements and pedagogical analysis.

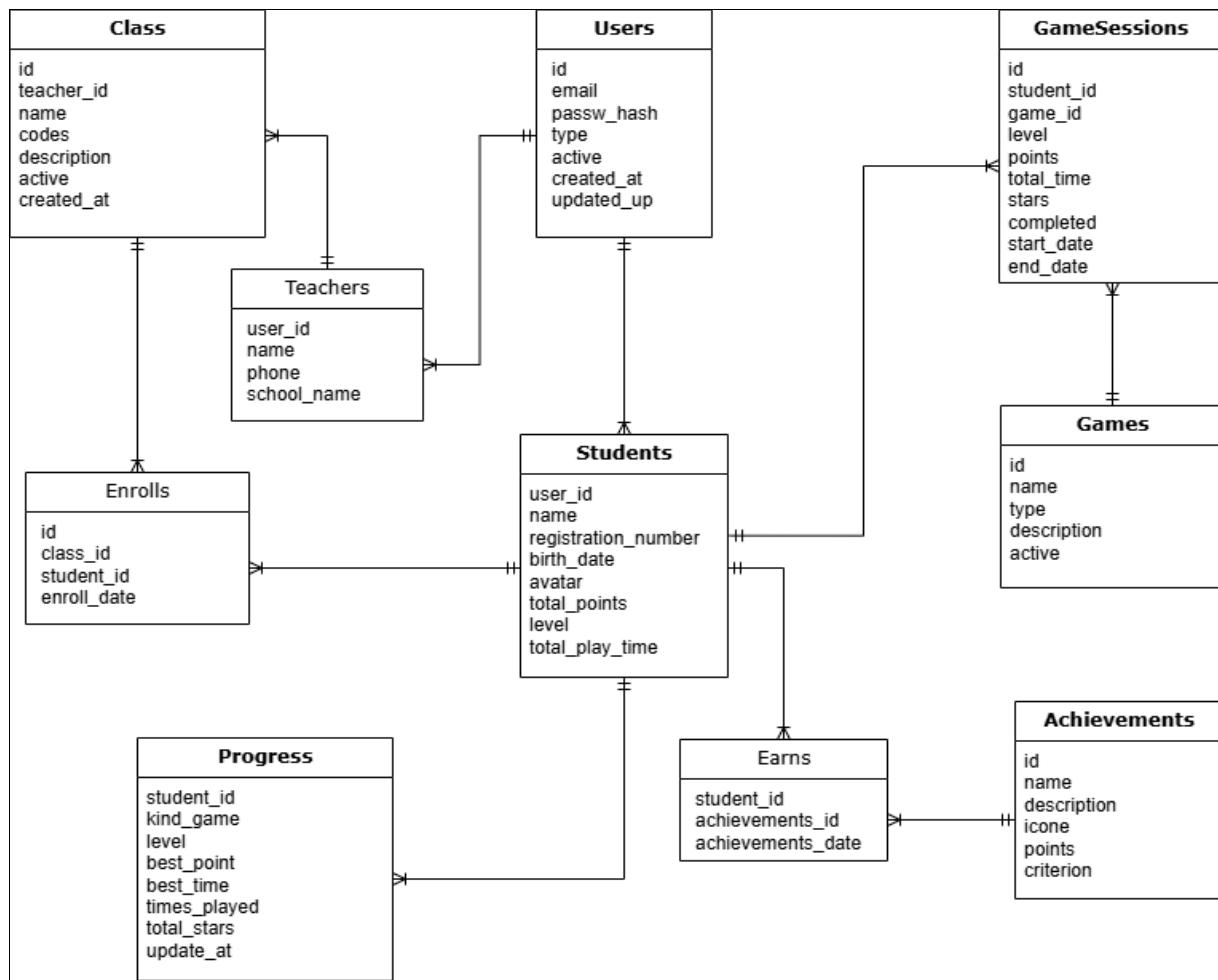


Fig 4: Relational database schema of the proposed platform, showing entities related to users, mini-games, gameplay sessions, and performance records.

By adopting a structured and extensible data model, the platform enables the generation of basic reports for educators and provides a foundation for future enhancements, such as longitudinal learning analysis or adaptive gameplay mechanisms.

5. Evaluation and Results

The evaluation of the proposed educational game platform was conducted with an exploratory and qualitative focus, aiming to assess its functional performance, usability, and pedagogical adequacy for early childhood education. Given the applied and developmental nature of the study, the evaluation prioritized verifying whether the platform meets its design objectives and educational requirements rather than performing large-scale experimental validation.

5.1 Evaluation Procedure

The evaluation process was structured in three complementary stages. First, functional tests were performed to verify the stability of the system, ensuring that all mini-games operated correctly across different devices and browsers. These tests focused on interaction consistency, responsiveness, and error handling during gameplay sessions.

Second, usability and accessibility aspects were assessed based on heuristic inspection and expert feedback. Educators and researchers with experience in early childhood education and educational technologies reviewed

the platform, focusing on interface clarity, ease of navigation, appropriateness of visual elements, and suitability for non-reading users. Particular attention was given to the size of interactive elements, color contrast, and the clarity of audiovisual feedback.

Finally, an exploratory pedagogical assessment was conducted to analyze the alignment between gameplay mechanics and the intended learning objectives. This stage examined whether the activities effectively stimulated the targeted competencies, such as coordination, language development, emotional recognition, and logical reasoning, as defined in the pedagogical design.

5.2 Functional and Usability Results

The functional evaluation indicated that the platform operates reliably across desktop and mobile environments. All mini-games were executed without critical failures, and the system successfully recorded gameplay data, including time spent, scores, and completion status. The web-based architecture demonstrated adequate performance for educational use, even on devices with limited computational resources.

From a usability perspective, expert feedback highlighted the simplicity and intuitiveness of the interface. The use of large buttons, consistent visual cues, and straightforward navigation was considered appropriate for children aged 4 to 7 years.

Responsiveness was also positively evaluated. The interface

adapted effectively to different screen sizes and input modalities, supporting interaction via mouse, keyboard, and touch. This characteristic reinforces the platform's potential for use in diverse educational contexts, including classrooms with shared devices or mobile-based activities.

5.3 Pedagogical Assessment

The pedagogical assessment indicated a strong alignment between the mini-games and the competencies defined in the pedagogical design. Each activity required the execution of actions directly related to the intended learning outcomes, reducing the gap between gameplay and educational objectives.

The Drag and Fit mini-game effectively stimulated visual perception and fine motor coordination through drag-and-drop interactions. Painting Emotions supported emotional recognition and expression by associating colors, facial expressions, and narrated feedback. Magic Words promoted early language skills by linking visual representations with phonological elements, while Right Path encouraged logical reasoning and planning through simple navigation challenges.

Educators involved in the evaluation emphasized that the activities encourage active participation and allow repeated attempts without penalization, fostering a supportive learning environment. The absence of punitive mechanics and the presence of positive reinforcement were identified as important factors for maintaining motivation and reducing frustration among young learners.

5.4 Discussion of Results

Overall, the evaluation results suggest that the proposed platform fulfills its primary design goals, providing a functional, accessible, and pedagogically coherent educational game environment. While the evaluation did not aim to measure learning gains quantitatively, the qualitative findings indicate that the system is well-suited to support early childhood learning activities aligned with the BNCC.

The results also highlight the advantages of a web-based approach for educational games, particularly in terms of accessibility and deployment. By eliminating installation requirements and supporting multiple devices, the platform addresses common barriers identified in the literature regarding the adoption of digital educational tools in public and under-resourced educational settings.

6. Conclusion

This paper presented the design, implementation, and exploratory evaluation of a web-based educational game platform aimed at supporting early childhood education in alignment with the Brazilian Base Nacional Comum Curricular (BNCC). By integrating pedagogical principles with game-based learning strategies and an accessible technical architecture, the proposed system addresses key challenges related to inclusion, curricular alignment, and technological sustainability in educational games.

The main contribution of this work lies in the explicit integration of BNCC competencies into the design of interactive mini-games, ensuring that gameplay mechanics are directly connected to pedagogical objectives. Unlike many educational games that prioritize entertainment or isolated learning activities, the proposed platform embeds

learning goals within core interactions, promoting meaningful engagement and supporting the development of cognitive, motor, emotional, and social skills.

From a technical perspective, the adoption of a web-based, modular architecture based on open-source technologies enables broad accessibility across multiple devices and operating systems. This approach reduces barriers related to installation and platform dependency, facilitating the adoption of the system in diverse educational contexts, including public schools and environments with limited technological infrastructure. The separation of concerns across frontend, backend, and data persistence layers further enhances maintainability and scalability.

The exploratory evaluation results indicate that the platform is functional, usable, and pedagogically coherent for its intended audience. Qualitative feedback suggests that the mini-games are age-appropriate, intuitive, and capable of stimulating targeted competencies in early childhood education. While the evaluation did not include large-scale quantitative measurements of learning outcomes, the findings support the platform's potential as an educational support tool aligned with curricular guidelines.

Despite these contributions, this study presents some limitations. The evaluation was conducted in an exploratory manner and relied primarily on qualitative assessments and expert feedback. Additionally, the number of participants involved in the evaluation was limited, and long-term learning impacts were not measured. These constraints are acknowledged as inherent to the scope and context of an initial applied research project.

Future work will focus on extending the platform through the development of additional mini-games aligned with other BNCC competencies, as well as the integration of learning analytics to support more detailed pedagogical assessment. Planned enhancements also include longitudinal studies involving larger groups of children and educators, enabling quantitative analysis of learning outcomes and engagement over time. Furthermore, adaptive mechanisms based on user performance may be incorporated to personalize learning experiences and further improve educational effectiveness.

By bridging pedagogical theory and applied computing, this work contributes to the advancement of accessible, curriculum-oriented educational technologies. The proposed platform demonstrates how web-based serious games can support early childhood education in an inclusive and scalable manner, providing a foundation for future research and practical applications in educational contexts.

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