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Digital games and metacognition: an experience in the early years of elementary school

Jogos digitais e metacognição: uma experiência nos anos iniciais do ensino fundamental

Juegos digitales y metacognición: una experiencia en los primeros años de la enseñanza primaria

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Abstract

The field of education faces the challenge of consolidating practices that overcome passivity and the linear transmission model, prioritizing students' cognitive autonomy. In this context, the ability to reflect on one's own thinking becomes strategic for knowledge and metacognitive regulation. This article discusses the potential of the educational digital game "Cai balão" in promoting metacognitive experiences among children in the literacy phase. The methodology consisted of a

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qualitative and longitudinal investigation, based on participant observation over sixteen sessions. Data, recorded in observation scripts and field diaries, were processed through thematic analysis. The results reveal that the game's architecture operates on four axes: the interface as a device of disequilibrium; error as a driver of metacognitive regulation; immediate feedback as support for monitoring; and the transition from mechanical action to conscious decision-making. It was observed that the interaction stimulates students to take an active role, testing linguistic hypotheses and autonomously adjusting strategies. We conclude that incorporating educational digital games into teaching practices can support the literacy process by providing students with opportunities for conscious knowledge and control over their own learning.

Keywords: Metacognition. Digital Games. Literacy.

Resumo

O campo da educação enfrenta o desafio de consolidar práticas que superem a passividade e o modelo de transmissão linear, priorizando a autonomia cognitiva do estudante. Nesse contexto, a capacidade de refletir sobre o próprio pensamento torna-se estratégica para o conhecimento e a regulação metacognitiva. Este artigo discute o potencial do jogo digital educativo "Cai balão" na promoção de experiências metacognitivas em crianças em fase de alfabetização. A metodologia consistiu em uma investigação qualitativa e longitudinal, fundamentada na observação participante ao longo de dezesseis sessões. Os dados, registrados em roteiros de observação e diários de campo, foram tratados via análise temática. Os resultados revelam que a arquitetura do jogo atua em quatro eixos: a interface como dispositivo de desequilíbrio; o erro como motor da regulação metacognitiva; o feedback imediato como suporte ao monitoramento; e a transição da ação mecânica para a decisão consciente. Observou-se que a interação estimula o aluno a assumir um papel ativo, testando hipóteses linguísticas e ajustando estratégias autonomamente. Conclui-se que a inclusão de jogos digitais educativos às práticas docentes pode apoiar o processo de alfabetização oferecendo oportunidades ao aluno de conhecimento e controle consciente sobre a própria aprendizagem.

Palavras-chave: *Metacognição. Jogos Digitais. Alfabetização.*

Resumen

El campo de la educación enfrenta el desafío de consolidar prácticas que superen la pasividad y el modelo de transmisión lineal, priorizando la autonomía cognitiva del estudiante. En este contexto, reflexionar sobre el propio pensamiento se vuelve estratégico para el conocimiento y la regulación metacognitiva. Este artículo discute el potencial del juego digital "Cai balão" en la promoción de experiencias metacognitivas en niños en fase de alfabetización. La metodología consistió en una investigación cualitativa y longitudinal, basada en la observación participante durante dieciséis sesiones. Los datos, registrados en guiones de observación y diarios de campo, fueron procesados mediante análisis temático. Los resultados revelan que la arquitectura del juego actúa en cuatro ejes: la interfaz como dispositivo de desequilibrio; el error como motor de la regulación metacognitiva; la retroalimentación inmediata como apoyo al monitoreo; y la transición de la acción mecánica a la decisión consciente. Se observó que la interacción estimula al alumno a asumir un papel activo, probando hipótesis lingüísticas y ajustando estrategias de manera autónoma. Se concluye que la inclusión de juegos digitales educativos en las prácticas docentes puede apoyar el proceso de alfabetización, ofreciendo al alumno oportunidades de conocimiento y control consciente sobre su propio aprendizaje.

Palabras clave*: Metacognición. Juegos Digitales. Alfabetización.*

1. Introduction

Learning is an intrinsic condition of human development, characterized by an interest in and a predisposition toward understanding surrounding phenomena. However, a mismatch is commonly observed in schools between this natural propensity and institutionalized pedagogical practices, which frequently neglect the potential of exploratory activities in learning in favor of mere information transmission. By prioritizing passivity and compliance, this model distances students from developing autonomy and exercising reflective thinking.

In a context where developing student potential is the focus of pedagogical practices, the teacher guides students "[...] to take control of their own learning, that is, learning to identify when they understand and when they need more information; what strategies they can use; how they can elaborate their own theories about phenomena and test them effectively, and so on" (Portilho & Dreher, 2012, p. 192, *our translation*).

This transition from a state of passivity to the conscious control of one's own learning underpins the concept of metacognition, which currently occupies a prominent place in discussions regarding learning processes. The dissemination of this term is attributed to Flavell (1979), who proposed that metacognition designates a person's ability to analyze their own mental mechanisms, monitoring and adjusting their reasoning throughout the execution of an activity. For the author, metacognition is structured around two major fundamental components: metacognitive knowledge and metacognitive control.

Metacognitive knowledge "[...] develops through the subject's awareness of how certain variables interact to influence the outcomes of cognitive activities" (Ribeiro, 2003, p. 111, *our translation*). It is influenced by variables related to the "person", the "task", and the "strategy". Conversely, control, according to Portilho and Dreher (2012, p. 185, *our translation*), is "the ability that a person possesses to evaluate task execution and make corrections when necessary; in other words, it is the control of cognitive activity, under the responsibility of central executive processes that evaluate and guide cognitive operations." Control relates to the variables of "planning", "monitoring", and "evaluation".

In educational literature, it is also common to associate metacognition with the concept of self-regulated learning. Zimmerman (2000) argues that students considered self-regulated are able to choose study methods, monitor their own progress, and ponder the results they achieve. From this author's perspective, this reflective process favors the development of cognitive autonomy and the enhancement of academic performance.

Adopting pedagogical approaches oriented toward metacognition requires that the educational space go beyond the simple transmission of knowledge, encouraging the autonomy mentioned by Zimmerman (2000). In this context, utilizing methods such as reflective portfolios or learning diaries are alternatives to lead students to understand how they organize their thoughts, since these instruments help systematize ideas and allow students to recognize and organize their own learning pathways.

In this scope, the potential of digital games with educational purposes has been investigated as a favorable environment for fostering metacognitive processes (Kiili, 2005; Shute & Ventura, 2013; Hwang *et al.*, 2024). Educational games frequently require users to make decisions, experiment with different paths, and repeatedly evaluate the consequences of their actions. In this sense, the literature points out that this type of interaction offers opportunities for the exercise of metacognitive abilities, such as strategic planning, performance monitoring, and course correction.

However, the development of digital educational games cannot be restricted merely to the transposition of traditional pedagogical activities into the digital medium; instead, it must seek to create environments that stimulate this more active and reflective stance. From this perspective, the present article aims to discuss the potential of an educational digital game to promote metacognitive experiences in children in the literacy phase. The analysis of the game entitled "Cai balão" [1] aims to discuss how its interactive elements can transform the literacy process into a space of monitoring and learner autonomy. To achieve the proposed objective, the present article is structured into five sections. In addition to this introduction, the second section synthesizes research findings that have associated the use of games with metacognitive processes; the third details the methodological process adopted in this study; the fourth

[1] CAI BALÃO. An educational digital game aimed at teaching the Portuguese language in the 1st year of elementary school. Available at: https://www.ludicamente.net/cai_balao/. Accessed on: May 8, 2026.

section presents the analysis of results; and, finally, concluding remarks are presented regarding the potentialities of this resource for metacognition.

2. Theoretical Framework

Recent studies suggest that game-based learning environments are among the pedagogical activities capable of promoting metacognitive awareness and self-regulation. A systematic literature review on digital games and metacognition conducted by Hwang *et al*. (2024) indicated that educational games frequently prompt players to reflect on their learning processes and modify their strategies to achieve proposed objectives. In this context, the need to overcome obstacles and ponder choices fosters metacognitive exercise and the development of self-assessment processes, leading students to become more aware of their approaches and performance during the activity.

According to Kiili (2005), digital game-based learning is understood as an experiential process, heavily inspired by the learning cycle advocated by Kolb (1984). In this cycle, the player cycles through continuous phases of action, feedback, and reflection, wherein the concrete in-game experience is constantly reinterpreted in light of the obtained results. The author maintains that game-based learning is more meaningful when the resource fosters moments of reflection integrated into the action, rather than separate from it. This implies incorporating informative feedback, clear goals, and systems that encourage experimentation and strategy revision. In this context, reflection is not a subsequent stage of the activity, but a constitutive element of the interaction with the game itself, closely aligning with the notion of situated metacognition. Thus, digital games can be understood as environments conducive to articulating experience, reflection, and self-regulation, promoting not only content acquisition but also the development of skills related to the conscious control of their own learning process (Kiili, 2005).

For Shute and Ventura (2013), digital games offer favorable conditions for developing metacognition by integrating clear objectives, progressive challenges, and immediate feedback. These elements configure an environment where error is not only permitted but functional, encouraging players to test and revise hypotheses, consider new strategies, and persist in the face of difficulties. This context is ideal for metacognitive experiences to occur, as the game presents a contextualized situation directly linked to action, where the subject learns to evaluate the effectiveness of their decisions and adaptively regulate their actions.

These authors argue that well-designed games incorporate dynamic and adaptive feedback systems that allow players to monitor their own performance in real time, adjusting strategies as they advance through tasks. This process fosters the development of metacognitive skills, since the learner is constantly prompted to reflect, even if implicitly, on their actions, choices, and results, promoting continuous cycles of self-regulation (Shute & Ventura, 2013). Still, according to the authors, observing students' behavior while playing allows inference of cognitive and metacognitive states, such as planning, monitoring, and strategy revision. Therefore, games allow not only to stimulate but also to assess metacognition in a timely and contextualized manner, positioning this resource as an element capable of integrating content learning demands and the development of self-regulatory processes (Shute & Ventura, 2013).

The articulation between digital games and metacognition, as discussed by Kiili (2005) and Shute and Ventura (2013), allows for visualizing its utilization at a crucial point in the educational field: literacy. Learning to read and write, especially in the early years, depends heavily on the students' ability to monitor their comprehension, identify errors, and adjust decoding and interpretation strategies. In this sense, metacognition is not an accessory element, but a constitutive one of the literacy process itself, making it particularly relevant to investigate how digital games can favor this type of experience within the context of language.

The skills involved in literacy, such as phonological awareness, word formation, and reading comprehension, require constant monitoring by the teacher, who must be able to identify difficulties and potential flaws in the students' process of understanding and writing the language. The use of digital educational games focused on language can support teaching practice by creating instructional situations in which students must test hypotheses about sounds, spellings, and meanings, receiving immediate feedback on their choices and decisions. This process directly approaches the cycles described by Kiili (2005) and the adaptive feedback dynamics discussed by Shute and Ventura (2013),

demonstrating that games can act as tools to support teaching practice that operationalize metacognitive experiences in the linguistic domain.

Seeking to demonstrate the potential of digital tools for reading development in the early years, Jamshidifarsani *et al*. (2019) conducted an analytical literature review covering publications between 2000 and 2017. The authors examined 42 studies that evaluated a total of 32 technology-based or technology-assisted reading intervention programs. The analyzed studies utilized a variety of technological formats, including computer software, digital educational games, tablet applications, and online learning environments. They concluded that while educational technologies have a recognized potential to support learning to read and write, the efficacy of these tools depends heavily on identifying pedagogical demands and alignment with the specific competencies intended for development. Therefore, when utilizing a digital resource, a precise design of the skills expected to develop is fundamental, at the risk of not obtaining the desired effects.

Still according to Jamshidifarsani *et al*. (2019), the most frequently used activities focused on developing phonological awareness (rhyme identification, syllabic segmentation, and phoneme manipulation) and word formation. Interventions focused on reading comprehension were also verified, which utilized interactive questions, concept maps, and inference exercises. However, the authors found that interventions dedicated to reading fluency are scarcer and, when they existed, presented a lower average duration than the other categories.

In the scope of investigations on literacy in English, Patel *et al*. (2022) conducted a relevant study by evaluating the effects of a phonics intervention based on the game "GraphoGame", aimed at developing reading skills in first- and second-grade students in India. The results indicate that the intervention generated general positive effects on language acquisition, highlighting gains in decoding and word recognition. It was also observed that first-grade students showed relatively greater benefits than second-grade students, suggesting that early interventions can be more fruitful. Additionally, children classified with more significant reading difficulties demonstrated more significant progress, pointing to the potential use of the tool as a remedial learning resource.

A study conducted by O'Brien *et al*. (2019) investigated the efficacy of educational software focused on English language literacy, analyzing how different instructional units impact the performance of children at risk of learning difficulties. The sample included 147 first- and second-grade students in Singapore. The authors concluded that interventions focused on smaller units, such as phonemes, tend to be particularly effective in early stages, especially for students with specific difficulties. On the other hand, approaches with larger units prove to be more suitable for advanced learners, suggesting the need for a progression adjusted to student development. This differentiation reinforces that digital tools can offer significant advantages due to their capacity for adaptation and personalization, allowing the adjustment of task complexity and feedback type based on user performance.

It is also worth highlighting the study conducted by Calvo-Ferrer (2021) on vocabulary learning in digital game contexts. The author argues that when students experience instances of success, these episodes can be understood as manifestations of positive metacognition, which act as significant predictors of both objective performance and subjective perception of learning. The term, initially proposed by Beer and Moneta (2010), refers to the favorable beliefs and assessments individuals construct regarding their own cognitive processes, which are associated with the perception of control and efficacy. By recognizing a correct response, students not only consolidate content but also reconfigure their perception of the learning process itself, strengthening their confidence and engagement. Calvo-Ferrer (2021) demonstrates that immediate and frequent feedback amplifies the opportunities for these episodes to occur, promoting continuous monitoring cycles. Thus, by articulating these principles, educational games create conditions for students to monitor, evaluate, and adjust their own cognitive processes in an enjoyable and learning-appropriate way.

However, despite this potential, the use of technology and innovative methodologies in educational contexts does not, by itself, guarantee improvement in educational processes. While positive impacts on motivation and academic performance are identified on one hand, negative effects can, on the other hand, occur when the integration of these resources is poorly implemented. It is clear that the success of an educational game depends not only on its technology, but on a design that balances linguistic challenge with support for student autonomy. It is not enough to simply convert a curricular content into digital form; it is necessary to ensure that game mechanics invite reflection

rather than a mere search for quick rewards. In this regard, the game “Cai balão” presents itself as a privileged object of analysis. By transposing phonological awareness principles into an environment that requires constant monitoring of player choices, this resource allows for the investigation of how children, in the midst of the literacy phase, begin to take control of their own way of learning.

3. Methodology

This investigation adopts an exploratory qualitative approach, a choice justified by the scarcity of studies on the topic (Gil, 2010).

To understand how a digital game can function as an instrument capable of promoting metacognitive experiences, we investigated the elements that a literacy-oriented game must possess to achieve this purpose. To this end, an educational Portuguese language game was developed for first-grade elementary school students, based on the principles of Interactive Design.

Developing educational games involves challenges that go beyond those found in entertainment games, as the former must reconcile pedagogical objectives with meaningful playful experiences. To achieve this balance, several authors emphasize the importance of player-centered approaches grounded in iterative design processes. In this context, the Iterative Design methodology advocated by Schell (2019), combined with empirical testing with the target audience—also known as Playtesting— is an appropriate approach for academic projects, enabling continuous refinement of the game based on empirical evidence to guide both usability improvements and the achievement of learning objectives.

The methodology begins with an analysis and contextualization phase, defining the educational problem, the application context, and the target audience. In this stage, active teacher participation is fundamental, since these professionals hold in-depth knowledge of the curriculum, pedagogical practices, students' recurring difficulties, and the actual conditions of the school setting. According to Penuel *et al.* (2011), the participation of educators in designing educational technologies fosters pedagogical relevance, curricular alignment, and the effective adoption of these solutions in real teaching contexts.

Next is the game conception phase, which defines elements such as genre, theme, platform, and the player experience. Initial design decisions guide the entire development process and directly influence how the player interacts with the system (Schell, 2019). In the case of educational games, these definitions must be made to promote the integration between content and gameplay.

Based on the game concept, educational objectives are established to describe the knowledge, skills, or competencies to be developed. Prensky (2001) highlights that effective educational games do not merely present content, but create situations where players learn through action and problem-solving. Thus, educational objectives must be clear and measurable, preferably aligned with curricular frameworks.

Subsequently, educational mechanics are defined. These are considered central to game design because they structure player interactions and give meaning to their actions (Salen & Zimmerman, 2004). In educational games, mechanics must directly represent learning concepts or processes, avoiding expository approaches disconnected from the playful experience.

Once these definitions are established, the prototyping phase begins, involving the creation of simplified versions of the game to test core ideas and mechanics. The prototype is then subjected to playtesting, where the game is tested with members of the target audience. Unlike traditional playtesting, this stage evaluates not only fun and usability aspects but also learning indicators (Fullerton, 2018).

The playtesting results inform the evaluation and refinement phase, where the game is adjusted and improved. This cycle of prototyping, testing, and refinement is repeated throughout development, characterizing the iterative nature of the methodology. Similar approaches are supported by Design-Based Research, which emphasizes the continuous improvement of educational artifacts based on their application in real contexts (Design-Based Research Collective, 2003).

Grounded in these principles, the game “Cai balão” was developed in collaboration with K-12 teachers and other professionals in the field. The pedagogical objective of the game is to work on word formation through the completion of final syllables. The choice of this theme sought to address the need, presented by the teachers, to work on this content within technology-mediated teaching practices.

The game “Cai balão” aligns with the skill “Relate phonetic elements [...] to their written representation” under the “Linguistic/Semiotic Analysis” axis and the “Construction of the alphabetic system and orthography” object of the National Common Curricular Base- BNCC (Brasil, 2018).

The game is set on a small island featuring coconuts with printed syllables. When the game starts, an animal descends from the sky suspended by balloons. Upon landing, a message appears containing its name and a blank space for the final syllable. To complete the activity, students must select the coconut containing the missing syllable and drag it to the word. If the answer is correct, the animal ascends with the balloon; if incorrect, the game provides an audio cue, and the coconut returns to its initial position, allowing for a new attempt. This cycle repeats until the proposed activities are completed.

To capture the game's potential to promote metacognitive experiences, the investigation adopted participant observation as the core procedure, with data systematically recorded through observation guides and field notes. This recording strategy allowed for capturing the complexity of metacognitive processes in real time, focusing on student behavior during game use and analyzing whether students were able to reflect on their own knowledge to plan new strategies for completing words, transforming mechanical interaction into a conscious decision-making process. Data processing followed the thematic analysis technique, where field note records and observation guide tabulations were cross-referenced to identify behavioral recurrences. The focus of the analysis was not on the literal transcription of speech, but on interpreting manifestations of intent and incidents that evidenced cognitive monitoring.

The use of the game was observed within the context of a project aimed at training and enhancing the knowledge of elementary school teachers regarding the Game-Based Learning methodology in a municipal public school in the interior of the state of São Paulo. This project included the participation of three first-grade teachers and two second-grade teachers, along with their respective classes, two undergraduate scholarship students, the primary researcher responsible for the project, and two partner researchers. Observations were conducted by the researchers and scholarship students throughout the 2023 school year.

In this context, the game implementation was integrated into the Game-Based Learning methodology. In total, sixteen classes using the game were observed: three in 1st grade A, four in 1st grade B, five in 1st grade C, two in 2nd grade A, and two in 2nd grade B. This stage allowed us to validate the refinement of the artifact in a real context and identifying the need for new modifications, ensuring that the iterative cycle resulted in a game better suited to the demands of students and teachers.

4. Results and discussion

The results presented here derive from the iterative playtesting process conducted and seek to evaluate the characteristics of an educational digital game that has the potential to enrich educational processes. Rather than merely validating the technical functionality of the game “Cai balão,” the analysis sought to identify how interaction with the artifact can foster students' ability to monitor, control, and evaluate their own cognitive processes.

In general terms, observations indicated that students demonstrated a high level of engagement with the activity. Beyond individual interaction with the software, there were instances in which occurred where students sought to clarify doubts, assisted peers in solving challenges, and expressed pride upon validating their achievements.

This overview of the game's context of use presents a positive indicator for pedagogical practices sensitive to metacognitive development, given that “metacognitive knowledge requires the active involvement of the learner in learning” (Ribeiro, 2003, p. 113).

It is also possible to understand behaviors such as asking questions, helping peers, and showing pride in completing the activity as indicators that the game “Cai balão” functioned as a trigger for metacognitive experiences. Based on Flavell's (1979) perspective, it is understood that during the activity, students mobilized knowledge about

their own cognitive processes and developed control strategies. By seeking to clarify doubts, students reflected on what they knew about the task and, identifying a gap, sought assistance as a means to solve the problem.

Conversely, when students volunteered to help their peers, they demonstrated an understanding that they not only mastered the activity but also possessed the necessary knowledge to guide others. The act of verbalizing reasoning to peers demanded thought organization and the externalization of metacognitive strategies to perform the task.

The expression of pride during game use can be interpreted as a conscious manifestation that cognitive effort was successful. The relevance of this behavior correlates with the findings of Calvo-Ferrer (2021), who points out a relationship between the perception that an in-game action generates positive results and the creation of cognitive bonds that expand learning possibilities.

Understanding oneself as capable of adequately solving problems contributes to a more positive perception of one's own abilities, directly influencing the "person" variable. For Flavell (1979, p. 907), "The person category encompasses everything that you could come to believe about the nature of yourself and other people as cognitive processors". Thus, the feeling of competence promotes the self-confidence of the learning subject, motivating them to regulate future actions with greater autonomy. According to Piaget (2021, p. 31, *our translation*):

> All successes and failures of the activity are recorded in a sort of permanent scale of values, the former raising the subject's claims and the latter lowering them with respect to future actions. This results in a self-judgment to which the individual is gradually led and which can have major repercussions on the entire development. Certain anxieties, in particular, result from real and, above all, imaginary failures.

In this context, the feelings of self-worth displayed by students during game use, besides being highly relevant to their metacognitive processes, are of utmost importance for pedagogical practices. This is because such feelings influence how students predispose themselves to learn something new and engage in an activity.

Thus, it is understood that the reactions of enthusiasm and collaboration observed in the classroom are not isolated phenomena, but the direct result of how the game's components were able to interface with these children's (meta)cognitive processes. To understand the technical and pedagogical features that sustained this scenario of student agency, the following discussion details the constituent elements of the game. The analysis will be conducted through four fundamental analytical axes, which allow for the observation of aspects ranging from the visual structure to the informative feedback provided to the student: Game Scenery and Components; Game Rules and Mechanics; Game Learning Objectives; and Game Feedback.

4.1 Scenery and components of the game "Cai balão"

The analysis of the properties of the scenery and other game components reveals an environment designed to mediate the relationship between students and curricular content, where each visual element acts as a facilitator of metacognitive processes.

The game is set in a simple scenery with few components and a playful aesthetic that goes beyond mere decoration: it creates a fantasy environment with components that evoke childhood. Figure 1 presents an image of the game.

Figure 1 – Digital game "Cai balão."

Source: Developed by the authors (2026).

During the observations, the game's playful aesthetic was found to help students understand of the school activity as a game, reducing the weight of their choices. Within a playful environment, children understood they were in a context free from external judgment, which decreased their inhibitory load and favored the development of behaviors necessary for literacy learning. Children were also observed to be more inclined to ask questions, as illustrated by the following questions directed at the researchers: "How do you do this one?" [2] and "*Tia*[3], what animal is this?".

In some cases, students clearly created narratives about the game, developing make-believe contexts that involved the characters and justified the importance of their own actions—completing the words—for the resulting plot, usually associated with the need to help the animals. In one of the classes, a dialogue between students expressed the creation of a game narrative, as exemplified by the remarks: "You have to drag [the coconut] to save them from the island" and "It [the animal] came down to drink water."

The game architecture provided opportunities for this type of experience since it did not propose an explicit narrative to the user, leaving room for the children's imagination to flourish. Engaging in make-believe play is of great importance for developing symbolic functions in children, which are essential for fostering metacognition. According to Oliveira *et al*. (2023, p. 109), educational games contribute to metacognitive processes by articulating symbolic function with the development of self-regulation, autonomy, creativity, and the anticipation of responses.

Regarding the scenery design, its simple and well-defined nature facilitated a quick understanding of the proposed objectives, allowing students to turn their attention to the action of completing words. There were few distracting components; colors were chosen to convey a sense of calmness, and student focus was directed toward viewing the word by a pulsing arrow that signaled the cognitive challenge. Within this context, the arrow can be understood as a guide to metacognition, indicating exactly where mental effort should be applied. This sensitized students to the relevance of the available information, directly influencing the "task" variable (Flavell, 1979) of metacognitive knowledge.

[2] The statements presented were recorded during the observations and are reported anonymously.
[3] *Tia* (literally "aunt") is an affectionate term commonly used by Brazilian children to address teachers and other adult authority figures within the school environment, including the female researchers in this study.

In summary, the scenery and information components of the game "Cai balão" helped students perceive that certain information acts as clues regarding activity demands, and that identifying such resources facilitates their learning process.

Another "information" presented by the game was the visual representation of syllables inside the coconuts. By presenting syllables associated with the idea of physical objects (coconuts) that can be manipulated, the game lends a concrete tone to the abstract. This visual representation transforms the syllable into a manipulable unit, allowing children to visualize their choices. From a metacognitive standpoint, the coconut ceases to be just an image and becomes a hypothesis-testing tool, facilitating the visual monitoring of thought.

4.2 Rules and Mechanics of the Game "Cai balão"

The concepts of game rules and mechanics develop together within the game development process; however, they address distinct principles. Rules can be understood as the concepts that define game objectives, whereas mechanics are the actions available to a player under those rules. As defined by Munhoz and Battaiola (2018, p. 37*, our translation*): "Game rules, generally speaking, establish the objective of the game, which is the primary factor that prompts the player to act within the game. [...] Mechanics are the implementations of the rules, providing the means available for the player to make decisions and act in the game."

In the game "Cai balão," the proposed rules are: the player must complete words with the missing syllables until the activity is finished; a word is only completed if the syllable is positioned over the text box; progression to the next level is conditional upon correctly solving the current word; there is no limit on attempts; and activity execution is not constrained by a fixed time limit.

The first rule — requiring players to complete words with missing syllables until the activity ends — constitutes the core challenge of the game. As discussed in the previous section, aesthetic choices facilitated students' understanding of this as the task to be fulfilled, eliminating the need for further explanatory elements. Whenever students faced difficulties in understanding, they sought ways to manipulate components to observe how these "responded" to their actions. In other words, when students did not immediately grasp the game's objective, they devised means to discover it, seeking to learn through an active stance toward their educational process.

The rule specifying that a word can only be completed if the syllable is positioned over the text box — rather than on any other element, such as the character — aims to convey the idea to students the idea that distinct components combine to form a single unit. This rule proved fundamental for learning, as it prompted students to reflect on the action of completing words through the mechanical act of joining syllables. In one observed situation, a student questioned: "*Tia*, I'm putting it there, but it's not working." In response to this inquiry, it was explained that to form the correct word, the missing syllable had to be placed together with the others.

This design choice targets the perception that letters and syllables are part of a symbol system that can be manipulated through union or separation, yet belong to the same "family." This is fundamental when considering that the operations of gathering or separating are physical actions in the world before they become operations of thought (Piaget, 2021).

The condition preventing students from leaving an activity without correctly identifying the syllable for that level is essential for both cognitive and metacognitive development. Many digital games are not designed with this perspective, allowing users to advance through activities without being immediately confronted with the fact that their response was incorrect. This type of game contributes little to the understanding of "what one does not know about something" and functions merely as an external evaluative tool of student knowledge. Fostering metacognition requires exactly the opposite: it demands that subjects autonomously perceive what they know or do not know. This strategy employed in "Cai balão" favored the monitoring of cognitive activities by the students. This translated into the ability to identify their own errors and pace, as observed in the students' remarks: "Oh! I got it wrong..." and "I'm almost done. Which one are you on?".

The rules that do not limit the number of attempts and do not stipulate a time limit for completing the activity proved to be another positive factor for student immersion. By avoiding elements of external pressure on students' cognitive activity, a state was fostered in which students do not need to react impulsively; on the contrary, they can

pause to reflect on their actions. Within this context, “Cai balão” functions as a safe space for cognitive and metacognitive experimentation, reinforcing the idea that in the learning process, building cognitive and metacognitive strategies to achieve a goal is more important than rushing to meet external targets and expectations.

In terms of mechanics, “Cai balão” follows its minimalist proposal by presenting only drag-and-drop functionality. Although seemingly simple, this action is challenging when applied to young children who, in most cases, lack computer access and are still developing their motor skills. Observations showed that some children faced difficulties coordinating the movements required to perform the task; however, because it is a game with a simple and playful theme, they persisted. For some students, the game also aided in mouse usage and control.

To drag the coconuts, students must coordinate a pincer grasp with sliding their hand across the table, requiring mental concentration and motor coordination. Furthermore, this movement aligns with the child's thought cadence, allowing them to change their mind before completing the action; that is, “Cai balão” helps align motor control with metacognitive control. Unlike a simple click, which is instantaneous, the act of dragging requires students to sustain their decision throughout the entire trajectory of the mouse or finger — which, for children, takes a considerable amount of time. We observed that this interval between “dragging” and “dropping” provided a space in which students' metacognition could operate: some were seen interrupting the movement, changing the trajectory, or confirming their hypothesis while watching the object approach its destination.

Finally, it bears emphasizing that the proposed mechanics demonstrated that the manipulation of the coconuts allowed for the externalization of students’ mental processes.

4.3 Learning objectives of the game “Cai balão”

The objective of an educational digital game is to address curricular content interactively, promoting the students' active engagement with the object of knowledge. Since there is no “playing” without the player's action, the game environment becomes a privileged space for students to exercise control over their own thought processes during task resolution. Within this context, pedagogical intentionality must be the central element; without this guideline, the resource is reduced to a mere pastime and loses its educational potential.

Under this premise, the game “Cai balão” was developed based on the real needs of K-12 teachers, ensuring that the design of the activity was intrinsically linked to classroom challenges and the demands of teaching mediated by digital technologies.

This intentionality manifests in the game's objectives, which propose that the student engage in a conscious reflection on the writing system rather than just performing the simple exercise of completing words. For this process to occur, the game introduces orthographic conflicts and a difficulty progression system.

The game “Cai balão” aligns with the National Common Curricular Base, addressing the “Linguistic/Semiotic Analysis” axis (Brasil, 2018), which is understood within its potential for learner cognition and metacognition. That is, the choice of this learning objective, by itself, is already a favorable element for understanding “Cai balão” as an instrument with the potential to promote metacognitive experiences. It prompts the student to pause and think about how language works, offering an interactive space to perceive that the word “URSO” [bear] is composed of syllables and that a graphic correspondence exists for each sound—and further, that there are syllables with the same sound but formed by different letters.

Students see the image of the animal, think of its name (sound), and must identify which “word part” (the coconuts containing the syllables) completes that written representation. This is a direct exercise in syllabic segmentation and synthesis, requiring a correlation between the sound (phoneme) and the spelling (grapheme) of words. For example, when students look at “GA__” and must choose the coconut with the syllable “TO” [4] , they are not merely reading; they are performing a mental operation of analysis, experiencing the concepts of segmentation and comparison.

A strategic pedagogical choice in “Cai balão” was offering only three response options for each challenge. This decision is grounded in the reality of first-grade classrooms, which frequently include children at different literacy levels

[4] To form the disyllabic Portuguese word gato (cat), requiring the student to match the final spoken syllable with its written form.

— ranging from pre-syllabic to alphabetic. By making the syllables available on physical objects within the scenery (the coconuts), the game reduces working memory load. Children do not need to hold all phonetic possibilities solely in their "heads"; they can perform a visual scanning, which facilitates monitoring and self-regulation, allowing them to focus their cognitive energy on comparing the available phonemes and graphemes. Thus, design intentionality ensures that the challenge is accessible and promotes successful experience for different learner profiles.

At this point, students are prompted to evaluate what they already know about the language and reflect on their existing prior knowledge: "Do I know how this word ends? Do I know how to write TO?". This is an essential activity for fostering metacognition, which involves knowledge about one's own knowledge and control over one's own cognitive processes. During the observations, it was common to see children saying the names of the animals out loud, and some even verbalized the syllables they were manipulating, demonstrating active task monitoring in search of the solution, as shown in the following student records: "It's gato! [cat]" or "Ur-so. So. [bear]"

Finally, another pedagogical feature of the game is difficulty progression. The game ranges from words with two syllables to words with five syllables, requiring students to adapt their problem-solving strategies. The use of polysyllabic terms such as "RINOCERONTE" [rhinoceros] and "HIPOPÓTAMO" [hippopotamus] increases the scope of the challenge, requiring students to go beyond sound identification and sustain their attention for a longer period. This continuous demand can encourage students to allocate their cognitive resources more efficiently, which becomes a central skill for monitoring and self-regulating their own learning.

4.4 Feedback of the Game "Cai balão"

Feedback is undoubtedly one of the most important resources of an educational game. It is the element that distinguishes the mere transposition of "traditional" activities into the digital medium and transforms the resource into a mediator of educational processes. Its role is fundamental within interactive learning resources, as it allows for the creation of strategies that promote and sustain student engagement in the activity. Furthermore, according to Butler and Winne (1995), feedback enables students to perceive competence — feeling that they are on the right track and capable of executing a task — which is essential for maintaining motivation. According to these authors, feedback is characterized as crucial information that students utilize to monitor their own performance within a self-regulated cycle; to be effective, its main objectives must be developing self-assessment and strengthening self-efficacy, transforming the student into an active agent.

The game "Cai balão" employs five feedback resources: an error sound; the return of the coconut to its original position in the event of an incorrect answer; a success sound; the animal exiting the screen; and earning stars as progress indicators. The first two resources—the error sound and the return of the coconut—are primarily responsible for promoting cognitive disequilibration. When students selected incorrect syllables, the audio cue and the object's return to its origin generated a sense of doubt. These resources functioned as a trigger for reflection. Among the questions externalized by the children upon making an error, the following remark was recorded: "Why didn't it work?".

At this precise moment, the monitoring of cognitive action occurs: the child pauses, observes the remaining coconuts again, and seeks a new phonetic relationship. This dynamic is vital, since "[...] every behavior tends to ensure an equilibrium between internal and external factors or, more generally, between assimilation and accommodation" (Piaget, 2021, p. 89, *our translation*).

From Flavell's (1979) perspective, this disequilibration is characterized as a metacognitive experience that interrupts the automatic flow and forces subjects to monitor their actions to reestablish equilibrium, adjusting their strategies according to task demands. In this view, metacognition is activated when something goes unintended: the game does not "punish" the error but provides valuable data for the learner's control system. Complementing this dynamic, the auditory feedback featuring the sound of the syllable during a failure awakens the subject's awareness. The sound not only marks the error but offers linguistic content so that the metacognitive experience is completed, allowing for the revision of the word-assembly strategy. When attempting to form the word "URSO" [bear], for instance, students start from a hypothesis; upon hearing the actual sound of the incorrect syllable, a contradiction occurs between expectation and the presented object. By processing this data, children build more solid knowledge regarding

the phoneme-grapheme relationship. During the observations, this became evident when a student, trying to complete the word “PEIXE” [fish], reproduced the final sound with the letter “i”, which is commonly pronounced this way regionally. She verbalized out loud while dragging the coconut: “Pei-xi. Xi.” After a few attempts at dragging the syllable “XI”, the student paused and, in silence, tried dragging the syllable “XE”, thus meeting the correct spelling of the word.

The success sound resources and the animal exiting the screen are also sensory stimuli, but unlike the previous ones, they serve as external validation of the student's internal strategy. This is the moment when children confirm their achievement. The success sound, revealing the pronunciation of the complete word, and the animal “ascending” in the balloon indicate that the hypothesis was correct. Such a situation has the potential to generate a successful metacognitive experience, motivating students to apply the same analytical logic in subsequent phases. This transition between effort and achievement is what Flavell (1979) identifies as the moment when the metacognitive experience alters knowledge about one's own competence. In this regard, the manifestation of feelings of self-efficacy was observed through students' spontaneous reactions as they verbalized their success out loud, as recorded in the following remarks: “I got it right on the first try!” and “Look, *tia*, I got it right!”.

The animal's departure functions as a cognitive “full stop”. Visually, this resource “clears” the scenery and signals task completion, avoiding ambiguity and preparing attention for the new challenge. For children who created narratives (such as helping the characters), their departure is the materialization of playful success: they did not just get the syllable right, but solved the animal's “problem”. Finally, the star scoreboard fulfills the need for self-monitoring. Beyond representing achievement, it functions as a progression indicator (what has been done and what is left). The absence of this marker can generate discomfort and disorientation regarding the required effort. Thus, the design of “Cai balão” offers a clear visual indicator that helps students manage their time and cognitive energy until the activity is completed.

4. Conclusion

Based on the analyses and discussions presented throughout this study, the results indicate that the game “Cai balão” can function as a device to foster metacognitive thinking. Unlike mechanical repetition activities, the game embeds students in a continuous cycle of action, monitoring, and regulation. The activities proposed in the game require children to reflect on language structure, establish relationships between phonemes and graphemes, and evaluate their own repertoire of prior knowledge. The transition from mechanical action to conscious decision-making is mediated by a playful aesthetic, an informal activity setting, and, primarily, the absence of direct pressure for correct answers, which reduces inhibition and makes students more comfortable reflecting on their actions. Together, these elements remove students from the position of passive receptors and position them as protagonists who test hypotheses and validate their own conclusions.

It is also important to highlight that the game grants students control over the information flow; they decide the pace, how many times to analyze a given syllable, and when to perform each action. This characteristic is essential for developing cognitive autonomy. The circumstances observed during the game sessions demonstrate that such control favors persistence in the face of difficulty, peer collaboration, and the emergence of feelings of self-efficacy, such as the pride displayed by the children upon succeeding in the activity. These elements reinforce the perception of competence and consolidate positive self-regulation cycles.

However, it is fundamental to emphasize that using the game does not diminish the teacher's role; on the contrary, technology is integrated as a tool to enrich teaching practice, not as a substitute. By observing a child hesitate or noticing that they verbalize their reasoning before completing an action, teachers gain privileged access to metacognitive processes that previously remained concealed. The game does not compete with other teaching practices but offers educators a tool for diagnosing student learning, enabling them to intervene more precisely and in a personalized manner.

In conclusion, if systematically and consciously incorporated into teaching practice, the use of the game “Cai balão” can support the literacy process by offering students opportunities for conscious knowledge and conscious control over their own learning. Beyond an activity about words and syllables, the game creates opportunities for

children to learn from their successes and failures, learn to monitor their learning, and, above all, develop a reflective relationship with their own thinking.

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