

Computational Fables: Design and Validation of a Digital Game to Assess Computational Thinking Skills in Elementary School

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Abstract

Computational Thinking (CT) is a set of skills based on the foundations of Computer Science that help us deal with complex problems. CT teaching is covered by the Brazilian National Common Curricular Base (BNCC), both in its Computing Supplement and in the area of knowledge of Mathematics and its Technologies. In 2022, the National Education Council (CNE) established new rules on teaching from Elementary to High School, defining the inclusion of Computer Science teaching in the BNCC. This decision specifies that all schools in Brazil will have CT teaching, among other content related to Computing Science, which generates a demand for teaching materials and qualified teachers for this new knowledge. Different approaches can stimulate CT skills, among which we highlight games. Gaming environments promote protagonism and learning through play, as recommended by Game-Based Learning (GBL). According to the literature, the most common CT assessment methods are tests, questionnaires, and programming tests, resources not considered very interactive. Given this problem, this research presents the design, validation, and testing processes of a digital game named “Computational Fables”, developed to assess Computational Thinking skills using Game Learning Analytics techniques. The research aims to highlight the implications of using a digital game as an assessment instrument for Computational Thinking with elementary school students. The Design Science Research Methodology (DSRM) approach was used as a methodological path, as it legitimizes the development of artifacts to produce scientific knowledge. The pedagogical and gameplay aspects of the game were evaluated by undergraduate students in Computing Science using the questionnaires Model of Criteria for the Evaluation of Educational Software and Model for the Evaluation of Educational Games (MEEGA+). Subsequently, the game was assessed as a CT assessment resource, and the test was applied together with the formal Bebras Challenge test to assess elementary school students. As a result of the evaluation, we found that the game has potential both in terms of pedagogy and game quality, satisfactorily addressing Computational Thinking skills and presenting good aesthetic and gameplay quality. As a result of the tests, we identified similar results in the Bebras Challenge and the Computational Fables, with a tendency for better performances in the game concerning the formal test, a factor that can be justified by the possibility of making several attempts in the game, as well as by its playful nature, which enhances the engagement and motivation of students in the face of difficulties. We concluded from the Computational Fables experiment that games represent an efficient resource for assessing Computational Thinking skills and, when designed especially for assessment purposes, they can be more effective instruments than traditional assessment methods, as games bring more engagement and break the paradigm of assessment as something punitive.

Keywords: *Game-Based Learning, Computational Thinking, Game Learning Analytics, Elementary Education*

1 Introduction

The inclusion of technologies in education has already become a reality, and educational software has been widely used to help teachers and students in the teaching and learning processes. In this sense, selecting good educational software for use in the classroom can be a challenge, given the wide variety of available resources. Several Information and Communication Technologies (ICT) have been explored with the aim of improving educational processes and promoting the development of skills in students. Such technologies include everything from the use of computers, tablets, and digital whiteboards to the application of software, such as educational games and applications for mobile devices, among others (Petri, 2020).

Among these resources, digital games stand out, as learning through games is in line with the needs and learning styles of the current and future generations, in addition to being incredibly versatile and can be adapted to different disciplines or skills to be learned (Prensky, 2021). Games stand out as part of people's daily lives. They are complex and attractive platforms that transcend gender and age barriers. They offer possibilities for interacting with a different world through immersive experiences and encouraging the experimentation of several emotions (Pimentel, 2021). Challenges, objectives, goals, and rewards surround the games, and through them, the users learn and develop themselves to achieve victory (Carvalho, 2015). This process is possible thanks to a set of rules inherent to these environments, both explicit and implicit. These rules bring order and direct the game flow, allowing the users to learn through them (Carvalho, 2015). Games are also capable of assisting the development of problem-solving skills, providing students with the opportunity to establish action plans to achieve their goals, execute these plans through the game, and evaluate their effectiveness based on the results obtained (Kishimoto, 2017). Among the problem-solving skills that can be worked on through games, we highlight Computational Thinking (CT).

The Brazilian Computer Society (in Portuguese, SBC) describes that the CT is based on the fundamentals of Computer Science to develop capabilities in understanding, defining, modeling, comparing, solving, automating, and analyzing problems and solutions in a careful and systematic way through the construction of algorithms (Brasil, 2018). More than an exclusive skill in the field of Computing, Computational Thinking is an essential skill for everyone (Siqueira, 2022). Wing (2006) argues that CT should be taught from an early age, becoming a basic skill for children, just like reading, writing, and arithmetic. In 2022, the Brazilian National Education Council (in Portuguese, CNE) established that all schools in Brazil must implement the teaching of Computational Thinking (Siqueira, 2022).

A systematic mapping conducted by Nipo and collaborators sought to investigate scientific works related to Game-Based Learning and Computational Thinking in elementary education, published between 2017 and 2022 (Nipo et al., 2024). The mapping revealed that research focuses on learning objectives, leaving aside the use of games for reinforcement or as an assessment resource, with assessment through games being the least explored. Nipo and collaborators's (2024) research also reinforces the importance of student assessment being procedural and centered on their formative process and that games can be a viable resource for verifying student learning.

This research results from a master's dissertation and presents the processes of design, validation, and testing of a digital game entitled “Computational Fables”, developed as an assessment tool for Computational Thinking skills using Game Learning Analytics (GLA) techniques, focusing on elementary school students. We seek to examine the game in order to address the following research question: “Can digital games serve as an effective instrument for assessing the development of Computational Thinking skills?”

The present study is justified by the National Education Council’s mandate establishing the teaching of Computational Thinking in Basic Education, which creates demand for appropriate

materials and adaptations (Siqueira, 2022); by the scarcity of consolidated methods and resources, given that the use of games for learning assessment remains incipient (Oliveira et al., 2019); by the potential of playful assessment approaches to serve as a highly relevant instrument across multiple educational domains, helping to challenge paradigms that frame assessment as punitive (Rowe et al., 2021); and by the limited availability of games used in CT instruction that simulate everyday problem-solving, as most existing games still provide low-interactivity environments based on command-block systems (Israel-Fishelson et al., 2021; Zhao & Shute, 2019; Grizioti & Kynigos, 2021).

Given that this research involved the development of a technological artifact, we adopted the Design Science Research Methodology (DSRM), formulated by Peffers and colleagues, as the foundation for constructing the methodological path of the study (Pimentel et al., 2020). Design Science Research is an approach that legitimizes the development of artifacts as a means for generating scientific knowledge.

The data collected in this study are quantitative in nature and were obtained from 46 elementary school students through the Bebras Challenge, a formal Computational Thinking assessment test, and through stealth data capture using Computational Fables, the digital game developed in the research. The pedagogical and gameplay aspects of the game were evaluated by 28 undergraduate students in Computing, using the questionnaires Model of Criteria for the Evaluation of Educational Software (Silva et al., 2011), and Model for the Evaluation of Educational Games (MEEGA+) (Petri et al., 2017). The game was evaluated as a CT assessment resource along with the formal Bebras Challenge test, with 46 students from the 5th to 8th grade of Elementary School.

As a result, we identified that games specifically designed for assessment purposes can serve as an effective resource for evaluating Computational Thinking skills, potentially offering greater engagement than traditional methods and helping to break the paradigm of assessment as a punitive practice.

2 Theoretical Foundation

2.1 Computational Thinking

Among the skills originating from Computing, Computational Thinking (CT) stands out, which consists of the ability to carry out computational processes within their limits, whether conducted by a machine or human beings (Wing, 2016). Despite being a recent term, CT has been considered one of the fundamental pillars of the human intellect, as well as reading, writing, and arithmetic, because, like them, CT serves to describe and model the universe and its processes (Raabe et al., 2017). Debates about CT and its contributions have received increasing attention in recent years from groups investigating the teaching of Computing, especially regarding its introduction into the educational context (Falcão & Barbosa, 2015). Using CT strategies, we can systematize, represent, analyze, and solve problems (Pouza, 2020; Raabe et al., 2017). Among the skills developed by the CT, we can highlight: 1) delimiting problems so that we can use the computer or tools to solve them; 2) organizing, abstracting, representing, and analyzing data; 3) automating solutions through algorithms; 4) identify, analyze and implement solutions, aiming for the path of highest efficiency/effectiveness of steps and resources; 5) generalize problem-solving processes to a wide variety of situations (Wing, 2016).

The Brazilian National Common Curricular Base (in Portuguese, BNCC) highlights the relationship between some CT skills and Mathematics, such as algorithms, decomposition, and pattern recognition. The document highlights the relationship between algorithmic language and algebraic language, especially concerning the concept of variables (Brasil, 2018). With the

Computing complement to the BNCC, CT knowledge goes beyond what is in Mathematics (Siqueira, 2022). The BNCC also lists a series of skills and abilities that must be taught in each year of formal education, such as: 1) develop the ability to recognize and identify patterns, building sets of objects based on criteria of quantity, shape, size, color, and behavior; 2) experience and identify different forms of interaction mediated by computational artifacts; 3) playfully create and test algorithms with artifacts from the environment and with body movements, individually or in groups; 4) solve problems using decomposition to divide them into smaller parts, identifying steps, stages or cycles that repeat themselves, and that can be generalized or reused for other situations (Siqueira, 2022).

According to the opinion approved by the National Education Council (CNE/CEB No. 2/2022), which establishes guidelines for teaching in Basic Education, the teaching of Computing knowledge will be incorporated into the Brazilian National Common Curricular Base (BNCC) and will therefore become part of the curriculum in all schools in the country (Siqueira, 2022). With this measure, the teaching of Computing in basic education becomes a public policy, creating demand for qualified teachers as well as materials and methods that enable the teaching of these new competencies.

BNCC outlines a wide variety of approaches to developing Computational Thinking. The most common is the use of programming logic in creating simple projects in visual environments. Programming is done by organizing blocks of commands that must fit together like a puzzle. In this context, students need to focus their attention only on the logic of their project since the block system eliminates the need for coding and syntax (França & Tedesco, 2015). There are also CT teaching methodologies without using technology through fun activities involving the fundamentals of Computer Science, such as Unplugged Programming (Vieira et al., 2013). Playful strategies tend to capture students' attention and contribute significantly to the construction of knowledge. In this sense, games also stand out as a viable alternative for CT development.

2.2 Game-Based Learning

The quest to make learning more attractive is a constant challenge for educators, and teachers must use assorted materials and methodologies. Traditional methodologies see the teacher as the main authority and source of knowledge, with the predominant use of expository classes (Lovato et al., 2018). Social changes have promoted new perceptions about teaching and learning, leading to the emergence of Active Learning Methodologies, such as Problem-Based Learning (PBL), Problematization, Project-Based Learning, Team-Based Learning (TBL), Peer Instruction, and Flipped Classroom (Lovato et al., 2018). Active Learning occurs when the student interacts with the content (listening, speaking, doing, questioning, discussing, and teaching), being encouraged to lead the construction of their knowledge instead of just receiving it passively. In this scenario, the teacher acts as a mediator, the facilitator of the learning process, instead of being the only source of information and knowledge (Barbosa & Moura, 2013).

A trend that has been gaining prominence is learning through Digital Games due to its ability to promote motivation in teaching and learning processes, increasing students' interest in learning (Falcão & Barbosa, 2015). Over the years, electronic games or digital games, one of the most captivating forms of media in simulation culture, have undergone a series of transformations, ranging from aspects of technology and the market to advances in techniques and research (Alves, 2013). Research into the use of digital games in the educational context emerged in the 1980s, addressing the development of reasoning in the electronic age and highlighting the role of TV, computers, and video games (Alves, 2008).

When discussing games applied in education, we are going back to Game-Based Learning, which is also part of Active Learning Methodologies and is a trend that has been increasingly incorporated into education (Sena et al., 2016). Among the advantages inherent to the use of

Digital Games we can highlight immediate feedback of actions, learning in practice, learning from mistakes, goal-guided learning, discovery-guided learning, question-guided learning, contextualized learning, training, constructivist learning, accelerated learning, selecting from learning objects, and intelligent instruction (Sena et al., 2016). Game-based learning also engages with the learning style of current generations, provides motivation through fun, and can be adapted to the most diverse disciplines and skills to be learned (Prensky, 2021).

However, among the many possibilities for using games in education, the assessment of learning is often the most neglected. Educators report difficulties in using games in evaluation processes (Fellows et al., 2022), in many cases, due to the lack of reports in the literature and consolidated methods and resources (Oliveira et al., 2019). In this context, an approach that has gained prominence in learning assessment through games is Game Learning Analytics (GLA) (Nipo et al., 2024). The collection of educational data, also known as Learning Analytics (LA), is an emerging field in which data-science-based tools are employed to capture data with the aim of improving learning and education in virtual environments (Farias, 2019). When these techniques are applied within games, interactive environments in which multiple types of data are generated, we enter the domain of GLA, which refers to the collection of educational data in game environments for the purpose of understanding and optimizing learning (Alonso-Fernández et al., 2019). Through GLA techniques, it is possible to capture data related to educational aspects and their underlying sciences, technical data about the game and its architecture, as well as data about the user and their experience (Nascimento et al., 2021).

Prensky (2021) states that we can combine games with educational processes in many different ways and games can achieve results that are as good as or even better than those obtained through traditional learning methods. Given the potential of games in education, it is essential to conduct new educational game projects and research in the most diverse areas of knowledge.

3 Methodology

Since this research involved the production of a technological artifact, we chose to adopt the Design Science Research (DSR) approach as the basis for constructing the methodological path, specifically the Design Science Research Methodology (DSRM) by Peffers and collaborators (2007), an approach that legitimizes the development of artifacts as a path for the production of scientific knowledge (Pimentel, 2017). The term Design Science was created in the 1960s by Fuller and Gregory in response to the need to find a more systematic way to develop artifacts or improvements, thus creating DSR. In the 1970s, Design Science Research began to be widely used in projects involving the areas of electrical engineering and computer engineering, and in the 1990s, it reached computer science (Rodrigues, 2018). Figure 1 shows the research steps.

The DSRM is structured into six steps: (1) Problem Identification and Motivation, in which the problem within the studied context is defined and justified by explaining why it is worth solving, whether due to scientific, social, or practical relevance, along with an analysis of its causes, impacts, and gaps in the literature; (2) Definition of Objectives, in which the desired characteristics of the solution are established, including its criteria and requirements, thereby determining the ideal solution to address the identified problem; (3) Design and Development, during which the artifact (model, method, tool, software, etc.) is created, resulting in a product capable of solving the problem and/or meeting the defined objectives; (4) Demonstration, in which the artifact is tested in a controlled context to demonstrate its functioning and to show how it solves the problem in practice; (5) Evaluation, where it is assessed whether the artifact effectively solved the problem by examining its efficacy, efficiency, utility, usability, and alignment with the objectives; and (6) Communication, in which the research results are disseminated to the scientific

and professional communities in order to share the knowledge produced and enable the reuse or evolution of the artifact (Peffer et al., 2007).

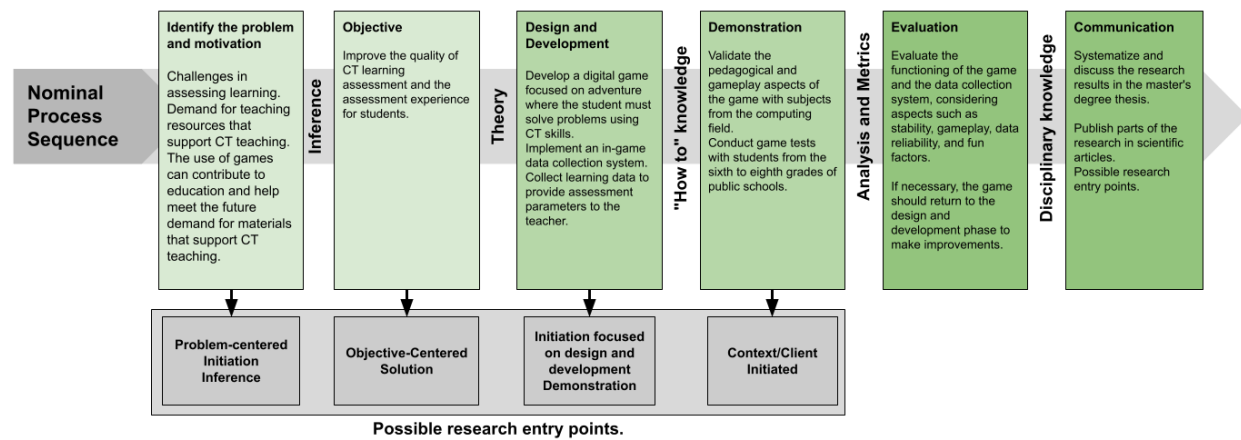


Figure 1: Methodological path based on DSRM.

Based on the DSRM methodological approach, we delimited the research field and its objectives, developed the educational game prototype Computational Fables, tested and evaluated the prototype in the field, and analyzed and discussed the collected data.

3.1 Problem Identification and Motivation

The identification of the problem emerged from the new demand for teaching Computing and Computational Thinking concepts in Basic Education, as established by Opinion No. 2/2022 approved by the National Education Council. This mandate determines that, among other Computing-related content, the teaching of Computational Thinking becomes a public policy and will be present in all schools in Brazil, generating a need for instructional materials and qualified teachers capable of teaching these new competencies (Siqueira, 2022).

A literature review on games and Computational Thinking revealed that few studies focus on the use of games for reinforcement or as an assessment resource, with game-based assessment being the least explored dimension (Nipo et al., 2024). A motivating factor for conducting this research is the belief that playful assessment strategies may represent a highly relevant instrument across various areas of education, helping to break paradigms that frame assessment as punitive (Rowe et al., 2021). We consider that student assessment should be process-oriented and centered on the learner’s developmental trajectory, and that games may constitute a viable resource for verifying students’ learning (Nipo et al., 2024).

In this context, the selection of the research object was motivated by the belief that games can enhance educational practices, offering benefits to both teachers and students, as well as by the expectation of growing demand for instructional materials that support the development of Computational Thinking, driven by the incorporation of Computing competencies into the BNCC.

3.2 Game Development

The conception of Computational Fables started with the choice of Computational Thinking content to be worked on, taking the Computing Complement of the BNCC as a basis. The CT Knowledge Objects were selected for 6th-grade Elementary School students due to the diversity of skills covered and their applicability to real-world problems, since from the 7th grade onwards, the Knowledge Objects are centered on programming and focusing on computational environments.

The contents covered in the game were: 1) Data Types: “(EF06CO01) Classify information, grouping it into collections (sets) and associating each collection with a ‘data-type’” (Siqueira, 2022). 2) Programming Language: “(EF06CO02) Develop algorithms that involve sequential, repetition, and selection instructions using a programming language; (EF06CO03) Accurately describe the solution to a problem, building the program that implements the described solution” (Siqueira, 2022). 3) Decomposition: “(EF06CO04) Construct problem solutions using the decomposition technique and automate such solutions using a programming language” (Siqueira, 2022). 4) Generalization: “(EF06CO05) Identify the resources or information needed (inputs) to solve problems, as well as the expected results (outputs), determining the respective types of data, and establishing the problem definition as a relationship between input and output; (EF06CO06) Comparing different particular cases (instances) of the same problem, identifying the similarities and differences between them, and creating an algorithm to solve them all, using variables (parameters) to allow the treatment of all cases in a generic way” (Siqueira, 2022).

As for game design, we chose to use the contributions of Jesse Schell (2008) as a strategy, who divides the game through its constituent parts in the Elemental Tetrad (Figure 2). The tetrad can be applied both in the creative process of conception, combined with the creative strategy of brainstorming, and in the documentation process, serving as a basis for structuring the Game Design Document (GDD). The Elemental Tetrad allows us to understand a game through its constituent elements, divided into four elementary parts related to each other: aesthetics, mechanics, history, and technology.

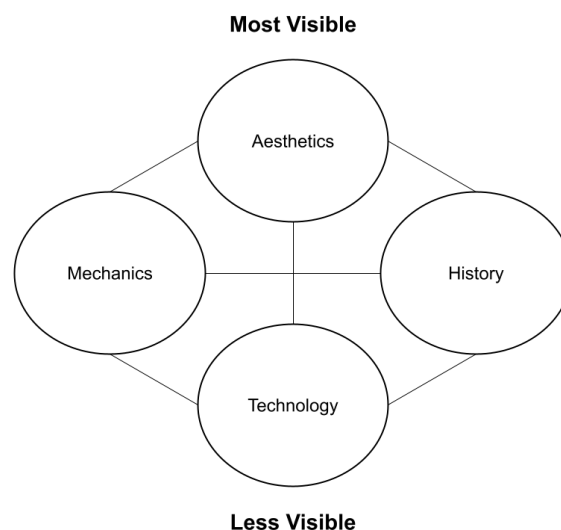


Figure 2: Elemental Tetrad.

The mechanics of a game refer to its procedures and functioning, that is, the game rules. It clearly describes the objectives and what is available for the player to achieve them. The

narrative is the sequence of events that unfold in the game and the story we want to tell and will be revealed as we play. The story can be presented linearly, with previously determined events, or in a branched way, when there is the possibility of choosing the paths to follow. Aesthetics is related to everything that our senses capture when we play and is mainly associated with what we see, the art of the game, but Schell (2008) also refers to what we hear, smell, taste, and sensations. Besides being the most notable element, aesthetics is closely related to the player experience. Technology is how the player interacts with the game. It is essential to understand that, when addressing technology, Schell (2008) is not necessarily referring to sophistication. Technology can be pencil and paper, plastic pieces and a board, or virtual reality glasses; they are the resources, the means that allow communication between the player and the game.

From the moment we observe the Elemental Tetrad and the game elements separately (and we can understand the role of each one), we acquire an understanding of the process of creating a game and its parts: design, sound, programming, technology, and script. Thus, playful strategies were implemented in Computational Fables to address Computational Thinking content.

3.3 Participating Subjects

This research had the collaboration of two groups of participating subjects with different profiles and functions: one group participated by analyzing and evaluating the game Computational Fables as an educational resource, formed by subjects with experience in computing and Computational Thinking, and another group participated by being evaluated by the game, formed by elementary school students.

Twenty-eight students in the Course of Degree in Computer Science at the BLIND REVIEW analyzed and evaluated the game Computational Fables. The choice of these participating subjects is justified because they are future computer science teachers who will work in elementary education schools; they are students in the second half of their Degree in Computer Science and have already studied theoretical subjects in Computational Thinking. The recruitment of undergraduate students and the testing and evaluation of the game Computational Fables occurred during the Computing Teaching Methodology classes, a mandatory curricular component of the undergraduate degree in computing. The discipline, which was in its final months, had the analysis of educational software or games as an assessment activity. In this sense, it was convenient for both parties, researchers and undergraduate students, that Computational Fables were the object of analysis of the activity.

Six of the 28 undergraduate students were female, and twenty-two were male, aged between 19 and 59. The participants performed a self-assessment on their levels of knowledge of Computational Thinking and affinity with games, using a Likert scale from 1 to 5, where 5. very high, 4. high, 3. moderate, 2. low, and 1. very low. Regarding Computational Thinking, undergraduate students self-assessed their knowledge as 7.1% very high, 42.9% high, and 50% moderate. Regarding affinity with games, the self-assessments were 35.7% very high, 14.3% high, 28.6% moderate, 17.9% low, and 3.6% very low.

The group that participated in the tests, evaluated by Computational Fables, was formed by 46 students from the 5th to 8th grade of Elementary School, students from the municipal education network of Recife, Pernambuco. The choice of these subjects is justified by the relationship between these school years and the Computational Thinking content covered in the game, chosen following what the Computing Supplement of the BNCC specifies. The tests were conducted at the Citizenship Education Technology Units (in Portuguese, UTEC), advanced computer centers maintained by the Department of Education distributed across the city. The recruitment occurred through contact with the management of the UTECs, who invited the students and their guardians.

Twenty of the 46 elementary school students were female, and twenty-six were male, aged between 10 and 15. The distribution of students according to school grades was 17 5th-grade students, 11 6th-grade students, 9 7th-grade students, and 9 8th-grade students. The participants performed a self-assessment on their levels of Computational Thinking knowledge and affinity with games using the same Likert scale presented previously. Regarding Computational Thinking, elementary school students self-assess their knowledge as 12% very high, 38% high, 36% moderate, and 14% low. Regarding affinity with games, self-assessments were 44% very high, 40% high, 12% moderate, and 4% low.

Before starting the research with the participants, the project was submitted for consideration by the UFRPE Ethics Committee. The research project was registered on the Plataforma Brasil under the Certificate of Presentation of Ethical Appreciation (CAAE) No. 69837723.1.0000.9547 and approved for data collection with human beings by Consolidated Opinion No. 6.551.178.

3.4 Data Collection and Analysis Methods

The data collected in the research are quantitative, collected through different approaches and tools: Educational Software Evaluation Questionnaire, Bebras Challenge, and Computational Fables. According to Marconi & Lakatos, quantitative research represents reality through numerical data, allowing for precise evidence of the characteristics of observed scientific facts and/or phenomena to conduct objective, mathematical, and statistical data processing (Marconi & Lakatos, 2004).

Data collection with undergraduate students used an Educational Software Assessment Questionnaire, made available via an electronic formulary. The questionnaire was developed based on two questionnaires known in the literature: the Model of Criteria for the Evaluation of Educational Software, developed by Silva and collaborators (2011), and the evolution of the Model for the Evaluation of Educational Games (MEEGA+), developed by Petri and collaborators (2017). Furthermore, the BNCC Computing Complement was used to generate specific questions about the Computational Thinking Knowledge Objects present in the game (Siqueira, 2022).

Educational Software Evaluation Questionnaire and the Computational Fables prototype were available to undergraduate students. These students had three weeks to assess the game and submit their evaluations. The analysis of the questionnaire data was conducted using mean values, examining the distribution of responses for each question.

Data collection with elementary school students used the formal Computational Thinking test Bebras Challenge¹, and the digital game Computational Fables. GLA techniques were used in the game to collect data, according to contributions from Zapata-Cáceres & Martín-Barroso (2021), without interrupting the players and affecting their experience (Melo et al., 2020). GLA techniques were also used to record accurately player actions and evaluate their learning (Oliveira Neto et al., 2019). In the Bebras Challenge, the collection used an electronic formulary prepared according to evidence provided by Bebras Brasil.

Data collection with elementary school students was conducted over three weeks in face-to-face meetings at UTECs lasting 2 hours each, with 1 hour for the Bebras Challenge and 1 hour for the game, in that order. Before starting data collection, a brief presentation explaining the research objectives and the dynamics of the activity was given to the students. The students

¹ According to information on the Bebras Brasil website, the Bebras Challenge is an assessment applied in more than 70 countries aiming to develop Computational Thinking and draw attention to computer science, inviting participants to use essential skills for the future. The challenge's dynamics consist of solving multiple choice activities called TASKS. According to information from Bebras Brasil, the activities can be solved by children and young people without prior knowledge of computing.

participating in the tests had no prior contact with formal Computational Thinking teaching and only worked on concepts related to CT through robotics classes and game creation in the Scratch software.

The analysis of the Bebras Challenge data was conducted using mean values based on the participants' accuracy rates for each question. The data from Computational Fables, obtained through GLA, were analyzed using mean values derived from the number of attempts, correct responses, and time spent on the challenges. Additionally, a statistical analysis was performed using an independent samples t-test.

4 Results and Discussion

4.1 Computational Fables

The game Computational Fables (in Portuguese, *Fábulas Computacionais* or FC) was produced to be used as an assessment resource for Computational Thinking skills, with environments, challenges, and gameplay that would allow its completion by elementary school students within the time limit of one hour. Below are the key features of the game, divided according to its elementary parts according to Schell (2008): aesthetics, mechanics, narrative, and technology.

Due to the evaluative purpose of FC, we opted for an objective narrative that serves only as a backdrop, an objective contextualization of the game world. This story consists of a short adventure where Rose, the protagonist, enters a fantasy world. For the character to return to her world, she must solve a series of challenges and collect 12 magical jewels. This practice of placing less emphasis on the narrative, leaving space for other game elements to provide context, is common in some games in the industry. A well-known example occurs in *LIMBO*², a game where the narrative is told through the environment and challenges.



Figure 3: Aesthetics of Computational Fables.

² LIMBO is a game for Android, iOS, Mac, and Windows that tells the story of a lost boy searching for his sister. The situation becomes even more complicated when the protagonist enters Limbo, a dark place full of dangers. On his path, there are dangerous traps and macabre living beings! To defeat them, the players need to use their heads, solving scenario puzzles to open a path in the darkness.

The resulting aesthetic of Computational Fables was similar to its inspirations, games like *Zelda*³ and *Mario*⁴, with strong colors and lots of green in its elements (Figure 3). The game's scenarios provide an ambiance that dialogues with the narrative's proposal. In the external environments, which serve as areas for selecting the stages, we have small villages surrounded by trees. The scenarios are full of compositional elements that make the world more complete and real, simulating a magical forest.

Computational Fables was submitted to the SBGames 2023 Arts Festival, a competitive event with awards for the best arts in games, to validate and evaluate artistic quality. Computational Fables was recognized as one of the best pieces of art at the event, reaching 3rd place in the InGame Screenshot category. This award at an event like SBGames⁵, one of the biggest gaming events in Brazil, represents the recognition that Computational Fables, at least in terms of artistic quality, achieved its purpose of being on par with the entertainment games in the industry, having its quality recognized by the curatorship of the event's Arts Festival.

The mechanics of Computational Fables are centered on four puzzles with specific mechanics, objectives, and gameplay, each exploring a Computational Thinking Knowledge Object.

The Data Type puzzle (Figure 4) was named Object Grouping Puzzle. Its mechanics consist of carrying objects to a certain set, following the guidelines of each challenge. The gameplay of the Object Grouping Puzzle dialogues with what is recommended in the BNCC computing complement for Data Types: (EF06CO01) Classify information, grouping it into collections (sets) and associating each collection with a 'data type' (Siqueira, 2022).



Figure 4: Object Grouping Puzzle.

The Musical Puzzle (Figure 5) works with Programming Language. Its mechanics consist of creating a melody. To do this, the players must look for clues in the scene and select the instrument to be played, position the melody notes, and manage the number of notes using repetition instructions. The gameplay of the Musical Puzzle dialogues with what is recommended by the BNCC computing complement for Programming Language: (EF06CO02) Develop

³ The Legend of *Zelda* is a series of Nintendo video games created in 1986 by Shigeru Miyamoto and Takashi Tezuka. It focuses on action-adventure video games and some RPG elements.

⁴ *Super Mario* is a series of platform video games created by Nintendo, based on and starring the fictional plumber Mario. Alternatively called the *Super Mario Bros.* series or simply the *Mario* series, it is the core series of the larger Mario franchise.

⁵ SBGames - Brazilian Symposium on Computer Games and Digital Entertainment is the main event and pioneer in Games and Digital Entertainment in Brazil. It is promoted annually by the Special Interest Group on Games and Digital Entertainment (in Portuguese, CEJOGOS) of the Brazilian Computer Society (in Portuguese, SBC).

algorithms involving sequential, repetitive, and selection instructions using a programming language; (EF06CO03) Accurately describe the solution to a problem by building the program that implements the described solution (Siqueira, 2022).

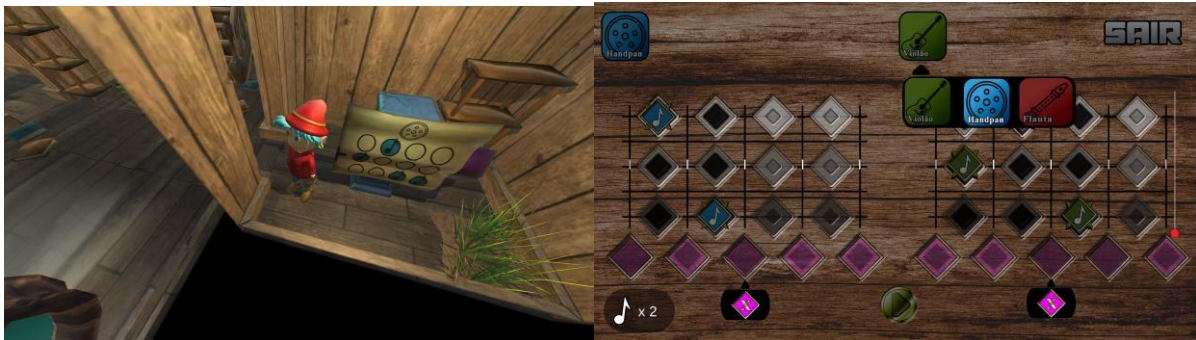


Figure 5: Musical Puzzle.

The Puzzle called The Path of Light (Figure 6) works on the Decomposition skill. Its mechanics consist of arranging mirrors to conduct the beam of light to a crystal. The gameplay of this Puzzle dialogues with what is recommended by the BNCC computing complement for Decomposition: (EF06CO04) Construct problem solutions using the decomposition technique and automate such solutions using a programming language (Siqueira, 2022).



Figure 6: The Path of Light.

The Recipe Puzzle (Figure 7) works on Generalization skills. Its mechanics are centered on collecting ingredients and actions and placing them orderly on tables to prepare a recipe. The puzzle gameplay dialogues with the BNCC computing complement for Generalization: (EF06CO05) Identify the resources or inputs needed to solve problems, as well as the expected results (outputs), determining the respective types of data, and establishing the problem definition as a relationship between input and output; (EF06CO06) Compare different particular cases (instances) of the same problem, identify the similarities and differences between them, and create an algorithm to solve them all, using variables (parameters) to allow the treatment of all cases in a generic way (Siqueira, 2022).



Figure 7: Recipe Puzzle

To evaluate Computational Fables and to better understand its potential and limitations as an educational resource, the game was first made available to a group of undergraduate Computing Education students. Tests were conducted, and the game was assessed using the Educational Software Evaluation Questionnaire.

4.2 Educational Software Evaluation Questionnaire

The 28 undergraduate students assessed the game and answered the Educational Software Evaluation Questionnaire. Its fifty-one questions evaluated pedagogical aspects, player experience, and Computational Thinking Knowledge Objects. The questions were answered using the Likert scale with a range of 1 to 3. The scale, which will be presented graphically in the following topics, is represented as follows: 1. strongly disagree (yellow), 2. neither agree nor disagree (gray), 3. agree (green).

4.2.1 Assessment of Pedagogical Aspects

To assess the pedagogical aspects of Computational Fables, we applied the “Criteria Model for Educational Software Evaluation,” which consists of 14 questions (Figure 8) (Silva et al., 2011). According to the data collected, there was a higher incidence of positive evaluations for the pedagogical aspects of Computational Fables, considering that the highest percentage of evaluations is three on the Likert scale.

We can emphasize some aspects evaluated in the Educational Software Evaluation Questionnaire, such as, for example, the first question: “It has different degrees of content complexity in the activities.” To this question, 88% of the evaluators considered that the game has this resource, 8% remained neutral, and 4% partially disagreed. As the data shows, Computational Fables met this requirement. In all challenges in the game, there is a progression of difficulty. Each puzzle in the game has three difficulty levels: the first has an easy, the second has medium, and the third challenge has a hard. The game also leads the student to follow this progression, preventing them from having access to medium or hard challenges when they are still learning to play at the beginning of the game.

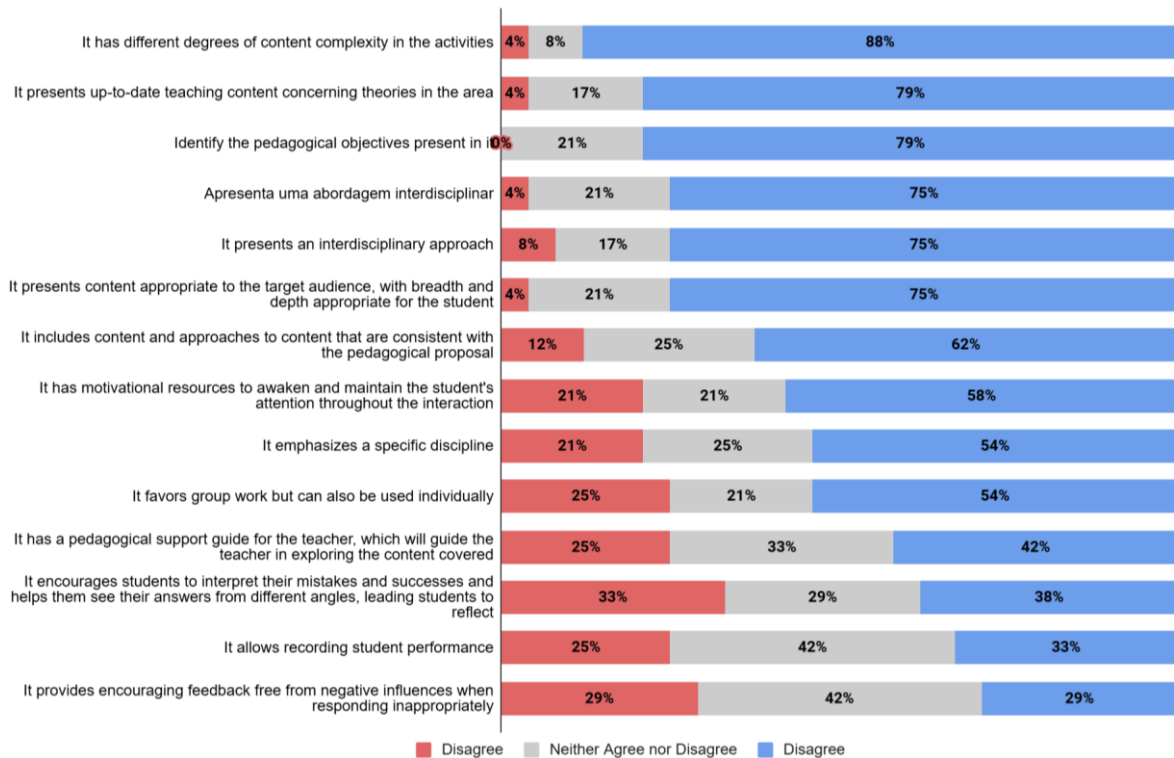


Figure 8: Pedagogical Questions.

The second question was: “It presents up-to-date teaching content concerning theories in the area.” Analyzing its answers, 79% of the evaluators considered the game content up-to-date, 17% remained neutral, and 4% disagreed. As validated by most evaluators, Computational Fables fully meets this requirement, as its challenges were designed based on the BNCC computing complement, a reference and updated document for teaching Computational Thinking (Siqueira, 2022). Other questions also highlighted the alignment with the content, such as “It presents content appropriate to the target audience,” positively evaluated by 75% of undergraduate students, and “It identifies the pedagogical objects present in it,” which received 79% of positive evaluations.

The exception to this trend of positive evaluations occurs in the last questions, which show a division between the evaluators and a high number of neutral evaluations. We will discuss some of these questions and whether or not the game addresses what is described in them.

Question 12 was: “It encourages students to interpret their mistakes and successes and help them see their answers from different angles, leading students to reflect.” It seeks to understand whether the game offers ways for students to reflect on their answers, whether right or wrong. According to the data, 38% of evaluators consider that Computational Fables has resources that help students identify their mistakes, 29% were neutral, and 33% assessed that the game does not have such resources. In all the Computational Fables challenges, a reward screen is immediately displayed whenever the player gets it right, giving a gem (Figure 9) that represents feedback that makes it clear to the students about their success.



Figure 9: Feedback screen displayed when winning a challenge.

The error is communicated differently for each type of challenge, given that Computational Fables has four puzzles with different mechanics.

In the Object Grouping Puzzle, after the student has placed all the objects in sets, the game checks the objects, and those placed in sets to which they do not belong are marked in red so that the players know where they went wrong. In the Musical Puzzle, when assembling a melody incorrectly, the musical box does not unlock the reward jewel and asks the student to continue editing the melody. In the Recipe Puzzle, as in the Object Grouping Puzzle, objects positioned in the wrong places are highlighted in red, which indicates to the students that part of their solution is incorrect. In The Path of Light, if the player gets the mirrors in the wrong position, the light goes out when the crystal is not found, the crystal is not illuminated, and the control screen shows an incomplete sequence of instructions. Understanding the instruction screen with the sequence of steps is part of the game-learning process.

Another crucial point about how the game encourages students to interpret their mistakes and successes. The students are taught from the first challenge that they earn a reward when completing a challenge. Therefore, if the players complete a task and do not receive the reward, they understand that something is wrong. It is also important to highlight that the game has an assessment purpose. Therefore, providing too much help could compromise the quality of the assessment.

Another question that divided the evaluators was number 13, about recording actions: “It allows recording student performance.” The data indicates that 33% of undergraduates evaluated yes, 42% were neutral, and 25% evaluated that the game does not allow the recording of student performance. Despite the assessments, Computational Fables has two resources that record student performance. The first is the pause screen, which displays the progress of the players, game time, and the number of gems collected (which correspond to challenges completed). In addition, the game has a data collection system that stores student identification information in an external file (such as name, age, gender, and grade) and game performance information, capturing the number of attempts, hits, errors, and time spent on each challenge. With this information, the teacher can analyze their class knowledge about CT, checking the general and specific performance of each Knowledge Object.

The last question, number 14, was: “It provides encouraging feedback free from negative influences when responding inappropriately.” Regarding this question, the game does not have

this feature. Due to the short time to research and develop the game, we opted to focus our efforts on diversifying the game's puzzle challenges.

4.2.2 Player Experience Assessment

To assess the gameplay experience aspects of Computational Fables, we applied the MEEGA+ instrument, which consists of 33 questions (Figure 10) (Petri et al., 2017). As in the evaluation of pedagogical aspects, we can observe a positive trend regarding gaming experience in the evaluations of undergraduate students. Below, we will analyze some of the questions and what their reviews say about the game.

The evaluations were favorable regarding Computational Fables being suitable for the development of Computational Thinking, which is evidenced by the indicators of question 1 (The game is an adequate teaching method for this subject), which shows 92% of the evaluators agreeing with the statement, while only 4% disagreed; and question 2 (It is clear to me how the game content is related to the subject), with 88% of evaluators considering the presentation of the content in the game to be clear, while 8% disagreed.

We can highlight the evaluations of questions 3 (The colors used in the game are understandable) and 5 (The game design is attractive (interface, graphics, board, cards, etc.)), which received, respectively, 83% and 79% positive evaluations. It helps to corroborate what was validated by the SBGames Arts Festival regarding the good aesthetic quality of the game. The fun factor also received positive evaluations from undergraduate students in question 13 (Something happened during the game that made me smile): 58% of students agreed with the statement, while 12% did not; and question 14 (I had fun with the game), where 58% of students agreed, while 8% did not. These evaluations indicate that Computational Fables also fulfill their playful objectives, an essential characteristic of any game, whether entertainment or educational.

Another essential factor in a game is the progression of difficulty, which was assessed in question 10: "The game offers new challenges (offers new obstacles, situations or variations) at an appropriate pace," where 67% of students agreed with the statement, and 17% disagreed. This evaluation reinforces what was evidenced in the pedagogical aspects of Computational Fables, specifically regarding the different degrees of complexity of content in the activities, which also received positive evaluations, validating this characteristic in the game.

We can also observe issues with negative evaluations and their justifications. For example, in question 31: "The game protects me from making mistakes," where 62% of evaluators judged that the game does not have this feature, while 12% evaluated that it does, and 25% evaluated it neutrally. As discussed previously, the non-existence of this resource is justified, because if it existed it could compromise the evaluative nature of the game.

Questions 30 (I was able to interact with other people), 27 (The game promotes moments of cooperation and/or competition between other players), and 32 (I felt good interacting with other people during the game) do not apply to Computer Fables, as the game was designed to be played by a single player.

Based on the data, we can conclude that Computational Fables has potential as an educational game. It has good aesthetics and is suitable for the development of Computational Thinking, presenting the contents clearly and objectively.

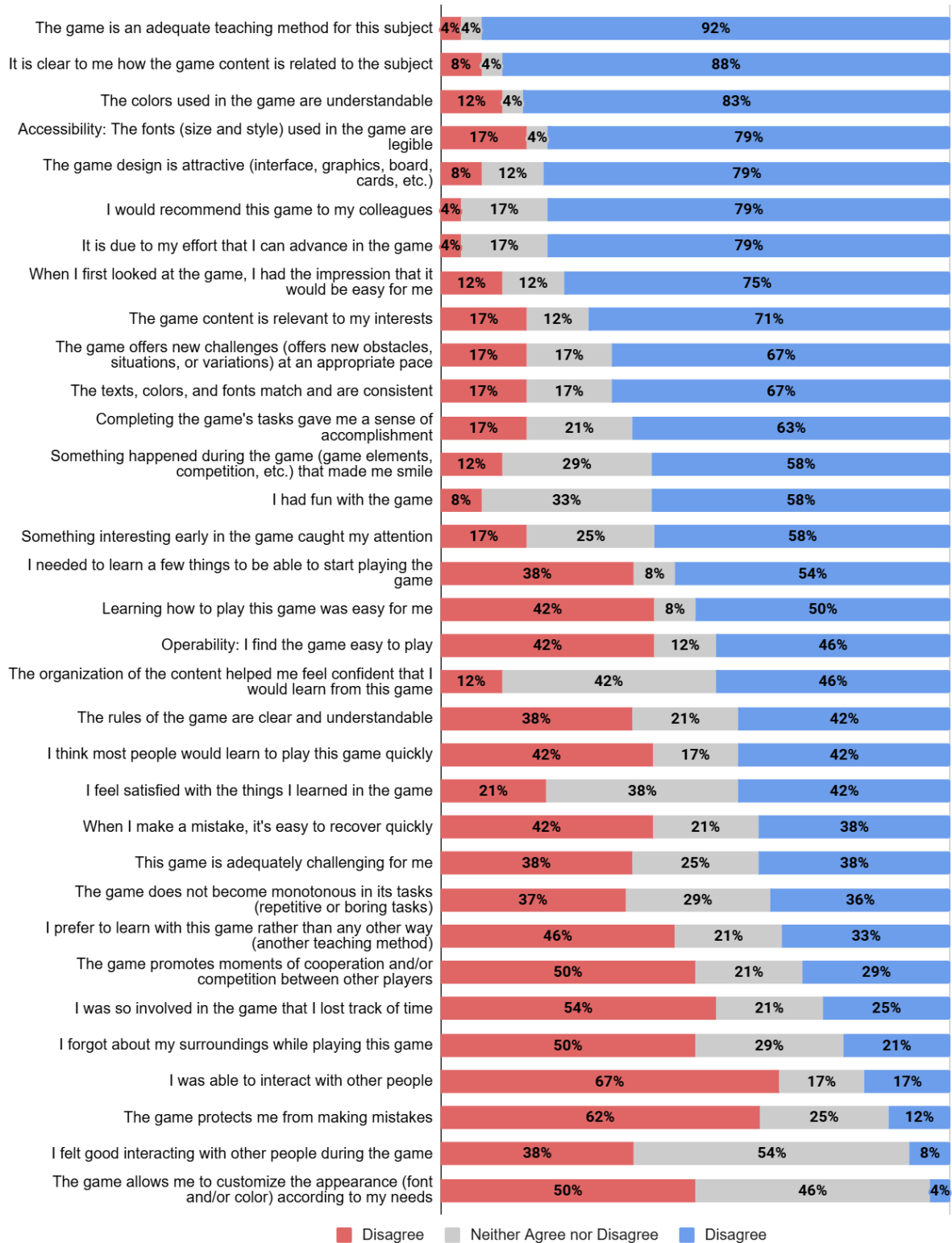


Figure 10: Questions about Player Experience.

4.2.3 Assessment of Computational Thinking Knowledge Objects

Four questions were created to evaluate the Computational Thinking Knowledge Objects present in Computational Fables. In each of the questions (Figure 11), undergraduate students should assess whether the game's challenges were linked to the CT Knowledge Objects, as specified in

the BNCC for 6th grade Elementary School students: Decomposition, Data Types, Programming Language and Generalization (Siqueira, 2022).

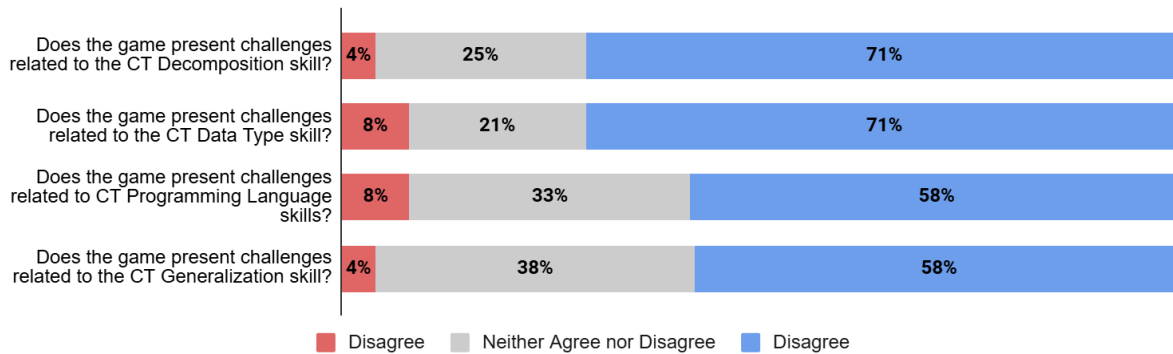


Figure 11: Questions about Computational Thinking Skills.

As the data shows, the evaluations of undergraduate students were significantly promising, with higher incidences of positive evaluations. Based on an observation of the average responses, 64% of students agree with the presence of CT Knowledge Objects in Computational Fables, 29% were neutral, and only 6% disagreed with the presence of CT content.

The Knowledge Objects Data Types and Decomposition were the most noticed by undergraduate students, both with 71% of the evaluations agreeing with their presence in the game. Regarding the Knowledge Objects Programming Language and Generalization, 58% evaluated them positively, agreeing with their presence in the game. Based on the evaluations of the undergraduate students, we can observe that the four Knowledge Objects of Computational Thinking implemented in Computational Fables were duly recognized.

This more significant perception of some Object of Knowledge compared to others can be justified by the fact that there are relationships between specific Objects of Knowledge. This is evident if we observe the BNCC texts. We can illustrate this with some excerpts from the BNCC, such as the one referring to the Knowledge Object Generalization: “Identify the resources or information needed (inputs) to solve problems, as well as the expected results (outputs), determining the respective types of data...”, which alludes to Data Types. Or the excerpt from Decomposition: “Build problem solutions using the decomposition technique and automate such solutions using a programming language”, which alludes to Programming Language (Siqueira, 2022).

4.3 Artifact Evaluation with Elementary School Students

4.3.1 Descriptive Analysis

Computational Fables was applied and tested as an assessment resource in a group of 46 elementary school students, together with the formal Bebras Challenge test. Computational Fables and Bebras Challenge have twelve challenges, divided equally into easy, medium, and hard difficulties. The Bebras Challenge was applied to evaluate students' CT knowledge through a consolidated method and investigate possible relationships with the data obtained through the game. The Bebras Challenge was made available by Bebras Brasil, the group responsible for organizing the test in the country. Bebras Brasil provided the version of the Bebras Challenge test for 6th and 7th grade students, applied in 2022 (Figure 12).

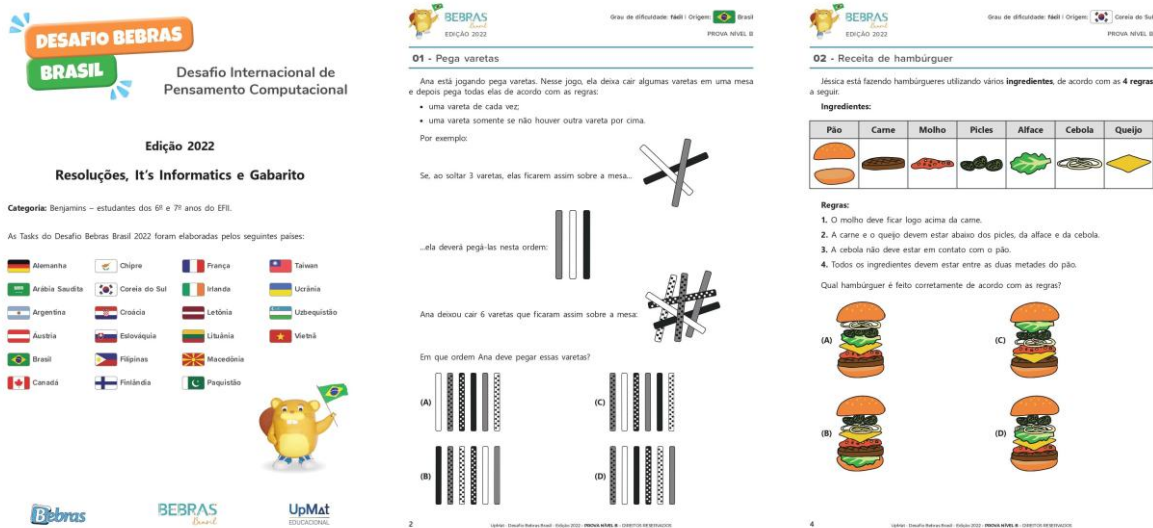


Figure 12: Bebras Challenge 2022.

All forty-six students first took the Bebras Challenge test and then played Computational Fables; each activity lasted 1 hour. Table 1 shows the data corresponding to the correct answers in the Bebras Challenge, on the left with the letter B, and in the Computational Fables, on the right with the letter F.

Table 1: Overview of results in Bebras and Computational Fables.

	Average	Median	Standard Deviation	Lowest Score	Highest Score
5th Grade	B 3,4 / F 7,4	B 3,3 / F 7,5	B 1,6 / F1,6	B 0,8 / F 5,0	B 6,6 / F10
6th Grade	B 3,4 / F 6,8	B 3,3 / F 5,8	B 1,7 / F1,7	B 0,8 / F 4,1	B 6,6 / F10
7th Grade	B 3,9 / F 8,1	B 4,1 / F 8,3	B 1,4 / F0,8	B 1,6 / F 6,8	B 5,8 / F9,1
8th Grade	B 4,0 / F 7,2	B 3,3 / F 7,5	B 1,8 / F1,4	B 1,6 / F 5,0	B 6,6 / F10

In Table 1, we can observe higher mean scores in the game compared to the Bebras Challenge. The lowest average in the game was 6.8 for the 6th grade, and the highest was 8.1 for the 7th grade, while in the Bebras Challenge the lowest and highest averages are, respectively, 3.4 for the 6th and 7th grades and 4 for the 8th grade. The 7th grade also presented the most cohesive performance, with a standard deviation of 1.4 in Bebras and 0.8 in the game, while the 8th grade presented the most dispersed results in Bebras, with a deviation of 1.8.

The minimum and maximum grades also deserve to be highlighted in the analysis: 5th, 6th, and 8th grades had students who scored the maximum grade in the game, with 10 being the highest grade. These three classes also presented the same maximum grade in Bebras, 6.1; the highest and lowest grades of the 7th grade were 9.1 in the game, which is also a good grade, and 5.8 in Bebras. The lowest score in the game was in the 6th grade, which scored 4.1, while the other classes scored five or more in the lowest scores. Figure 13 graphically shows the difference in performance in Computational Fables and Bebras Challenge.

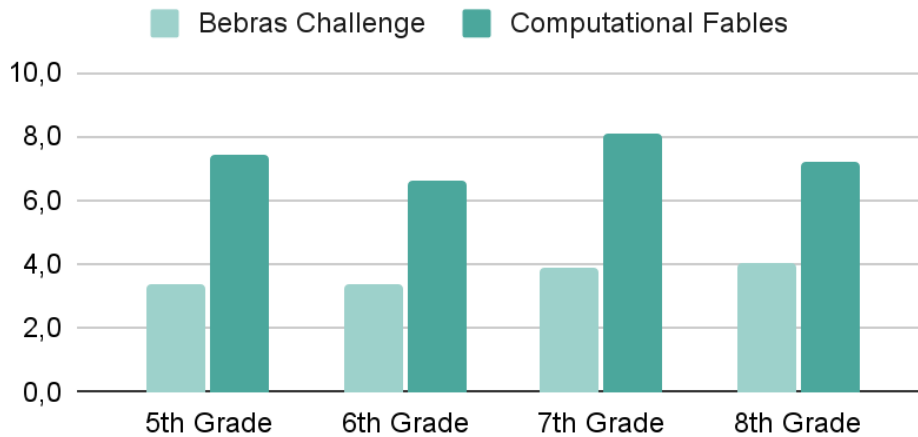


Figure 13: Comparison between performances in Computational Fables and Bebras Challenge.

As Figure 13 shows, student performance was 30% to 40% higher in Computational Fables compared to the Bebras Challenge. As previously presented, the 7th grade had the best performance in the game, and the 8th grade had the best performance in Bebras. Figure 14 graphically presents another comparison between the performances in the Bebras Challenge and the Computational Fables, organized according to the three levels of difficulty.

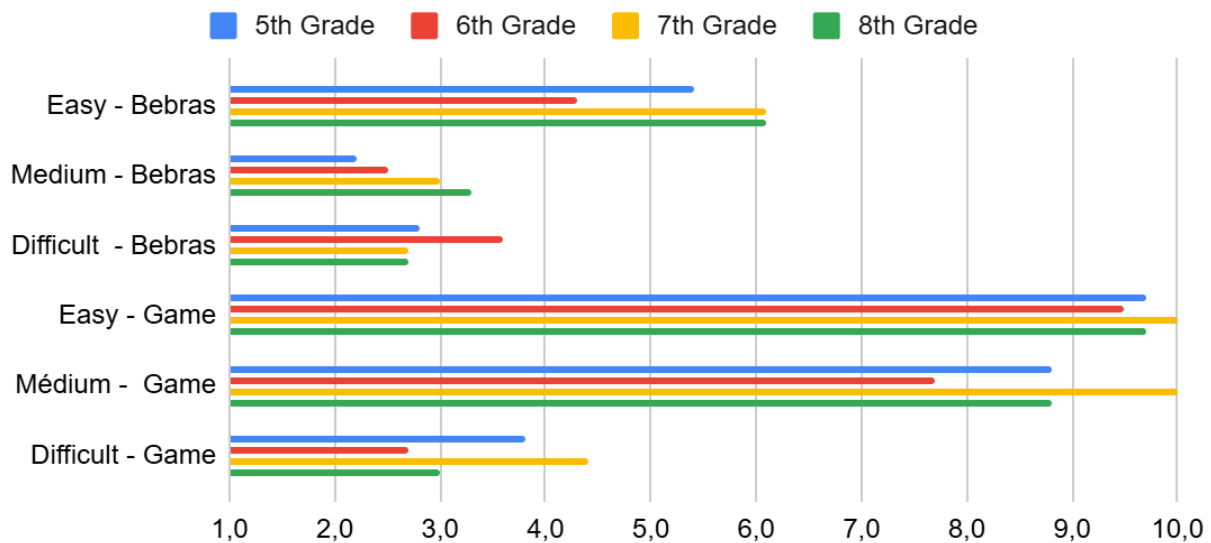


Figure 14: Comparison between performances in Computational Fables and Bebras Challenge by difficulty.

The results of the Bebras Challenge and Computational Fables were close in the hard. To validate this observation, we can highlight the 6th grade, which recorded averages of 3.6 in Bebras and 2.7 in the game, a difference of 0.9, and the 8th grade, which recorded averages of 2.7 in Bebras and 3 in the game, a difference of 0.3.

Analyzing data from the Bebras Challenge and Computational Fables, we can observe results indicating little mastery of CT skills by students. However, we observed scores that were, on average, 36% higher in the game compared to the Bebras Challenge. Some justifications in the literature can help to understand these results, and it is necessary to highlight the differences between the two evaluation resources. First, the Bebras Challenge: 1) due to its traditional

assessment format, the Bebras Challenge may not be stimulating for students, which may have caused disinterest in the face of the difficulties of the questions and tension due to the punitive nature associated with traditional assessments (Ferreira & Nascimento, 2014). 2) The Bebras Challenge only gives students one chance to try each question. The students selected the alternatives they considered correct without receiving feedback. 3) Students come from a post-pandemic scenario, and studies indicate that teaching in times of the COVID-19 pandemic had a negative impact on student learning. Correa and collaborators (2022) identified that teaching in the initial years of elementary school was compromised, identifying many difficulties for students continuing their studies at school. A study conducted by Freitas (2023), where the quality of teaching during the pandemic was evaluated by teachers, highlighted several difficulties faced by students when returning to in-person classes.

Regarding the game Computational Fables: 1) Even though it is an assessment game, Computational Fables encourages learning through experimentation and discovery, as recommended in the literature on games (Sena et al., 2016). In this sense, the game has elements that may have favored the acquisition of CT skills. As the game was applied after the Bebras Challenge, the results of the formal test did not reflect this learning. 2) The game allows the student to try to solve the challenges more than once. Failing a challenge in Computer Fables makes the students lose time, but they can try again within the 1-hour time limit corresponding to the test duration. 3) The game promotes motivation and engagement among students, making them more motivated to overcome challenges and achieve goals. 4) We can also consider the need to calibrate the difficulty of the game compared to the formal Bebras test. One justification that validates this possibility is the proximity between Bebras' results and the game on higher difficulties.

4.3.2 Game Learning Analytics and Statistical Analysis

In addition to recording students' correct answers in Computational Fables, data analysis techniques were used in a game environment known as Game Learning Analytics (GLA). We defined the data that would be captured in the Computational Fables game based on the model by Zapata-Cáceres & Martín-Barroso (2021), where data such as time, number of attempts, and wins are collected in the game phases.

Based on this data, a series of parameters were calculated to help evaluate the performance of the students in the game. These parameters are Persistence: refers to the number of attempts in a phase. It is represented by a value that can be zero as a minimum, and there is no limit to the maximum value. Achievement: consists of the percentage of challenges overcome in relation to the number of attempts. It is a value between 0 and 10. Skill: is the time needed to complete a challenge, the shorter the time, the higher the Skill value, which is a value between 0 and 10. Mastery: is computed according to the Achievement and Skill scores. It is a value between 0 and 10. We calculate Mastery by averaging the Achievement plus the Skill. Table 2 presents the students' Mastery data, as it is the most complete parameter.

Table 2: Game Learning Analytics, Domain Data.

	Average	Median	Standard Deviation	Lowest Score	Highest Score
Data Type					
5th Grade	4,2	4,2	1,4	2,1	6,6
6th Grade	3,7	2,9	1,9	1,3	6,9
7th Grade	5,1	5,3	0,9	3,4	6,6
8th Grade	4,9	5,4	2,2	2	8,2
Programming Language					
5th Grade	4,4	4,4	1,5	2	7,5
6th Grade	3,3	2,3	1,8	1,5	6,9
7th Grade	4,9	4,7	0,8	3,9	6,5
8th Grade	4,9	5,4	2,4	1,9	8,4
Decomposition					
5th Grade	5,4	5,2	1,5	2,7	8,1
6th Grade	4,9	4,8	1,9	1,9	7,8
7th Grade	6,3	6,5	1	4,5	7,8
8th Grade	5,8	6	1,8	3,3	8,9
Generalization					
5th Grade	4,7	4,7	1,5	2,3	7,8
6th Grade	3,6	3,1	1,8	1,6	7,4
7th Grade	5,3	5,2	0,8	4,4	6,8
8th Grade	5,2	5,7	2,4	2,2	8,6

Analyzing the Mastery data in Computational Fables, we can see results equivalent to what was revealed by the Bebras Challenge. In general, the class averages are between 3.3 and 6.6. We can also observe that the 7th grade presents the best general averages of Mastery in all Knowledge Objects, with emphasis on 6.3 in Decomposition. The 7th grade also presents the smallest deviations, especially in Programming Language and Generalization, with a 0.8 standard deviation, which indicates the best cohesion in its results.

The Knowledge Object Data Type is the one that presents the highest distance between the results of Bebras and the game among all the skills. The smallest gap was in the 6th grade, which scored 2.5 in Bebras and 3.7 in the game, a difference of 1.2. It is important to remember that the 6th grade presented a standard deviation of 1.9 in both Bebras and the game, with minimum and maximum scores in Bebras of 0 and 5 and minimum and maximum scores in the game of 1.3 and 6.9. The characteristics of the grades and the high dispersion of the students were reflected identically in Bebras and the game.

Analyzing the Knowledge Object Programming Language, we observe the proximity between the results of Bebras and the game. In the 6th grade, the difference between the averages is 0.3, the smallest difference among all the data, being 3.6 in Bebras and 3.3 in the game. The biggest gap between the averages of Bebras and the game in Programming Language was recorded in the 5th, 7th, and 8th grades, all with a 0.7 difference between the grades. It is also important to highlight that this is the only comparison between Bebras and Mastery in the game in which there was a higher performance in Bebras.

Decomposition has the best result obtained in the game in relation to the other Knowledge Objects, with an average of 6.3 for the 7th grade. The 7th grade, together with the 6th grade, also had the best Decomposition averages in the Bebras Challenge, scoring an average of 4. Given this, the 7th grade recorded the best overall performance in Decomposition, scoring 4 in Bebras and 6.3 in the game, with respective deviations of 2.5 and 1, with the Mastery data being more cohesive in Decomposition. The difference between Bebras' and the game's averages in the 7th grade is 2.3 points.

Finally, in Generalization, we can observe the proximity between the results of the Bebras Challenge and Computational Fables. Highlight for the 7th grade, which obtained the best Generalization result. The 7th grade scored 4.6 in Bebras and 5.3 in the game, with respective deviations of 2.6 and 0.8, with the game results being more cohesive. The difference between Bebras' and the game's averages is 0.7. The lowest and highest grades in the 7th grade were 2 and 8 in Bebras and 4.4 and 6.8 in the game.

Data analysis was also applied using Jamovi, an open-source software with a graphical interface for statistical analysis, using the T-test for independent samples, a statistical test that aims to compare the averages of two samples, checking whether there is a significant difference between them. Table 3 shows the data. If the p-value is equal to or less than 0.05, it indicates that there is a statistical difference between the groups.

Table 3: Independent Samples T-Test.

	Statistic	GL	p-value	Mean Difference	Standard Error of Difference
General Grade	-11.09	90.0	< .001	-3.68	0.332
Data Type Grade	-13.03	90.0	< .001	-5.18	0.398
Programming Language Grade	-4.52	90.0	< .001	-2.2	0.487
Decomposition Grade	-10.29	90.0	< .001	-4.49	0.437
Generalization Grade	-8.04	90.0	< .001	-3.58	0.445

Note. $H_a \mu_{\text{BEBRAS}} \neq \mu_{\text{JOGO}}$

Students' grades are statistically different in the Bebras Challenge and the Computational Fables since, in all categories, the p-value is less than 0.05. We can also observe the highest distance between the means of Data Type in the mean difference data, which shows the distance between the means of each category, with a value of -5.18 points. This means that the scores on the game-based test were, on average, 5.18 points higher than on the formal test. We also observed the highest proximity between the averages in Programming Language, with a value of -2.2. In this case, the scores in the game were, on average, 2.2 points higher than in the test.

According to the descriptive and statistical analyses of the data, the difference between the students' performance in the assessment resources in the Bebras Challenge and the Computational Fables is notable, with better performances in the game. However, this difference does not invalidate the evaluative resources assessed, as they have distinct characteristics. Prensky (2021) states that we can combine games with educational processes in many different ways and that games can achieve results that are as good as or even better than those obtained through traditional learning methods. Given the specific characteristics of the game, as recommended in

the literature, we can understand and justify the differences identified in the results of the Bebras Challenge and Computational Fables, as they are resources with different potentialities and limitations. Despite presenting different results, the Bebras Challenge and Computational Fables meet the evaluation purpose.

5 Final considerations

The inclusion of Computing Science in the curriculum of Elementary Education aims to enable the development of computational skills, supporting science and its various areas of knowledge. These skills expand the ability to solve problems and create processes and products (Raabe et al., 2017). For Prensky (2021), in a few years, digital game-based learning will become a very common way of learning. Believing in the potential of games for education and the need to support the development of CT skills, we conducted research during a master's degree, intending to evaluate a game as an assessment resource for CT. To help answer our research question, we developed the game Computational Fables, designed based on the four Knowledge Objects specified in the BNCC computing complement for 6th-grade students: Data Type, Programming Language, Decomposition, and Generalization.

Computational Fables was evaluated by undergraduate students in the Degree in Computing Science at UFRPE, who analyzed pedagogical, gameplay, and Computational Thinking aspects to validate the game among subjects in the computing area. According to undergraduate students' evaluations, the game Computational Fables meets the requirements of a good educational resource. It is viable as a CT assessment tool. The students assessed that the game has good visual and mechanical quality and that it contemplates the Computational Thinking Knowledge Objects, as specified by the BNCC, presenting the content clearly and appropriately for the target audience.

Through tests conducted with elementary school students, we identified potential in using digital games to assess Computational Thinking. Comparing the results obtained in Computational Fables with the formal test Bebras Challenge, we identified identical scores in both assessment methods, indicating that the game can adequately measure student performance. It is important to highlight that data collection in digital games, through GLA techniques, allowed data to be obtained precisely and stealthily without the need to interrupt students to conduct the assessment. We collect information about wins, losses, time spent solving problems, and paths taken, among other important data for the evaluation process; fundamental data to assess the level of knowledge of Computational Thinking of students, which can guide teachers about their students and the learning environment, and future decision-making.

We identified that the game provided greater engagement and motivation in students compared to the traditional Bebras assessment, as recommended in the literature (Valente, 1993; Sena et al., 2016; Prensky, 2021). It was possible to notice the students' interest in exploring the game's challenges and overcoming them, testing their knowledge while having fun (Sena et al., 2016; Kishimoto, 2017; Prensky, 2021). In addition to being effective in the evaluation process, we observed that the game offers possibilities that traditional methods do not have, such as the interactive simulation of problems (Israel-Fishelson et al., 2021), increased student stimulation through the playful factor, and breaking the paradigm of evaluation as something punitive (Rowe et al., 2021).

We hope that the findings of this research will contribute to strengthening the fields of Game-Based Learning and Computational Thinking, as well as the assessment of learning. Paulo Freire says in his book *Pedagogy of Autonomy* that teaching is not about transferring knowledge

but creating the possibilities for its own production or construction. We continue to research and develop games and produce and disseminate knowledge with this belief.

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