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Development and Usability Testing of TurbeLab Serious Game: A Game for Executive Functions Development

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Abstract

Stimulating Executive Functions (EFs) is vital because they are part of the individual's life. In this sense, this work aimed to create, develop and evaluate the usability of the TurbeLab serious game. Its creation was designed to assist in therapies for EFs development, more specifically working memory, cognitive flexibility and inhibitory control, focusing on the greater engagement of children in Elementary School. The TurbeLab project had the stages of analyzing the target audience's needs, game design and usability pilot study, where the System Usability Scale (SUS) and a questionnaire assembled by the team were applied, recording high scores, saying that the chosen methodology must work on future tests. An evaluation stage by the judges, and EFs experts, was also performed, obtaining an excellent content index. A future applicability study will be conducted with children with Attention Deficit Hyperactivity Disorder (ADHD).

Keywords: executive functions, serious games, game design.

1. Introduction

Executive Functions (EFs) help an individual develop inhibitory control, working memory and cognitive flexibility, led by the prefrontal cortex (Marques et al., 2020). Self-control is related to the child's ability to resist temptations, remain more attentive, act less impulsively, and focus more on his work. Working memory refers to the ability to keep information in mind so that it can be used later to link ideas, mentally calculate and set priorities. Cognitive flexibility is the ability to think creatively and adjust to new situations, allowing creativity to solve problems.

As the EFs play an essential role in development from childhood to adulthood, finding ways to favor their evolution is important, affecting the ability to hierarchize, differentiate and complement information received by the nervous system (Poon, 2018). Besides, the learning potential can be optimized with improved performance of executive, cognitive and conative functions, which form the functional triad of learning in neuroscience (Fonseca, 2014).

One of the ways to develop EFs in children and adolescents is through serious games. Serious games are "a computerized application, where the original intention is to consistently combine serious aspects, as a non-exhaustive and non-exclusive condition for teaching, learning, communication or information, with the ludic springs of videogames" (Alvarez & Djaouti, 2011).

The literature on the development of serious games designed specifically for EFs development brings, as most scientific articles, literature (Tourinho et al., 2016) or systematic reviews (Hounsell et al., 2018), which report the use of commercial entertainment games, adapting their mechanics for stimulating EFs during therapy sessions or classroom using. There is a gap in digital games that promote inhibitory control in school settings (Cerqueira et al., 2020) When used, they are commercial games that were not designed for therapeutic purposes.

When we talk about the development of the serious game applied to EFs development, it is necessary to think, for example, about the use of colors, positioning of elements, construction of the level design and speed of the tasks to be accomplished. All these elements must consider the target audience's characteristics and the game's objective to develop EFs. Games can bring cognitive overload to players, interfering with the quality of interaction and content acquisition. Therefore, the concern with game design becomes a key part (Krause et al., 2018).

Given this scenario, this article presents the construction of the TurbeLab serious game developed to stimulate elementary school children's EFs (working memory, cognitive flexibility and inhibitory control). The article reports the development stages of the TurbeLab game and its respective artifacts generated during its conception, passing through the three rounds of pilot usability testing with the target audience and validation by judges. The last two stages contribute to this extended and revised version of the original article "TurbeLab: a serious game on the science for EFs development," published in the annals of SBGames 2022. These tests aimed to obtain feedback to improve the game quickly. Tests on the applicability of FE development in children with ADHD will be conducted in future studies.

The studies found in the literature review on the theme, the detailed construction of the game, and the conclusions and suggestions for future works are presented below. The TurbeLab game is now available for download on the Google Play Store[1].

2 Literature review

There are works in the literature that relate serious games and EFs. Krause et al. (2018) conducted a systematic mapping of the literature. They concluded that serious games could stimulate cognitive control, decision-making, inhibitory control, judgment, persistence, planning, memory, attention and cognitive flexibility.

Krause et al. (2018) reported a 160% increase from 2013 to 2018 in the scientific production of serious games for EFs, there is still a scarcity of data for children since most of the found articles had adults as their target audience without prejudice to EFs. There are also a few serious games for EFs development with a science theme, although it is addressed in schools throughout Elementary Education. In the National Curricular Common Base (Base Nacional Comum Curricular - BNCC) (Ministério da Educação 2023), we found skills that address the themes of the game, such as prokaryotic cells (bacteria) and eukaryotic cells (amoebas). Their teaching is included in skill EF06CI05 for grade 6: “explain the basic organization of cells and their role as the structural and functional unit of living things”.

Cerqueira et al. (2020) reaffirm this challenge in finding studies on EFs in children and adolescents. They obtained only three results from their inclusion and exclusion criteria between 2014 and 2019.

Peñuelas-Calvo et al. (2020), in a systematic review, show that most games used for intervention in children with ADHD are serious games. Still, some commercial games can be adopted for therapeutic purposes, such as Tetris, which inspired one of the games cited in the article. An example of a serious game mentioned by the author is the “Pan-It Commander”, elaborated by Bul et al. (2016), in which participants need to choose between 10 different missions and have three minigames that require time management and skill planning by asking the character to go to a specific location to explode it, in addition to friendly behavior. The authors report an improvement in day-to-day tasks, such as time management, planning and organization, during a 10-week treatment in which children played the game three times a week. In these reported works, it may be noted that short games with various stages may contribute to the child’s motivation to keep on performing tasks.

3 TurbeLab

The TurbeLab game was developed by a multidisciplinary team composed of researchers from Computer Science, Digital Game Development and Developmental Disorders areas. The design of the game was carried out in four stages:

1. **Needs analysis:** contains the study of the literature on serious games for EFs and brainstorming for TurbeLab ideation. An online survey was performed with 53 children and adolescents, aged between 10 and 14 years old, both genders, to identify characteristics of the games most accessed by them.
2. **Game design:** game theme definition, character definition (planaria) and game name (TurbeLab); proposed phases and game mechanics aimed at developing EFs; projection of screens in wireframes for debate and validation of interface and navigability requirements and art design; sound effects and soundtrack.
3. **Implementation:** creating an executable TurbeLab prototype using the Unity 3D platform.
4. **Usability pilot study:** conducted with the target audience to obtain feedback about the interface and understanding of the TurbeLab mechanics.

3.1 Needs Analysis

The research conducted with the target audience for analysis of needs showed that the children chose to “overcome challenges” and “break records”, mechanics that were incorporated into the TurbeLab proposal. Still, on game mechanics, 64% of the children opted for “games with phases”, against 32% with “long games” and 14% with a preference for “short games”. The choice of “mobile device” is the majority, with 84% of responses. Therefore, TurbeLab was designed for a mobile environment (Android).

3.2 Game Design: Defining theme and game mechanics

The Microbiology theme was chosen due to the possibilities of exploring game content and mechanics, using laboratory glassware to create colliders and scenarios, and using living beings to give life to the characters in the minigames. The planarian was defined as the main character and inspiration for the name “TurbeLab” game.

The TurbeLab game consists of five stages with minigames and a final Quiz stage. Each game level is made up of 3 minigames. To engage the player, three

[1] https://play.google.com/store/apps/details?id=com.DefaultCompany.TurbeLab

difficulty levels (easy, medium and difficult) are available for all phases (Figure 1). There is a rule for unlocking the game phases: as the player wins the difficulty levels of each step, the other ones are released.

Each phase of the TurbeLab game will stimulate three EFs strands: cognitive flexibility, inhibitory control and working memory. The research performed by Krause et al. (2018), identified and associated twenty-two game mechanics with EFs skills and consequently served as a basis for the TurbeLab game minigame mechanics so that they could be related to each of the three EFs strands.

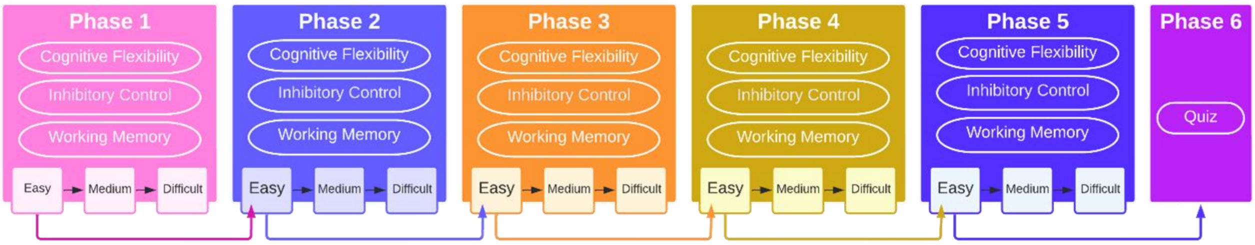

Figure 1. TurbeLab game phases flowchart (Source: author)

After completing all five phases of the TurbeLab game, a QUIZ will be available to the player (phase 6), generating extra emblems (medals) for the player.

Next, the proposed mechanics for developing the respective EFs are presented, as well as the task associated with it and the difficulty levels of the first three phases of the project already executed. Phases 4 and 5 and the quiz (Phase 6) were planned but not yet implemented and will be developed for future works.

COGNITIVE FLEXIBILITY

PHASE 1 - "Pipetting" Minigame

- **Mechanics:** Being induced to maintain actions and suddenly suspend them for a while, returning to the previous induced action.
- **Task:** Making pinching movements, applying "zoom-in" and "zoom-out", changing the pink liquid level inside the pipette until reaching the highlighted level, which remains in constant motion.
- **Difficulty levels:** Difficulty linked to the speed in changing the position of the highlighted level.

PHASE 2 - "Pinocytosis Labyrinth" Minigame

- **Mechanics:** Solving and discovering riddles or logical patterns.
- **Task:** Passing a water molecule through the maze until you reach the purple amoeba. To do so, the player must discover the movement pattern of the enemies (red characters) moving through the labyrinth spaces.
- **Difficulty levels:** Increased number of enemies making moves, requiring greater attention to the movement pattern on the player's part.

PHASE 3 - "Bacteria in its proper plate" Minigame

- **Mechanics:** Being induced to maintain actions and suddenly suspend them for a while, returning to the previous induced action.
- **Task:** Dragging the bacterium in the screen's center to the Petri dish of the corresponding color. Petri dishes can change places, making the player changes his actions (move the orange bacterium always to the right, for example).
- **Difficulty levels:** The Petri dishes change their position more times at each level.

INHIBITORY CONTROL

PHASE 1 - "Washing test tubes" Minigame

- **Mechanics:** Resisting the temptation to repeat or do what is perceived as more effortless.
- **Task:** "Cleaning" the test tubes by making the drawn dirt disappear until little stars appear. Controlling the movement speed is crucial for the tube to "break" or "stay clean".
- **Difficulty levels:** Greater sensitivity to finger drag speed can make the pipe "break" easier.

PHASE 2 - "Amoeba Phagocytosis" Minigame

- **Mechanics:** Navigating around obstacles or distractors while capturing targets.
- **Task:** Collecting (capturing) the blue particles with the purple amoeba without touching the enemies (red characters). If you touch an enemy, you return to your starting position.
- **Difficulty levels:** Greater number of enemies, affecting the challenge of the game route and more blue particles to be captured.

PHASE 3 - "Creating culture media" Minigame

- **Mechanics:** Alternating actions, movements, and patterns.
- **Task:** Filling in the dotted line correctly, without touching the Petri dish's edges or the antibiotics in the way.

- **Difficulty levels:** More tortuous routes require a change in the pattern movement.

WORKING MEMORY

PHASE 1 - “Decorating explosions” Minigame

- **Mechanics:** Remembering the sequence of tasks (steps, objectives, missions) to be accomplished.
- **Task:** Memorizing the order in which explosions appear in the tubes and repeat it in sequence.
- **Difficulty levels:** More pipes flashing each sequence make the game more challenging.

PHASE 2 - “How many feet does the amoeba have?” Minigame

- **Mechanics:** Remembering what needs to be selected (items).
- **Task:** Decorate the amoebas on the screen, noting the number of feet of each shown character. After a few seconds, the amoebas “lose” their feet, and an image of one of the characters is revealed. The player must tap on the character that is the same as the requested character.
- **Difficulty levels:** Greater quantity of amoebas appearing on the screen at a time.

PHASE 3 - “Plates Memory Game” Minigame

- **Mechanics:** Pairing information (it has or has not), observing differences among screens (like the seven mistakes game)
- **Task:** Memorizing the sequence of the presented plates. They are “face down”, turning them all gray. When one of the plates appears, the player must click on its corresponding one.
- **Difficulty levels:** In more challenge levels, the cards already hit are shuffled, requiring more attention and memory from the player.

The scoring scheme is affected by the game’s three difficulty levels, where points are multiplied by 1.0, 1.5 and 2.0, respectively, making the player engage with the possibility of scoring more by completing more complex tasks. The number of stars corresponds to the objectives accomplished in the minigame, which add up to points. The score can be checked on the Storage screen (final score screen), available in the game’s initial menu.

3.3 Screens and Wireframes Projection

Figure 2 shows the TurbeLab activity flowchart. The player starts navigating from an initial screen containing the “Play”; “Storage”, which is composed of the player’s achievement of stars; and “Settings” options.

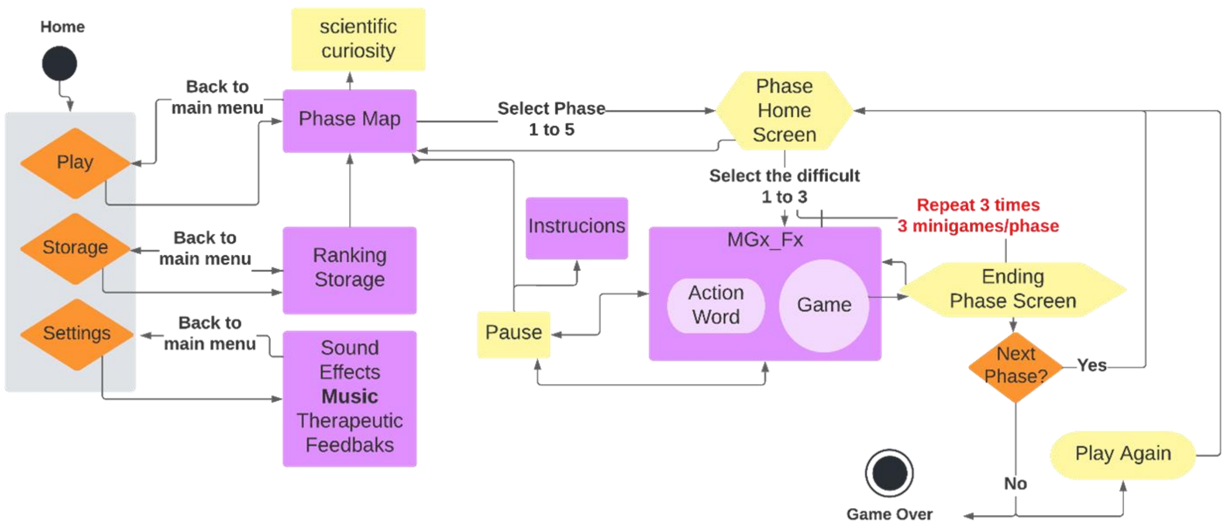

Figure 2. TurbeLab activities Flowchart (Source: author)

The next stage was to create the sketches of the screens in wireframes. Figure 3 shows an example of wireframes designed for creating the Phase 3 minigames.

Figure 3. Phase 3. (a) Bacteria on its proper plate minigame; (b) Creating culture media minigame; (c) Plates memory game minigame (Source: author)

3.4 Art Design, Animations, Sound Effects and Soundtrack

TurbeLab artwork was developed using the Clip Studio tool, and animations were created in Unity 3D platform. The sound effects were chosen from the free Sound database, which enables to obtain files in mp3 format for free. The soundtrack chosen for TurbeLab was acquired for free from the Uppbeat website and adapted for the game. Audios with sound effects were incorporated into the game to improve the feedback of the player's actions.

3.5 Implementation

The TurbeLab implementation was developed on the Unity 3D platform using C# language and is available for free in the Google Play Store app store. Below are some screens implemented by TurbeLab.

Figure 4. (a) Storage screen; (b) Phase screen; (c) Initial phases screen (Source: author)

Figure 5. Phase 1. (a) Pipetting minigame; (b) Washing test tubes minigame; (c) Decorating explosions minigame (Source: author)

Figure 6. Phase 2. (a) Amoeba phagocytosis minigame; (b) How many feet does the amoeba have? minigame; (c) Pinocytosis labyrinth minigame (Source: author)

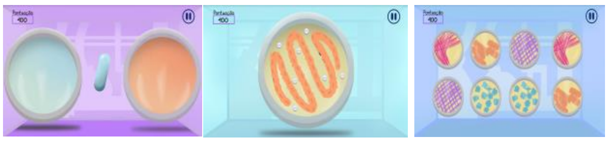

Figure 7. Phase 3. (a) Bacteria in its proper plate minigame; (b) Creating culture media minigame; (c) Plates memory game minigame (Source: author)

4 Pilot Usability Study

The intervention script worked with a task that induced players to navigate through the game, discovering the mechanics and functions of the game, based on the objective of knowing if the instructions were clear and the navigability was easy to understand. In this study, only the game's usability was evaluated to generate results for improving the TurbeLab game. Applicability tests with a target audience will be performed for future work.

In a formative usability study, that is, when the product is still being developed, Albert & Tullis (2023) recommend recruiting around five to eight participants for each evaluation, as usability findings plus projections will be observed with the first five participants. Thus, we divided our study into three rounds, the first with 3 children (just to check if the game was well accepted by the children and if there were any bugs or more serious usability errors, such as not being able to advance a screen); and another two rounds with five participants each to verify minor usability problems such as interactions with objects, arrangement of objects on the screen, sequence of tasks, among others.

The first study was developed differently from the others, just to make sure that the target audience will understand the game. The next two studies followed an intervention script with three main tasks, described below, to induce the player to navigate through the game and discover the mechanics and functions of the game:

Access the TurbeLab game and explore the games to earn at least one star in each stage.

Did you notice that the game takes place in a laboratory? To learn more about this, find a scientific curiosity in the game.

You have just played TurbeLab. At what stage were you the best? Check your score within the game.

In addition to the intervention script, after playing the TurbeLab, the participants answered a questionnaire, including the System Usability Scale (SUS), with the questions translated into Portuguese (Lourenço et al., 2022) and placed on a Likert scale to analyze the data quantitatively. The questionnaire is divided into four parts: (a) usability (ease of use; interface and interaction issues); (b) gameplay (game rules and objectives, rewards and game mechanics); (c) design (art style, soundtrack and sound effects, icon identification); (d) technology acceptance (the player would download the game from the app store; the player would recommend the game to a friend; if the game was a good hobby). The questionnaires were based on the guide *Usability in Serious Games: A Model for Small Development Teams* (Procci et al., 2012), where usability testing models for serious games are explained. It´s possible consult all the questionnaires in work of Bagdzius (2022).

The improvements suggested by the participants and seen through the scores obtained in the applied questionnaires were further implemented in the TurbeLab game.

4.1 First Round of Usability Testing

The first Usability Pilot study with the game's target audience consisted of applying the SUS questionnaire translated into Portuguese (Lourenço et al., 2022) and a questionnaire prepared by the project team. This study was performed with three female children aged 11, 12 and 14. The study was approved by the Human Research Ethics Committee (CAAE 53582221.3.0000.0084 / Opinion: 5.270.428). The questionnaire was assembled in 4 parts, all of which used a Likert scale (from 1 - I totally disagree to 5 - I totally agree), except for those identified as open questions.

Part A – Usability (SUS): “I would play this game often”; “I found it confusing to use the game”; “I found the game easy to use”; “I needed help from other people to play the game”; “I thought that the parts of the game (menus, images, buttons, audio) match each other”; “The game had many problems”; “I imagine people will learn to use this game quickly”; “I found the game difficult to use”; “I felt confident using the game”; “I had to learn a lot of new things to be able to use the game”.

Part B – Gameplay: “The challenges of the game were clear, and I understood them quickly”; “I found the rules and objectives of the game easy to understand”; “The game allowed me to control the progress of the phases according to my will”; “It was easy to understand how I was scoring in the game”; “As I passed levels, I received rewards in the game”; “I enjoyed learning about scientific curiosities”; “Any suggestions for improving our game? (open question)”; “What did you like most about the game?” (open question); “What did you like least about the game?” (Open question).

Part C – Design: “The game icons were easy to understand”; “At any time I could go back to the game’s levels screen”; “When I had doubts, the game provided me with helpful resources”; “The texts used in the game were easy to understand”; “The pictures in the game were easy to understand”; “I found the game screens easy to understand”; “The colors used in the game were adequate”; “The sound effects used in the game were adequate”.

Part D – Technology Acceptance: “Would you download the game on your phone or tablet to play at home?” (Yes or No); “Did you have fun playing? Was it a good hobby?” (from 1- little to 5 - a lot); “Would you recommend the game to a friend?” (Yes or No).

Table 1 shows the SUS score obtained with the three participants, indicating good usability, but also pointing out that it still needs adjustments (SUS < 65). According to Bangor et al. (2008), the SUS scale score ranges are as follows: values up to 25 points define the usability of a system as the worst possible; between 25 points and below 40 points, the product is defined as having poor usability; between 40 and 52 points, of reasonable usability (with indication of potential problems); between 53 and 73 points usability is considered good; from 74 points to 85 points, usability is considered excellent; from 85 points, usability is considered the best possible.

Table 1. SUS scores

Participant 1 (14 years)	SUS = 65
Participant 2 (12 years)	SUS = 85
Participant 3 (11 years)	SUS = 85

Analyzing the qualitative questions, the three children reported missing more instructions during the minigames, saying they got confused with the tasks to accomplish. On the question, “What did you like most about the game?” the focus was on the design elements, where the participants highlighted the game’s colors, the characters and the first minigame, consisting of a Pasteur pipette. When asked, “What did you like least about the game?” the participants cited the memorization minigames, the minigame of breaking test tubes, due to a lack of instructions on how to play.

Most questions obtained maximum scores in the questionnaire assembled by the team (Part B, C and D). The statements “When I had doubts, the game provided me with helpful resources” averaged 4.3, the maximum score being 5, and “The texts used in the game were easy to understand” obtained an average of 3.6 in the answers. When asked, “Did you have fun playing? Was it a good hobby?” the answers averaged 4.6 on a scale from 1 to 5.

4.2 Second Round of Usability Testing

Test purpose: Understanding which usability improvements should be made in the game based on the user experience.

Hypothesis: The game’s interaction cues are easy to understand.

Participants: Three male players aged 12 (P4), 13 (P2) and 15 (P1) and two female players aged 11 (P3) and 14 (P5).

Results: The SUS questionnaire (Part A) had the best possible usability as an answer (score 85.5).

Part B of the questionnaire, answered by the participants responsible for analyzing the gameplay, only contained positive statements. Therefore, it was analyzed from a simple average, where it obtained 4.5 points (out of five in total), indicating good gameplay from TurbeLab. The negative feedback worked very well for the players to understand the game mechanics, which only appeared from minigame 2, “Washing test tubes”, onwards.

Within part B, participants were also able to answer open questions, which were analyzed qualitatively and are reflected in the improvements made for the second round. In addition to an option to choose the preferred minigame.

In part C, the information about the game’s design showed that the participants liked the icons and understood them. They also understood figures, texts and phrases. Still, they could not find helpful resources in the game nor understand the Storage icon - the screen of the score, which was being represented as a graph.

Technology Acceptance (part D) was excellent, with 80% of participants saying they would download the game to play at home and recommend it to a friend, in addition to stating that they had fun playing it, with an average of 4.6 points (out of a total of 5) for that last question.

Improvements:

Adding a level-locked message when the player clicks on a greyed-out difficulty level on the phase starting screens.

Design alterations of Scientific Curiosities.

Swapping the order of the “pipetting” and “cleaning test tubes” minigames so that players first experience a minigame with positive and negative feedback.

Putting animation on the yellow level of the “pipetting” minigame.

Changing the action word of the “Washing test tubes” minigame from “Scrub!” to “Clean!”.

New Storage icon: switch from the graph to the stars.

4.3 Third Round of Usability Testing

Test purpose: Understanding which usability improvements worked best after the first round of testing from the user experience.

Hypothesis: Changes made after the first round of testing improved the user experience.

Participants: Four male players, at the age of 12 (P3 and P4) and two at 14 (P2 and P5) and a female player aged 13 (P1).

Results: This time, the SUS questionnaire (Part A) indicated excellent usability (score 75.5) but was lower than the level of the second round of tests, because the improvements did not work as expected (Table 2). In the gameplay (Part B), the participants responded, and we obtained an average of 4.2, which also declined compared to the previous test.

The responses in part C showed that the sound effects were not as attractive this time, and the participants also did not find helpful resources easily.

Again, Technology Acceptance (part D) was very good, with 80% of participants saying they would download the game to play at home and 100% of them would recommend it to a friend, and average enjoyment was 4 points out of 5. Even with a lower usability score, the technology still had good acceptance, although less than when compared to the second round of.

Table 2. Comparisons between scores from the two rounds of the Usability Testing.

		2st round	3nd round
Observation Form	**The player likes the subject of the game**	4.2	4.2
	The player knows about the game’s subject	4	3.6
Part A	**Score from SUS**	85.5	75.5
Part B	**Gameplay**	4.5	4.2
	The player would download it at home	80%	80%
Part D	**The player would recommend it to a friend**	80%	100%
	The player had fun playing	4.6	4

Improvements:

Changed the action word “Squeeze!” to “Follow the level” in the “Pipetting” game.

Return the “pipetting” minigame as the first of the phase.

Returning the action word of the “Washing test tubes” minigame to “Scrub!” indicates an interactive activity in which the players better understand which movement should be made when interacting with the tablet’s touch screen.

Due to the lower results in this round, where the improvements didn't work as expected, the team opted to go back on some improvement decisions and make the game more like the version of the second round of tests. The result of this lower score may be related to the fact that children did not find it so easy to play, which generated a lower score in the usability test and, because of this feeling of not being so easy or intuitive, they did not feel like downloading at home or refer friends, questions that appear in section D of the usability test.

4.4 Evaluation by Judges

The validation stage by judges aimed to verify whether the content of the TurbeLab game is suitable for stimulating EFs in children and adolescents. Judges were recruited for convenience and asked to complete an online form.

Participants were selected from the indication of professionals in education or psychology fields who actively work with children aged 10 to 14 years and are part of study groups with EFs issues.

These participants received the link to the online form to watch a video demonstrating the game and, after that, evaluate on a 4-level scale (inadequate, needs major changes, needs minor changes or adequate) all nine minigames developed so far, considering:

Game mechanics improve Cognitive Flexibility.

The intuitive task for the target audience.

Difficulty level stimulates the player to stick to tasks.

Minigame motivates the player to stay in the game.

The game is visually appealing to the target audience.

Content Validity Index (CVI) was used to evaluate the data provided since it measures the proportion or percentage of judges who agree on certain aspects of the material produced and its items (Coluci & Alexandre, 2009).

The calculation of the answers is made through the sum of agreement of the items that were scored by the answers equivalent to “Adequate” and “Needs minor changes” (equal to answers 1 and 2) by the experts, eliminating the ones that were scored “Needs major changes” and “Inadequate” (like answers 3 and 4).

The form provided five questions for each of the nine evaluated minigames (three phases already implemented) for each of the seven judges, which totaled 315 answers. As answers 1 and 2 are considered in the CVI, 298 responses were considered, obtaining an index of 0.94.

$$CVI = \frac{298 \text{ (1 or 2 responses)}}{315 \text{ (total responses)}} = 0.94$$

Despite the judges’ suggestions for improvement, all minigames achieved a high Content Validation Index, with all scores above 0.84. The literature points out that indices above 0.78 are considered excellent (Bangor et al., 2008). The result obtained with all responses was 0.94, indicating a superb content index.

The judges’ suggestions will be considered for future changes, as the index proved excellent and can be part of the project’s following steps.

5. Conclusions and Proposals for Future Work

This work presented the design, development and creation of the TurbeLab serious game for EFs development. In addition to judges’ evaluations, usability testing was applied (divided into a pilot study and two testing rounds). They all obtained satisfactory grades.

These work contributions include proposals for minigames using mechanics to stimulate EFs in children aged 10 to 14 using the available literature; a pilot usability study with the target audience that confirmed the excellent usability of the minigames; the game is free and can be downloaded from the Google Play Store app store; a stimulating play area for health and education of school-aged children; many children with developmental disorders, such as Attention Deficit Hyperactivity Disorder (ADHD) and Autistic Spectrum Disorder (ASD) may benefit from the use of TurbeLab, both in a clinical and in a school environment.

As further studies for future works, we intend to undertake new usability studies with new participants to improve the interface and interaction aspects and have more data about TurbeLab usability, to prove that the chosen methodology must work; finish phases 4, 5 and 6, even with the game already published; conduct applicability studies with ADHD children to, by stimulating the EFs, present an improvement in school performance.

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