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Original Article

Construction of a Serious Games for children with Developmental Coordination Disorder

Construção de um Serious Games *para crianças com Transtorno do Desenvolvimento da Coordenação*

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Abstract

Introduction: Serious Games are games with a learning objective that aim to improve motor and cognitive skills by simulating challenges similar to real life. This makes them suitable as they allow the treatment, diagnosis and assessment of health conditions, making it possible to use them in interventions with children who have Developmental Coordination Disorder (DCD). **Objective:** To present the construction of a Serious Game for intervention with children diagnosed/suspected of DCD. **Methodology:** This is an exploratory and descriptive study that proposes the creation of a Serious Game to stimulate the motor performance of children with DCD. It was built by a team made up of three teachers and two students from the Occupational Therapy course, a teacher and a student from the Computer Science course, a teacher and a student from the Design course, from August 2020 to August 2022. **Results:** The game initially planned for the Kinect was adapted to work on computers with webcam recognition, resulting in the game "BRINCOORD". It includes three playable stages designed to work on performance skills in children with BDD. **Conclusion:** "BRINCOORD" is an innovative initiative that highlights games as a promising therapeutic tool. Although research in this area is developing, there are few studies on the effects of games on improving motor skills in children, especially children with DCD. Given this, it is hoped that "BRINCOORD" can contribute to future evidence on the use of Serious Games in intervention with children with DCD.

Keywords: Occupational Therapy, Computer Game, Motor Skills Disorders.

Resumo

Introdução: Os *Serious Games* são jogos com objetivo de aprendizagem que visam melhorar habilidades motoras e cognitivas ao simular desafios semelhantes aos da vida real. Isso os torna adequados, pois permite o tratamento, diagnóstico e avaliação de

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condições de saúde, sendo possível utilizar em intervenções com crianças que possuem Transtorno do Desenvolvimento da Coordenação (TDC). **Objetivo:** Apresentar a construção de um *Serious Game* para intervenção com crianças que apresentem diagnóstico/suspeita de TDC. **Metodologia:** Trata-se de um estudo exploratório e descritivo que propõe a criação de um *Serious Game* para estimulação do desempenho motor de crianças com TDC. Foi construído por uma equipe formada por três professoras e duas alunas do curso de terapia ocupacional, um professor e um aluno do curso de Ciências da Computação, uma professora e um aluno do curso de Design, no período de agosto de 2020 a agosto de 2022. **Resultados:** O jogo inicialmente planejado para o Kinect foi adaptado para funcionar em computadores com reconhecimento por webcam, resultando no jogo "BRINCOORD". Ele inclui três estágios jogáveis projetados para trabalhar as competências de desempenho em crianças com TDC. **Conclusão:** O "BRINCOORD" é uma iniciativa inovadora que destaca os jogos como uma ferramenta terapêutica promissora. Embora a pesquisa nesta área esteja em desenvolvimento, há poucos estudos sobre os efeitos dos jogos na melhoria das habilidades motoras de crianças, especialmente crianças com TDC. Diante disso, espera-se que o "BRINCOORD" possa contribuir paras as evidências futuras sobre o uso de *Serious Games* na intervenção com crianças com TDC.

Palavras-chave: Terapia Ocupacional, Jogos de Computador, Transtornos das Habilidades Motoras.

Introduction

In today's world, technology has been transforming the way society communicates, accesses information, and even learns (Jaramillo-Alcázar et al., 2022). In light of this reality, one of the technological tools being used in the fields of health and education is *Serious Games*, which, according to the Associação Brasileira de Telesserviços (1987), are games aimed at learning, intended to improve users' performance in their skills and abilities. Serious Games are hardware or software characterized by not having the central objective of mere entertainment, although they can still have a playful character. Their function goes beyond learning as a key point and aims to instruct, provide training, improve quality of life, and enable the social inclusion of the individual using them (Richvoldsen, 2009; Michael & Chen, 2005). This type of game has two main components: a rational one and an emotional one. The rational component identifies formal or structural characteristics common to everyday life that are identical to those of the game, thereby encouraging the player to deal with challenges encountered during their routine. The emotional component drives the player to want to understand how a set of sometimes conflicting combinations works, which nonetheless fosters learning (Ritterfeld et al., 2009).

The introduction of new therapeutic approaches in the health sector has favored the process of learning new skills, especially within games that combine stimuli and elements such as music, drawings, animations, and stories (Deguirmendjian et al., 2016). Serious Games is a category of game that makes this possible, utilizing a variety of tools and strategies to interact with children and young people, due to this population's predisposition to learning associated with their attraction to video games (Lamas et al., 2023). Furthermore, Serious Games are suitable for addressing important motor aspects and take place within a

motivating context. Thus, if applied continuously and repetitively, it is possible to enhance or acquire new motor skills, allowing for transfer to real-life daily activities (Arnoni et al., 2018). In this way, professionals can incorporate a more playful and interactive approach, increasing motivation and engagement of the population in therapeutic interventions.

With the growth of this type of game, due to its advantage of recreating a functional environment where users can encounter challenges similar to those in real life, various health conditions can be worked on, diagnosed, and evaluated through its use (Serafim et al., 2019). Among these are neuromotor and developmental disorders, cognitive deficits, and developmental disorders. By generally utilizing motor learning, Serious Games primarily focus on neuromotor conditions, considering that individuals first become proficient in executing movements and then reach a desired goal through practice and experience (Corrêa et al., 2011).

In this context, a condition that can benefit from the use of Serious Games is Developmental Coordination Disorder (DCD), characterized by a deficit in motor performance (MP) – which involves a combination of fundamental motor skills – and difficulty in acquiring new skills, ultimately limiting participation in daily activities such as leisure, sports, and shared play. This directly impacts the perceived quality of life and health of children and their families, resulting in more restricted learning (Araújo, 2019; Vallence et al., 2019; Pereira et al., 2012; Cândido Soares et al., 2019).

The term DCD (Developmental Coordination Disorder) refers to a neurodevelopmental condition characterized by significant difficulty, slowness, or imprecision in executing gross or fine motor skills (Nobre et al., 2023). The cause remains inconclusive; however, it is believed to be associated with brain function, as motor skills are directly affected, hindering satisfactory performance in daily living and leisure activities (Martins, 2021). DCD is typically diagnosed in children during the school years, generally between the ages of five and eleven, with a higher prevalence in males (American Psychiatric Association, 2014).

To establish a diagnosis, it is necessary to consider the criteria set forth by the Diagnostic and Statistical Manual of Mental Disorders – Fifth Edition (DSM-5), which include: a) the acquisition and execution of coordinated motor skills are substantially below what is expected, considering the individual's chronological age and opportunity to learn and use the skill; b) deficits in the motor skills from "criterion a" significantly interfere with age-appropriate daily activities, impacting academic productivity, pre-professional and professional activities, leisure, and play; c) the onset of symptoms occurs early in the developmental period; d) deficits in motor skills are not better explained by intellectual disability or visual impairment and are not attributable to any neurological condition affecting movement (American Psychiatric Association, 2014). In their study, Araújo (2019) reveals that children with DCD, when compared to typically developing children, participate less in activities at school and in the community, but participate with the same frequency in home activities, such as watching television and playing computer and mobile games. This occurs because these activities require fewer motor skills than activities like jumping rope, riding a bike, and playing hopscotch, which are typically done in other settings. Given the preference of children with DCD for activities that involve fewer motor skills and technology, it is important for professionals to rethink their approach when intervening with this population.

In this context, active video games have been proposed as a good alternative, aiming to motivate individuals who find sports or activities requiring greater motor

performance less appealing due to their body composition, low performance, or limited motor skills (Azevedo et al., 2022; Comeras-Chueca et al., 2021). Many studies have already indicated improvements in cognitive and coordination performance in healthy individuals through the use of video games; this raises the hypothesis that similar effects may occur across different age groups and various stages and types of motor difficulties (Borecki et al., 2013; Cavalcante Neto et al., 2019; EbrahimiSani et al., 2020). Considering this, children with DCD may benefit from the use of Serious Games in assessment and intervention, as they experience difficulties in several domains, such as motor control, executive function, and sensory-perceptual function, which limit their social, academic, and physical participation, impacting their quality of life (Mentiplay et al., 2019).

Despite the use of Serious Games being an innovative proposal in the health field, as it has the capacity to provide cognitive benefits and assist in acquiring both motor and cognitive skills, while also indicating which of these skills require further development (Camilo et al., 2016), there are still no studies on the creation of a Serious Game specifically for evaluating or intervening with children with DCD, even with evidence addressing the use, effects, and benefits of video games in interventions with children (Azevedo et al., 2022; Page et al., 2017; Mentiplay et al., 2019). Considering the importance of propositions that promote innovation and accessibility in therapeutic approaches, this study aims to present the development of a Serious Game for assessment and intervention with children diagnosed or suspected of having DCD (Developmental Coordination Disorder).

Objective

Considering the importance of propositions that promote innovation and accessibility in therapeutic approaches, this study aims to present the construction of a Serious Games for assessment and intervention with children diagnosed/suspected of DCD.

Method

Study design

This is an exploratory and descriptive study on the methodology for creating a Serious Game to stimulate motor performance and intervene with children who have DCD (Dias et al., 2016; Novak, 2010; Schell, 2008).

Ethical aspects

Methodology (ethical aspects): The project was approved by the Ethics Committee for Research with Human Beings at the Health Sciences Center of Universidade Federal da Paraíba - CEP/CCS/UFPB (CAAE: 31304420.3.0000.5188; opinion 4.040.770 from May 21, 2020) and was funded by the Research Support Foundation of the State of Paraíba, receiving financial aid through Public Notice No. 010/2021 - FAPESQ/PB - MCTIC/CNPq Young Researchers Infrastructure Program/First Projects Program – PPP.

Phase of Construction and Development of the Game

The construction of the Serious Game was conceived as part of a scientific initiation project titled "Construction of Active Games for Stimulating Occupational and Motor Performance in Children," resulting from the Laboratory of Investigation and Resources for Childhood and Adolescence in Occupational Therapy (LABIRINTO) at the Department of Occupational Therapy of Universidade Federal da Paraíba. The formulation team was multidisciplinary, consisting of students and faculty from the Occupational Therapy, Computer Science, and Design programs at Universidade Federal da Paraíba

For the planning of the game's construction, weekly meetings were held with the entire team (comprising three faculty members from the Occupational Therapy program, one faculty member from the Computer Science program, one faculty member from the Design program, one Computer Science student, one Design student, and two Occupational Therapy students) to discuss ideas, execute subsequent steps, and divide functions among different areas of expertise. Decisions were always made collectively, with the final approval of the project coordinator.

The development of the Serious Game, in its initial stage, involved a literature review and strategic planning for the creation of the digital game. In this stage, a review of the literature was conducted to explore traditional therapeutic interventions using games, aiming to understand how these interventions became effective. Additionally, searches were conducted for games that addressed functions similar to those targeted by this study. These searches were carried out by Occupational Therapy and Computer Science students. After the completion of the literature analysis, discussions were held with an occupational therapy professional who is an expert in working with children with Developmental Coordination Disorder to gather information about the main difficulties these children face in performing their activities. This information helped in composing the script, developing the game mechanics, and creating a meaningful playful experience.

Next, traditional interventions that could be adapted or translated into activities practiced by children were defined, leading to a playable context through the establishment of mechanics for a digital game. Thus, to construct the stages that would be addressed within the game, the team analyzed the content of several items from the assessment tool The Movement Assessment Battery for Children – Second Edition (MABC-2) (Henderson et al., 2007), considered the gold standard for evaluating motor skills, with the aim of creating a foundation for developing playable activities at each stage of the game.

After the previous stages, the data collected was documented in a file that included the story, level design, gameplay, user interface, game controls, interventions, and their objectives. This document, referred to as the Game Design Document (GDD), aims to organize and describe the functionalities of the game and serves as a guide for the team throughout the entire product development process.

Following the documentation, the selection of activities (games) to be included in the game was made. Considering that DCD is most often diagnosed during the school phase of children, it was decided to focus on the preschool age range of 3 to 6 years, using activities that address skills necessary for performance at this stage of development. The following activities were selected: "hopscotch," "putting coins in a piggy bank," and "drawing a path from one point to another" within a pre-existing layout. After choosing the activities to be featured in the game, an analysis of each was conducted, determining

the components of the activity, the skills, experiences, and capabilities needed for their execution, as well as aspects that could be improved for satisfactory performance. This analysis was carried out by two Occupational Therapy students, based on the document "Structure of Occupational Therapy Practice: Domain and Process – 3rd edition" (American Occupational Therapy Association, 2015), considering all the skills required in each activity and how each would be executed during the game.

Next, the product development stage was carried out by the computer science team, exploring technologies such as programming languages, frameworks, platforms, and libraries. These tools supported software development and aimed to simplify coding by assisting in the production of higher-quality code and reducing implementation time. The main concept supporting the use of these tools is to allow abstract functionalities to be reused across software projects. The subsequent activity was coding and testing. The development cycle followed the workflow of the *Scrum* methodology, which is a management method based on known experiences, aimed at streamlining and facilitating the development of products, processes, and services (Silva et al., 2023). In this stage, the project was divided into mini-project packages, corresponding to a set of functionalities that were developed. These packages were distributed on a *Kanban* board divided into four stages ("to do, doing, review and test, and done"), and weekly, a set of these packages was selected based on their value, following the flow of the board, resulting in the completion of the functionality. At the end of the implementation of all packages, integration tests were conducted to validate their union, along with functional tests to verify that the software did not exhibit unexpected behaviors.

For the finalization, the game design phase was carried out by the Design team, which included decisions on color palettes, logo, name, backgrounds, and characters. Initially, an idea gathering session was held with the team responsible for other areas, identifying the following needs: the software that would be used for design development; defining a playful and fun color palette; creating a logo and font for the game's visual identity; and representing visual elements (environments, characters, and navigation screens). The chosen software for design development included Adobe Color, which assisted in choosing colors, and Adobe Illustrator, for producing the game's graphic content. The color palette was designed to please and entertain the target audience, opting for a colorful and fun range, considering the child population.

After this conceptualization, the visual identity was developed, selecting different fonts and creating logo prototypes, which were then voted on so that everyone on the team could participate in selecting the most suitable font and logo for the game. Following this, manual sketches were created to guide the graphic development of the game. With these sketches, the scenarios were created in Adobe Illustrator, including: the path to school, an external environment where the child aims to take the chosen character from home to school; the character's bedroom, where the established task is to collect coins from a box and place them in a piggy bank; and finally, a yard with a hopscotch board containing ten squares leading to the "sky" (the endpoint of the hopscotch board). After creating the scenarios, the conception of the characters from a top view was carried out, with each character in two poses to be used in the hopscotch stage (as they are viewed from above). To finalize the design, the game screens were created, including: the home screen; stage selection screen; character selection screen; and information screen about the game and its developers.

Finally, there was the implementation phase of the game, where all the creations made at each stage were organized and grouped to form the final whole. The entire process for constructing the Serious Game took place from August 2020 to August 2022.

Results

According to the American Occupational Therapy Association (2015), performance skills are observable and goal-directed competencies that will result in the quality of performance in the occupations desired by the client. In the specific case of "BRINCOORD," its use aims to stimulate motor and process competencies, which are evident when the client performs an activity efficiently, safely, with ease, or without assistance (American Occupational Therapy Association, 2015).

The motor and process skills stimulated by "BRINCOORD" include: stabilizing, aligning, positioning, grasping, manipulating, coordinating, lifting, walking, calibrating, flowing, rhythmizing, focusing, complying, choosing, using, handling, asking, initiating, continuing, sequencing, finishing, searching/locating, navigating, perceiving/responding, adjusting, accommodating, and correcting. These skills are necessary for satisfactory performance in Activities of Daily Living (ADLs) for this age group, such as eating, personal hygiene, dressing, education, and especially in leisure and play. To integrate this perspective, the presence of an occupational therapist is essential, as they are trained to analyze whether there are difficulties in executing any skill and consequently in the individual's ADLs, making it possible to determine which competencies need to be enhanced through the game, allowing the player to develop better occupational performance (American Occupational Therapy Association, 2015).

The game is a product resulting from a scientific initiation project, designed to be reproduced on the Kinect®, a motion sensor created by Microsoft® that uses RGB cameras, infrared projectors, and motion detectors to map depth through calculations of light or time of flight. This allows the accessory to recognize the body structure of up to four people at 48 joint points, eliminating the need for a joystick, as the user's body serves as the controller (Pedro, 2021). However, due to software incompatibility, it was adapted to a computer game with recognition via webcam, enabling control of the character through a script for tracking colored objects, specifically blue, or motion identification. Consequently, objects needed to be created for tracking and movement identification, such as a pencil for the maze stage (the character's path to school, back home, and to the park), a glove for the piggy bank stage, and a vest for the hopscotch stage, all in blue.

The initial games conceived composed the stages of the game, which can be played in any order or in the sequence presented in the layout. These options were designed to allow therapists to use these activities both as outcome measures and in the intervention process, monitoring the children's progress at each stage.

The development process occurred over a period of twenty-four months. After completing the construction stages, the result was the computer game named "BRINCOORD," which features three playable stages: "Maze," "Piggy Bank," and "Hopscotch." The game is played by a character selected by the player. Among six children with different characteristics, this character will perform the activities

commanded by the player (with movement recognition of the object via the computer's webcam). The levels and sublevels of each stage of the game are presented as follows:

On the game's home screen (Figure 1), there is the logo and the three main buttons, which will be presented below. The "About the Game" button takes you to a screen that will present the game, the objectives, the audience and the reason why it was created (Figure 1).

Figure 1. Game home screen and "About the Game" button screen.

Source: Authors.

The "Developers" button provides information about the team of students and teachers responsible for planning, creating and developing the game.

When clicking on the "Start game" button, the characters screen appears, where the child can choose which one they want to play with. The characters were created seeking to cover, as broadly as possible, the physical and cultural diversities of children (Figure 2). After choosing the character, you need to select the stage to be played. These do not have an established order and do not depend on each other, so the professional can select according to the child's demands (Figure 2).

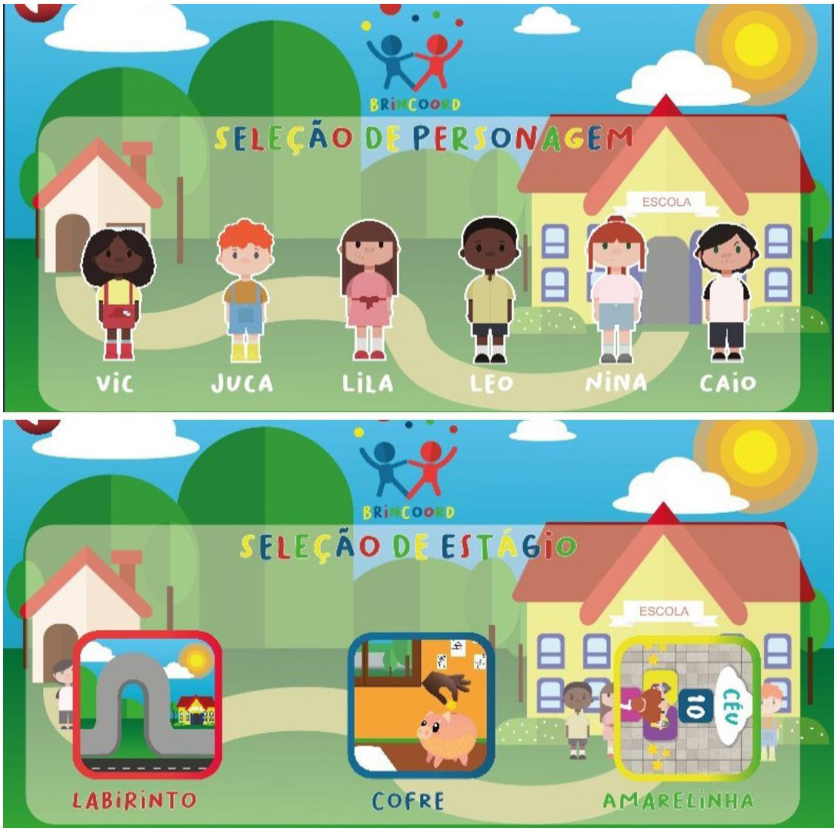

Figure 2. Character selection screen and stage selection screen.
Source: Authors.

Next, the stages present in the game are presented, what each one proposes and how to play it.

Stage 1: Labyrinth

The "maze" stage has three sub-stages, which feature different maze shapes. At this stage, the child will take the character, with the blue pencil (for tracking recognition), from one environment to another, following the shape of the maze, with the phase ending when he arrives at the destination (home, school and park) (Figure 3).

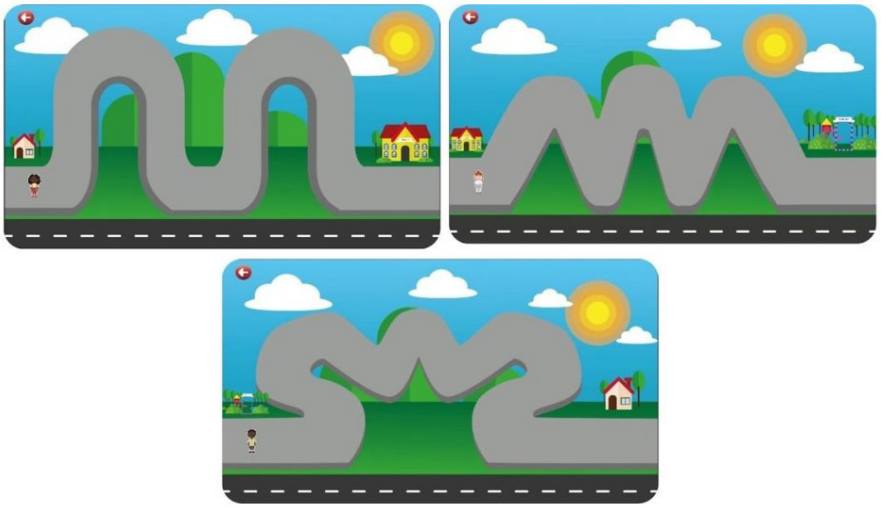

Figure 3. Screen of the maze substages.
Source: Authors.

Stage 2: Coins in the vault

The purpose of the coins stage in the safe is to fill the safe with the coins that are on the bed. The child must pick up the coins, using the blue glove and pinching pulp to pulp to move the game hand, and take them to the safe one by one, until it is full (Figure 4).

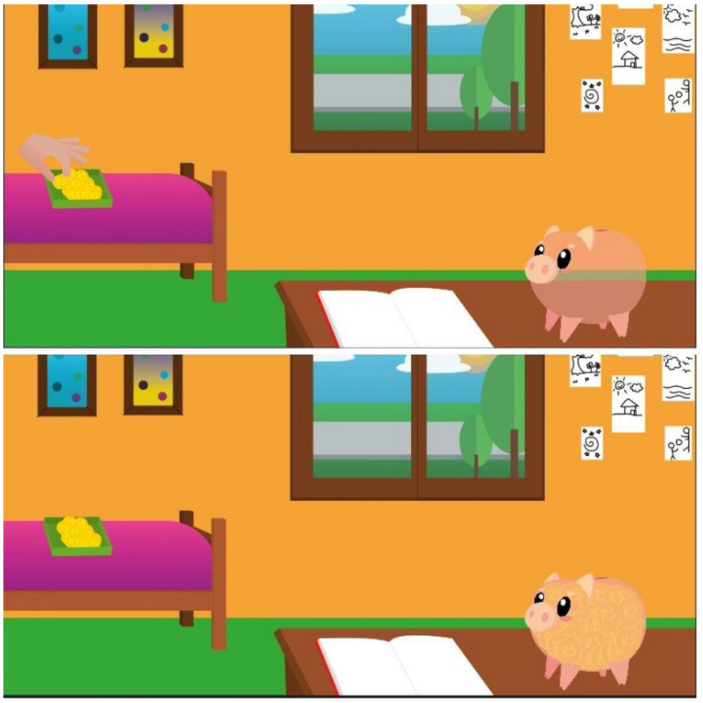

Figure 4. Safe stage screen.
Source: Authors.

Stage 3: Hopscotch

In the last stage, the child will play hopscotch, being played with the intention of reaching "the sky". To do this, a mat made in the shape of a hopscotch is placed on the floor, alternating the play with one or two feet, depending on the play.

Depending on the child's age group, the therapist can choose whether they want the child to strictly follow the rules of the game or whether they will grade the activity, asking the child to just jump with one or two feet following the sequence. At this stage, the game will detect the child's movement (jump), making the character move according to the child's movement, with each jump advancing one hopscotch square (Figure 5).

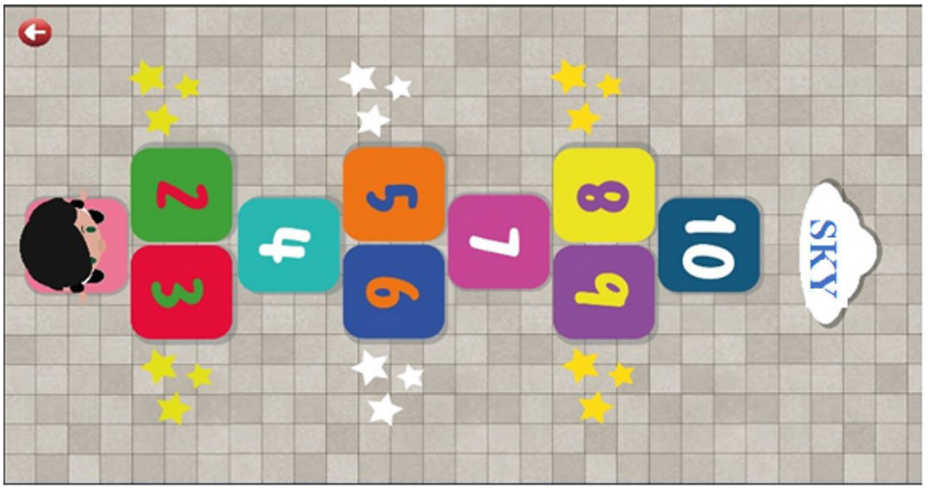

Figure 5. Hopscotch stage screen.
Source: Authors.

During the implementation process of the game and the initial testing with the team, a delay was noticed in the execution time and the responsiveness of movements on the computer screen. In light of this, these unexpected failures, commonly known as "bugs," needed to be reviewed and adapted to improve gameplay. Currently, the issues are in the adjustment process so that they can proceed to the next phase of testing with invited children.

Discussion

The development of the game "BRINCOORD" is an initiative that demonstrates the application of game technology as a therapeutic tool for children with Developmental Coordination Disorder. Technology is increasingly being used as an auxiliary tool in the therapeutic process, as various possibilities are being developed to incorporate new purposes in intervention, allowing the target audience to learn and experience new things according to their needs and interests. The goal is to improve communication, autonomy, social interaction, and ultimately promote inclusion (Watanabe et al., 2003).

As these are educational games, Serious Games require the involvement of a multidisciplinary team in their construction, where the professionals responsible for the game's content need to maintain constant communication with the design and development team in order to align ideas and achieve all the goals set for that game (Rodrigues, 2011). Furthermore, Serious Games have objectives aimed at learning and training motor skills, beyond entertainment, providing a motivating environment for therapeutic interventions (Associação Brasileira de Telesserviços, 1987).

Children born in the 21st century have been introduced to a world where technology is the foundation of personal relationships, making it very difficult to live without it. Consequently, children often prefer the virtual world (games and social networks) over traditional play (De Paiva & Costa, 2015). This is also a fact that can occur with children with DCD, considering their difficulty in engaging with groups, whether in school or community, due to unsatisfactory motor performance that prevents them from integrating into traditional games (Araújo, 2019).

In this context, an important element that the game formulated (BRINCOORD) in this study brings is being a personalized technological tool for this audience, with the potential to respond to the specific needs of the child (Lino et al., 2021; Cândido Soares et al., 2019). Another important component is providing a playful and motivating environment, as, according to Azevedo et al. (2022), motivation is a key ally in interventions using games, allowing for greater engagement, participation, immersive experiences, and increased motivational rewards for participants.

In a study conducted by Mentiplay et al. (2019), which systematically compared and analyzed research using virtual reality or video game-based interventions in children with DCD, it was found that these interventions are enjoyable, feasible, and potentially effective in improving physical functions such as strength, manual dexterity, and balance. Most of these studies used the MABC-2 as an outcome measure, indicating improvements in standard scores and some sub-scores of this assessment after the intervention, reflecting progress in motor functions. However, the study shows that few results specifically involve children with DCD, having addressed numerous pediatric cohorts. Additionally, the video game equipment used in the studies is no longer manufactured, and there has been no study utilizing Serious Games, highlighting the importance of new research to demonstrate the effects of these games on the motor limitations and restrictions of children with DCD.

In line with Mentiplay et al. (2019), the review conducted by Azevedo et al. (2022) also found that, despite the use of games showing significant gains in improving the motor performance of children with DCD, there is a gap in scientific evidence regarding the relationships between motor skills acquired through interventions using active games. Moreover, their study indicates that the most commonly used game in the research was the Nintendo Wii, and none of the 16 analyzed articles utilized a Serious Game.

In light of this, the innovation of "BRINCOORD" is evident, as it was designed to be a Serious Game aimed at children with DCD, with the goal of addressing the specific motor demands of this population. In this regard, the stages of "BRINCOORD" were constructed with activities focused on general and specific motor and cognitive skills. The "maze" stage, for example, requires movement planning, fine motor coordination, visuomotor coordination, attention, and focus, which are skills needed for writing, an

essential part of the educational occupation. The "safe" stage involves fine motor coordination, positioning, stabilization, balance, and movement calibration, which are skills necessary for activities of daily living (ADLs) such as feeding and oral hygiene. The "hopscotch" stage requires gross motor coordination, attention, and decision-making, which are skills needed for leisure and social participation. All of these skills are necessary for children to perform their occupational roles as satisfactorily as possible (American Occupational Therapy Association, 2015).

Additionally, "BRINCOORD" was designed to be an accessible game, requiring no high-cost materials for its production and execution. To use the game, an internet connection is not necessary; only a computer and webcam are required. This strategy was aimed at facilitating use by professionals in various fields, whether public or private, to enable broader dissemination of its use and, consequently, assist more children with DCD.

According to De Paula & Valente (2015), software changes and "bugs" in game systems are common and expected during the development process of these technologies; however, they are not permanent and can be corrected and improved. During the construction of "BRINCOORD," some of these processes were experienced, such as the shift from a console to a computer with a webcam, which further facilitated access to the game by professionals, and the slowness in response to presented movements, an issue being reworked by the team to enhance its final application.

Despite the limitations encountered throughout this process, the development of the "BRINCOORD" game is an initiative that demonstrates innovation in the realm of interventions and the application of game technology as a therapeutic tool for children with DCD. Furthermore, through its construction, the aim was to evaluate the relevance and potential impact of this game in pediatric therapy and in the approach towards these children regarding motor development, as this is a resource that can contribute to skill acquisition and the improvement of these individuals' performance, in addition to aiding in adherence to and engagement in the intervention.

Moreover, it is important to emphasize that Serious Games are allies and not substitutes for traditional therapeutic interventions. They can be used as a complement to therapeutic intervention but should not replace the guidance and feedback of a qualified therapist (Azevedo et al., 2022).

Conclusion

After bibliographic research and collaborative analysis by a multidisciplinary team, it was possible to create an accessible game that considers the skills to be evaluated and worked on alongside therapies for children with Developmental Coordination Disorder (DCD). Moreover, the study showed that the use of Serious Games is a promising approach for managing children with DCD, as it provides a playful and engaging environment focused on motor learning.

However, it is important to emphasize that the scarcity of research and studies addressing Serious Games and DCD simultaneously was a limitation for this work, as these studies would provide the evidence and points for improvement. Additionally, some changes needed to be made, such as replacing the Kinect console with a computer

and webcam, as well as addressing the "bugs" presented by the game, such as delays in command responses.

"BRINCOORD" has the potential to be a valuable tool for the intervention and assessment of children with Developmental Coordination Disorder. In its future phase, after undergoing necessary adjustments and tests, the game will be tested on a sample population to evaluate its use, with the application of usability and playability tests. The expectation is that it can assist therapists in promoting the development of motor skills and, consequently, improve children's participation in daily activities.

It is also suggested that more studies utilize Serious Games for intervention with the pediatric population, demonstrating the potential of this type of game and making the use of technology more accessible to the population, especially to children undergoing therapeutic processes.

References

American Occupational Therapy Association – AOTA. (2015). Estrutura da prática da terapia ocupacional: domínio & processo - 3ª ed. traduzida. *Revista de Terapia Ocupacional da Universidade de São Paulo*, *26*(esp), 1-49.

American Psychiatric Association – APA. (2014). *DSM-5: Manual diagnóstico e estatístico de transtornos mentais*. Porto Alegre: Artmed Editora.

Araújo, C. R. S. (2019). *Eficácia da Cognitive Orientation To Daily Occupational Performance Approach (Co-Op) com e sem adição de Occupational Performance Coaching em grupos para pais no desempenho ocupacional e na participação de crianças com transtorno do desenvolvimento da coordenação: ensaio clínico aleatorizado* (Tese de doutorado). Universidade Federal de Minas Gerais, Belo Horizonte.

Arnoni, J. L. B., Verdério, B. N., Pinto, A. M. A., & Rocha, N. A. C. F. (2018). Efeito da intervenção com videogame ativo sobre o autoconceito, equilíbrio, desempenho motor e sucesso adaptativo de crianças com paralisia cerebral: estudo preliminar. *Fisioterapia e Pesquisa*, *25*(3), 294-302.

Associação Brasileira de Telesserviços – ABT. (1987). *Jogos sérios*. Brasília: Imprensa Universitária da América.

Azevedo, L. L. O. C., Ramos, N. V. P. G., Lima, E. L. B., Lima, A. C. D., & Araújo, C. R. S. (2022). Uso de jogos ativos na reabilitação de crianças e adolescentes: uma revisão da literatura. *Revista Interinstitucional Brasileira de Terapia Ocupacional*, *6*(4), 1368-1384.

Borecki, L., Tolstych, K., & Pokorski, M. (2013). Computer games and fine motor skills. In M. Pokorski (Ed.), *Respiratory Regulation-Clinical Advances* (pp. 343-348). Netherlands: Springer.

Camilo, M. D. S., Cheng, C., Nascimento, J. O. D., Ribeiro, L. A. P. A., Pires, E. T. C., & Martins, S. G. (2016). Jogos sérios para a saúde: uma revisão narrativa. J. *Informação de Saúde*, *8*(Supl 1), 211-218.

Cândido Soares, J. C., de Moraes, B. L. C., Couto Paz, C. C. S., & Magahães, L. C. (2019). Influência do uso de jogos do Microsoft Kinect sobre o desempenho motor e funcional de criança com transtorno do desenvolvimento de coordenação. *Cadernos Brasileiros de Terapia Ocupacional*, *27*(4), 710-717. http://dx.doi.org/10.4322/2526-8910.ctoAO1630.

Cavalcante Neto, J. L. C., Steenbergen, B., & Tudella, E. (2019). Motor intervention with and without Nintendo® Wii for children with developmental coordination disorder: protocol for a randomized clinical trial. *Trials*, *20*(1), 1-12.

Comeras-Chueca, C., Marin-Puyalto, J., Matute-Llorente, A., Vicente-Rodriguez, G., Casajus, J. A., & Gonzalez-Aguero, A. (2021). The effects of active video games on health-related physical fitness and motor competence in children and adolescents with healthy weight: a systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, *18*(13), 1-23.

Corrêa, A. G. D., Monteiro, C. B. M., Silva, T. D., Lima-Alvarez, C. D., Ficheman, I. K., Tudella, E., & Lopes, R. D. (2011). Realidade virtual e jogos eletrônicos: uma proposta para deficientes. In C. B. M. Monteiro (Org.), *Realidade virtual na paralisia cerebral* (pp. 65-32). São Paulo: Plêiade.

Deguirmendjian, S. C., de Miranda, F. M., & Zem-Mascarenhas, S. H. (2016). Serious game desenvolvidos na saúde: revisão integrativa da literatura. *Journal of Health Informatics*, *8*(3), 110-116.

Dias, J. D., Mekaro, M. S., Cheng Lu, J. K., Otsuka, J. L., Fonseca, L. M. M., & Zem-Mascarenhas, S. H. (2016). Serious game development as a strategy for health promotion and tackling childhood obesity. *Revista Latino-Americana de Enfermagem*, *24*, 1-9.

EbrahimiSani, S., Sohrabi, M., Taheri, H., Agdasi, M. T., & Amiri, S. (2020). Effects of virtual reality training intervention on predictive motor control of children with DCD–A randomized controlled trial. *Research in Developmental Disabilities*, *107*, 103768.

Henderson, S. E., Sugden, D., & Barnett, A. L. (2007). *Bateria de Avaliação de Movimento para Crianças-2. Testes psicológicos APA*. London: Pearson.

Jaramillo-Alcázar, A., Arias, J., Albornoz, I., Alvarado, A., & Luján-Mora, S. (2022). Method for the development of accessible mobile Serious Games for children with Autism Spectrum Disorder. *International Journal of Environmental Research and Public Health*, *19*(7), 1-24.

Lamas, S., Rebelo, S., da Costa, S., Sousa, H., Zagalo, N., & Pinto, E. (2023). The influence of Serious Games in the promotion of healthy diet and physical activity health: a systematic review. *Nutrients*, *15*(6), 1-17.

Lino, F., Arcangeli, V., & Chieffo, D. P. R. (2021). The virtual challenge: virtual reality tools for intervention in children with developmental coordination disorder. *Children (Basel, Switzerland)*, *8*(4), 1-10.

Martins, A. P. S. (2021). *Inclusão de crianças com transtorno do desenvolvimento da coordenação (TDC) nas aulas de educação física escolar: uma revisão sob a perspectiva biopsicossocial* (Trabalho de conclusão de curso). Faculdade Ages de Senhor do Bonfim, Salvador.

Mentiplay, B. F., FitzGerald, T. L., Clark, R. A., Bower, K. J., Denehy, L., & Spittle, A. J. (2019). Do video game interventions improve motor outcomes in children with developmental coordination disorder? A systematic review using the ICF framework. *BMC Pediatrics*, *19*, 1-15.

Michael, D. R., & Chen, S. L. (2005). *Serious games: games that educate, train and inform*. Boston: Thomson Course Technology.

Nobre, G. C., Ramalho, M. H. D. S., Ribas, M. D. S., & Valentini, N. C. (2023). Motor, physical, and psychosocial parameters of children with and without developmental coordination disorder: a comparative and associative study. *International Journal of Environmental Research and Public Health*, *20*(4), 1-13.

Novak, J. (2010). *Game development essentials: an introduction* (2nd ed.). Clifton Park: Delmar.

Page, Z. E., Barrington, S., Edwards, J., & Barnett, L. M. (2017). Os videogames ativos beneficiam o desenvolvimento de habilidades motoras de crianças e adolescentes com desenvolvimento atípico: uma revisão sistemática. *Revista de Ciência e Medicina no Esporte*, *20*(12), 1087-1100.

Paiva, N. M. N., & Costa, J. (2015). A influência da tecnologia na infância: desenvolvimento ou ameaça. *Psicologia*, (Pt 1), 1-13.

Paula, B. H., & Valente, J. A. (2015). Errando para aprender: a importância dos desafios e dos fracassos para os jogos digitais na Educação. *Revista Novas Tecnologias na Educação*, *13*(2), 1-11.

Pedro, W. (2021). *O que é Kinect? 5 jogos que usavam o acessório*. Recuperado em 7 de março, de https://tecnoblog.net/responde/o-que-e-o-kinect-5-jogos-que-usavam-o-acessorio/

Pereira, É. F., Teixeira, C. S., & Santos, A. D. (2012). Qualidade de vida: abordagens, conceitos e avaliação. *Revista Brasileira de Educação Física e Esporte*, *26*(2), 241-250.

Richvoldsen, H. (2009). *Serious gaming: serious content in an entertaining framework* (Dissertação de mestrado). Norwegian University of Science and Technology, Noruega.

Ritterfeld, U., Cody, M., & Vorderer, P. (2009). *Jogos sérios: mecanismos e efeitos*. London: Routledge.

Rodrigues, H. F. (2011). *Aplicando Sistemas Hápticos em Serious Games: um jogo para a educação em higiene bucal* (Dissertação de mestrado). Universidade Federal da Paraíba, João Pessoa.

Schell, J. (2008). *A arte do design de jogos: um livro de lentes*. Boca Raton: CRC Press.

Serafim, A. R. R. D. M., Silva, A. N. S., Alcântara, C. M. D., & Queiroz, M. V. O. (2019). Construção de serious games para adolescentes com diabetes mellitus tipo 1. *Acta Paulista de Enfermagem*, *32*(4), 374-381.

Silva, G. M., Paula, S. L., Pinto, J. S., Santos, C. D. F. S. O., & Valença, S. B. (2023). Utilização do Scrum para o desenvolvimento de um banco público de práticas e soluções em saúde. *Revista Foco*, *16*(5), 1-28.

Vallence, A. M., Hebert, J., Jespersen, E., Klakk, H., Rexen, C., & Wedderkopp, N. (2019). Childhood motor performance is increased by participation in organized sport: the CHAMPS Study-DK. *Scientific Reports*, *9*(1), 1-8.

Watanabe, M. K. F., Tsukimoto, D. R., & Tsukimoto, G. R. (2003). Terapia ocupacional e o uso do computador como recurso terapêutico. *Acta Fisiátrica*, *10*(1), 17-20.

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