SEVEN
publicações acadêmicas

Use of digital games in the third age: A systematic review

https://doi.org/10.56238/Connexpemultidisdevolpfut-070

Matheus Augusto Souza dos Santos
Graduating in Digital Games Technology from IFBA
Federal Institute of Education, Science and Technology of Bahia
ORCID: https://orcid.org/0009-0000-3688-0562
LATTES: http://lattes.cnpq.br/3471862884991318
E-mail: msmsmatheusaugusto@gmail.com

Bruna dos Santos de Jesus
Graduating in Digital Games Technology at IFBA
Federal Institute of Education, Science and Technology of Bahia
ORCID: https://orcid.org/0009-0008-0720-2445
LATTES: http://lattes.cnpq.br/7108934252687514
E-mail: brunasjifba@gmail.com

Joacir Simões Ferreira
PhD in Knowledge Diffusion from UFBA (2018)
Federal Institute of Education, Science and Technology of Bahia
ORCID: https://orcid.org/0000-0002-9826-5319
LATTES: http://lattes.cnpq.br/1026500784646357
E-mail: joacir.ferreira@ifba.edu.br

Luiz Cláudio Machado dos Santos
PhD in Education from UFBA (2015)
Federal Institute of Education, Science and Technology of Bahia
ORCID: https://orcid.org/0000-0003-3864-9684
LATTES: http://lattes.cnpq.br/6294967085470113
E-mail: luizmachad@gmail.com

Marcelo Vera Cruz Diniz
PhD in Computational Modeling from SENAI/CIMATEC (2017)
Federal Institute of Education, Science and Technology of Bahia
ORCID: https://orcid.org/0000-0003-1772-7727
LATTES: http://lattes.cnpq.br/4162291555771478
E-mail: marcelodiniz@ifba.edu.br

ABSTRACT
Population aging is a global phenomenon that brings significant challenges to society. Increasing life expectancy and decreasing birth rates have led to the growth of the elderly population worldwide. In Brazil, this trend is no different, with projections indicating an increase in the number of elderly in the coming decades. In this context, the cognitive health of the elderly plays a crucial role, as it can be negatively affected by aging, impacting their quality of life and autonomy. Given these issues, the use of digital games as cognitive stimulation tools has aroused growing interest in the area of health and technology. These games offer entertainment opportunities and cognitive challenges that can promote the health and well-being of seniors, as well as slow or prevent the cognitive decline associated with aging. However, many digital gaming solutions on the market have limitations in terms of diversity, customization, usability, and accessibility for aging users. In this article, a systematic review of the literature on the application of digital games to the elderly was carried out, focusing on the age group of 60 to 75 years. The review covered studies that investigated the effects of digital games on the cognitive health of the elderly, as well as the limitations found in existing solutions. In addition, a proof of concept of a gaming device based on the Arduino platform was proposed, aiming to fill the identified gaps.

Keywords: Population aging, Senior citizens, Cognitive health, Digital games.

1 INTRODUCTION

Global demographic change has raised concerns about population aging and its impacts on society. According to the World Health Organization (WHO) (2022), it is estimated that by 2050 there will be about 2 billion people over the age of 60, which represents approximately one fifth of the

world's population. Taking Brazil as a cut, data from the Ministry of Health (2022) indicate that the country already has the fifth largest elderly population in the world, and projections indicate that, by 2030, the number of elderly will exceed the number of children between zero and 14 years old.

Health is an extremely important aspect for the elderly during the aging process, representing a harmony between behavioral, physical, cognitive and emotional factors, which are intrinsically related to well-being and satisfaction with one's own life, as pointed out by Chagas et al. (2022).

Given the vulnerabilities inherent to this phase of life, people called "Third Age", who are defined by the World Health Organization (WHO) as individuals aged 60 years or older, need to take care due to exposure to neurodegenerative diseases, which affect the cognition, memory and motor skills of individuals, as highlighted by Caetano et al. (2017). An example of these diseases is Alzheimer's, which was recorded as a cause of death for 17,700 elderly people between 1999 and 2019, with two-thirds of these elderly women being women, as evidenced in the study by Chaimowicz et al. (2022). Another disease with a high incidence is dementia, affecting about 1.2 million people in Brazil, according to data from the Ministry of Health (2021), and resulting in 2,600 deaths during the same period, as pointed out by Chaimowicz et al. (2022).

In the study raised by Moreno et al. (2021), normal aging and Alzheimer's can be differentiated from eight main aspects. These aspects include the distinction between occasional and persistent memory loss, temporal and spatial disorientation, aphasia versus forgetting punctual words, behavioral changes versus normal mood swings, occasional loss of objects versus inability to retrace steps, difficulties in making decisions versus occasional wrong decisions, periods of tiredness versus apathy and social isolation, and occasional difficulty in complex tasks versus significant difficulty in making basic daily activities. Also highlighted by Moreno et al. (2021), although the presence of a single symptom is not sufficient for a diagnosis of the disease, preliminary detection has a unique role in ensuring a better quality of life, as the disease evolves.

These complications, as well as other health conditions related to aging, can negatively affect the cognition of the elderly, leading to declines in memory, attention and other cognitive skills important for the performance of daily activities, logical reasoning, and other capacities that involve this cognitive aspect, as explained by the Ministry of Health (2021).

In this context, the use of digital games as cognitive stimulation tools has been a growing object of interest in the area of health and technology. This approach provides entertainment opportunities and cognitive challenges that can assist in promoting the health and well-being of older adults, as well as slowing or preventing cognitive decline. Cognitive decline is defined by Funcionalitá (2021) as a transitional condition between normal cognition and dementia, and has direct impacts on the social and work activities of the individual, as elucidated by the Jequitibá Mental Health Clinic (2020), and is also associated with aging, as mentioned by Domingos et al. (2018).

In addition, digital games have attractive characteristics, such as interactivity, immersion and the possibility of adapting to individual skills, making them a viable and accessible option for the promotion of cognitive health in the elderly, as is also cited by Domingos et al. (2018).

Although there are digital gaming solutions aimed at the elderly available in the market, many of them have deficiencies in terms of game diversity, customization, usability and accessibility for users, and these fissures generate the distance of users, as evidenced by Santos et al. (2013). Given the above, it is necessary to seek alternatives that meet the specific needs of the elderly and effectively stimulate cognitive development.

This article presents a systematic review of the literature on the application of digital games to the elderly public, with a specific focus on the age group of 60 to 75 years. The main objective is to analyze the available evidence and identify gaps and challenges that exist in this area of study. In addition, an exploratory study is carried out to support the creation of a proof of concept that aims to address some deficiencies found in the existing solutions in the market, through a device that will contain digital games embedded in an Arduino board.

The systematic review covered a careful selection of relevant and significant studies, considering both the interventions with digital games and the effects observed on the cognitive health of the elderly with the use of these tools. However, it is important to note that this study represents an early stage of development of the device proposal and is not intended to present a complete or conclusive solution.

The conduct of the research was used as initial validation to justify the need to create a proof of concept, whose objective is to develop a device integrated with Arduino, containing a set of digital games, with short duration, specially designed to stimulate the cognitive development of the elderly. This approach seeks to fill gaps and overcome challenges identified in existing solutions.

Therefore, it is important to highlight that this article represents an initial step in the exploration of this field of study and in the development of the proposal of the device. The goal is to provide a solid and grounded foundation for future research and advancements in the area of digital games aimed at the cognitive health of the elderly.

At the end of this article, it is expected to provide a sample of the current literature on digital games for the elderly, and to present a proof of concept that has possible potentials to contribute to the promotion of the cognitive health of this population and highlight the importance of investments in research and development in this field.

2 THEORETICAL FRAMEWORK

In this section will be presented some definitions and contextualizations of concepts that will be presented in the rest of the article.

2.1 POPULATION AGING AND COGNITIVE HEALTH IN THE THIRD AGE

Population aging is a global phenomenon that has intensified over the years. This process is related to the increase in life expectancy and the decrease in birth rates, as justified by the National Bank for Economic and Social Development (BNDES) (2017).

In Brazil, population aging is occurring rapidly and intensely. As presented by the Ministry of Health (2023), the Brazilian elderly population represents 14.3% of the total population of the country, which is equivalent to about 29.374 million people. In addition, life expectancy has increased over the years, reaching 75.72 years in 2016 for both sexes. These data highlight the importance of addressing cognitive health in the elderly, since aging can affect mental processes such as memory, attention, learning, language and reasoning.

According to Miranda et al. (2016), population aging brings with it a series of challenges and impacts on society. As the elderly population grows, it is necessary to address issues related to quality of life, health and specific care for this group.

In the context of the elderly, cognitive health gains an even greater relevance, so much so that according to the laws of BRAZIL (2003), the Statute of the Elderly guarantees the elderly the protection of life with regard to the "Right to Life". Cognition, which involves mental processes such as memory, attention, learning, language and reasoning, can be affected by aging. The elderly may present declines in these aspects, which directly impacts on their quality of life and autonomy, given the surveys done by Pereira (2019). Therefore, it is crucial to understand and address the cognitive health needs of this population in order to promote healthy and active aging.

2.2 DIGITAL GAMES AND COGNITIVE STIMULATION

Technological advances, especially portable devices such as *smartphones*, have provided greater access to technologies for the elderly. This integration with the digital world has the potential to motivate and improve the learning process, although research on its use in the digital inclusion of the elderly is still limited, as Ferreira et al. (2022) point out. Digital games emerge as a promising technological innovation to improve the quality of life of the elderly, offering fun and stimulating physical, socio-emotional aspects and cognitive abilities.

Also evidenced by Ferreira et al. (2022), the concept of "game therapy", which uses games to promote cognitive and physical benefits, has been an approach applied especially in elderly people with diseases such as Alzheimer's. In addition, they comment that the accessibility of digital games is an important factor to be considered, since the elderly may present physical and perceptual limitations. Given this, ensuring the accessibility of games, such as adjustable font size, intuitive interface and adaptation to different motor skills, is fundamental so that the elderly can fully enjoy the benefits of digital games and promote their digital inclusion.

Digital games have proven to be a promising tool in the field of cognitive stimulation, especially for the elderly. According to Darin (2020), these games, which have evolved significantly over time, have interactive and didactic characteristics that favor learning and can benefit the cognitive development of the elderly.

Also pointed out by Darin (2020), the use of digital games as cognitive stimulation tools has the potential to enhance various mental skills, such as memory, attention, logical reasoning and problem solving. Through challenges and adaptive activities, digital games can offer a playful and motivating environment for cognitive training, providing benefits for both the maintenance and improvement of the cognitive abilities of the elderly.

Other authors such as Carreiro et al. (2018), also defend that cognitive stimulation is a fundamental approach in the treatment of diseases such as Alzheimer's (which mainly reaches the target audience of the study of this article), aiming to adapt the patient to the disease and preserve their autonomy. In line with Darin (2020), the authors Carreiro et al. (2018) reinforce the use of several strategies such as the use of: music, photographs, objects, physiotherapy, games and reading. These activities stimulate memory, attention, concentration and cognitive skills, contributing to the patient's quality of life and slowing the progression of the disease

2.3 THE TECHNOLOGY OF ARDUINO AND ITS APPLICATIONS IN DIGITAL GAMES

The Arduino consists of a printed circuit board with a programmable microcontroller, which allows the connection and control of various electronic components, as McRoberts (2018) points out. Its functionality and flexibility make it a viable option for creating digital games, especially when looking to develop interactive and portable devices. It is also clarified by McRoberts (2018), that through the programming of the microcontroller, it is possible to control and synchronize the elements of the game, such as lights, buttons, sensors and screens, providing an interactive and immersive experience for users.

The integration of Arduino into a gaming device for the elderly offers several benefits and possibilities. First, the flexibility of the board allows the customization of the games according to the needs and abilities of the elderly, adapting to their cognitive and physical abilities. In addition, the portability of the device enables the elderly to play in different environments and situations, promoting social interaction and cognitive stimulation in different contexts, following the line of thought evidenced by Ferreira et al. (2022).

Another important benefit is the possibility of creating affordable and easy-to-use devices for the elderly. The integration of large and easy-to-operate buttons, for example, facilitates interaction and usability for people with motor or visual limitations, as elucidated by Santos (2013). In addition, the use of screens with good legibility and contrasting colors contributes to visual accessibility, as

explained by Tavares et al. (2012). In this way, the Arduino technology presents a great potential in the creation of gaming devices for the elderly, which can provide cognitive, social and emotional benefits for the elderly.

The flexibility of the platform, combined with the possibility of customization according to the context of the games, and the accessibility of the devices, makes it possible to develop concepts of promising alternatives to stimulate cognitive development and promote the well-being of this older population.

2.4 RECAP

In order to comprehensively investigate the use of digital games applied to the public of people between 60 and 75 years of age, a methodological approach of literature review was adopted. This methodology allowed to critically examine the available research and evidence, in order to identify gaps and challenges in the area, as well as to provide a basis that supports the proposition of a model, potentially beneficial to the target audience of this work.

In the scope of the systematic review, we sought to group relevant studies that have carried out investigations on the application of digital games in the context of people categorized as part of the "third age". For this, we conducted comprehensive searches, in search of databases using specific search terms related to digital games, aging and cognitive health. In addition, studies were included that address both the benefits of digital games for the cognitive health of the elderly, as well as the deficiencies found in the existing solutions on the market.

The critical and judicious analysis of these studies will allow us to notice the gaps and observe the evidence, and the unsolved challenges in this area. Based on the results, a favorable scenario for the presentation of an innovative solution that aims to meet the specific needs of the elderly, stimulating in a didactic and fun way the cognitive development, is created in a natural way according to the "atmosphere" of the occasionality.

In the next section, the methodology used to conduct this systematic review of the literature and related works in the area of digital games with a focus on the elderly will be detailed. The inclusion and exclusion criteria of studies, the selection process, and extraction of relevant data, as well as the analysis strategy adopted will be presented.

3 METHODOLOGY

The methodology adopted for the development of this project consisted of a systematic review of the literature to investigate the application of digital games to the elderly public, with the objective of analyzing the benefits, challenges and gaps in this area. The systematic review was conducted following some guidelines recommended by the *Preferred Reporting Items for Systematic Reviews*

and Meta-Analyses (PRISMA), made available by Page et al. (2021), in which search strategies, grouping of studies, data analysis, conclusions, among other procedures, are defined, at the time the following items recommended by PRISMA, Page et al. (2021) were chosen: 5, 6, 7, 9, 13 and 15. The steps involved in conducting this systematic review are described below.

3.1 SEARCH STRATEGY

The search strategy was based on the search for articles, digital games and related publications, focusing on the elderly public. Whether in repositories widely disseminated by educational institutions, Annals of conferences such as the Brazilian Symposium on Games and Digital Entertainment, or magazines, and or journalistic portals with relevant notoriety for the subject. Once the results were found, the content filtering was done, as will be discussed in the next subsection.

3.2 INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria adopted were: (1) studies published in peer-reviewed journals, (2) studies that investigated the application of digital games in individuals aged 60 years or older, (3) studies that evaluated the effects of digital games on cognitive health, (4) studies written in English, Spanish or Portuguese, (5) Preference was given to works produced in the Brazilian academic technological literature. Duplicate studies, conference abstracts, publications of online portals without recognized notability, were excluded from the analysis.

3.3 SELECTION OF STUDIES

After the initial search, the studies were selected according to the established inclusion and exclusion criteria. The selection was carried out in two stages: initial screening based on the titles and abstracts of the articles and a more detailed evaluation of the articles selected in the previous stage. The authors independently selected the studies, and any disagreements were discussed until a consensus was reached.

3.4 DATA EXTRACTION AND ANALYSIS

The extracted data were analyzed descriptively, identifying patterns and trends in the characteristics of the studies, interventions used and results obtained. In addition, a narrative synthesis of the main findings of the studies included in the systematic review was performed.

Based on the analysis of the data and the evaluation of the quality of the studies, the main results were synthesized and presented in a clear and concise manner. The trends, gaps and challenges in the application of digital games to the cognitive health of the elderly were identified.

3.5 LIMITATIONS

It is important to mention that the systematic review has its limitations, such as the possibility that not all relevant studies were included, the dependence on the quality and availability of data in the selected studies, and the impossibility of performing a meta-analysis due to the heterogeneity of the included studies. However, necessary measures were taken to ensure the validity and reliability of the results presented.

4 RESULTS OF THE LITERATURE REVIEW

In this section, we will discuss the benefits and challenges found in the literature in relation to the use of digital games by the elderly, as well as the gaps or deficiencies identified in the existing solutions in the market. The review covers a variety of studies investigating the effects of digital games on the cognitive health of the elderly, considering aspects such as memory, attention, logical reasoning and problem solving. In addition, the characteristics of electronic games that make this form of cognitive stimulation attractive and viable for the elderly will be explored, such as interactivity, immersion and adaptability to individual skills.

This critical analysis of the literature will also allow us to identify the limitations and challenges faced in the use of digital games by the elderly, including issues related to accessibility, usability and personalization of games. At the end of this section, it is expected to provide a comprehensive overview of existing studies and highlight the gaps or opportunities for improvement in current solutions, subsidizing the proposal of a proof of concept of a gaming device for the elderly based on the Arduino platform.

4.1 PRODUCTIONS FOUND

In this subsection, the main scientific productions found during the literature review will be presented. The studies that investigated the effects of digital games on the cognitive health of the elderly will be discussed, considering different approaches, methodologies and results obtained.

From the methodological process of curating works, four works were published in a period between 2017 to 2019, in which they carry out systematic analyses related in some aspect to the public of the third age, or that have in some way addressed the use of games for these people and their impacts on the cognitive system. The set of works that were analyzed was composed of the works presented in Table 1, in which will be described: the title of each selected work, the amount of games or related works selected for analysis, and the appropriate references of the authors.

Table 1. Selected Works for Systematic Analysis

Title of the work	Number of Productions Analyzed	Authors' Reference
"Electronic Games as Intervention Instruments in Cognitive Decline – A Systematic Review"	12	Cardoso et al. (2017)
"Usability of digital games for the elderly: preliminary data from a quasi-experimental study with older adults from an Open University of the Third Age"	3	Bonfim et al. (2019)
"A Systematic Mapping on Accessibility and Usability in the Development of Digital Games for the Elderly"	46	Santos et al. (2018)

Source: the Authors

4.1.1 Work by Cardoso et al. (2017)

Cardoso et al. (2019) conducts a systematic review of studies that investigated the impact of electronic games on the cognition of older adults with cognitive decline. The main objective is to identify and discuss the experiments carried out in this area in order to understand the effects of electronic games on the cognitive enhancement of this population.

The systematic review was conducted following the model of PRISMA, Page (2021). The searches were performed in the virtual databases PubMed, VHL and Scopus. Twelve studies were selected according to the established criteria. In total, 17 different electronic games were identified as intervention instruments in the studies analyzed.

The main results of the reviewed studies suggest improvements in memory, attention, information processing and executive functions in older adults with cognitive decline who use electronic games as an intervention. However, not all of the benefits found were maintained long-term or transferred to the participants' everyday lives.

Based on these conclusions, the final considerations of the article highlight the importance of conducting more research that compares the effects of different electronic games, aiming to clarify which games provide greater cognitive enhancement in a given population. It is also emphasized the need to study the effects of the same electronic game in both healthy elderly and elderly with cognitive decline, considering differences in learning time, exposure time required to obtain cognitive improvements and the possibility of transferring these improvements to everyday life.

4.1.2 Work by Bonfim et al. (2019)

Bonfim et al. explore the usability of digital games used by elderly participants of a University of the Third Age in Salvador-BA. The study seeks to identify how these games are perceived and used by the elderly, taking into account criteria of gameplay, design and content.

The study was conducted with six elderly people enrolled in the University of the Third Age, with an average age of 66.8 years. During five sessions, the seniors interacted with three digital games:

"Codycross," "Mazegame," and "Find the Pairs," as cited by Bonfim et al. (2019). After these sessions, they answered a usability questionnaire, in addition to observations of the interaction and unstructured interviews to understand the perception of the elderly in relation to the games.

The results showed that most of the elderly identified usability criteria in the games used, highlighting the gameplay and design as positive aspects. However, problems related to the quality of the texts, the inadequate content of the games, the difficulties in handling the tablet and the influence of cognitive difficulties that affect the performance of the games were pointed out.

The conclusion of the study highlights that the research contributes to the development of games aimed at the elderly public and to the expansion of the use of games as tools of cognitive stimulation. However, the authors highlight the need to conduct more comprehensive research, involving a larger number of participants and directed specifically to the elderly public, considering that this area is constantly growing. It is also emphasized the importance of investing in the creation of games that address themes relevant to the context of the elderly public, in order to promote greater representation and increase the motivation of players.

4.1.3 Work by Santos et al. (2018)

Santos et al. (2018), carried out a systematic mapping of the literature with the aim of understanding how, when and where aspects of accessibility and usability are addressed during the development of digital games for elderly users. We analyzed 20,270 initial results, sampled 1,755 articles and identified 46 publications relevant to the mapping.

The results of the mapping indicated a preference for research that addresses the evaluation of accessibility and usability in the development of digital games for the elderly. It was observed that, in the sample considered, accessibility was addressed mainly in conjunction with usability, or when usability was considered by the authors as a requirement for the accessibility of the game. In addition, the results showed a significant predominance of approaches that consider usability over approaches that consider accessibility in isolation.

The final considerations of the study highlight that the results of the mapping evidenced a high interest in research on techniques and methods of evaluation of accessibility and usability in the development of digital games for the elderly. However, it was observed that accessibility is predominantly addressed in the implementation and evaluation phases when combined with usability. The number of publications on usability was significantly higher than publications on accessibility in the context of the development of digital games for the elderly.

The study also identified the lack of prominence of specific vehicles with a significant amount of publications on accessibility and usability in this domain. This suggests an opportunity for the creation of events or periodicals focused on this theme. In addition, the study pointed out that research

in this area is still limited in Brazilian universities and research centers, highlighting the importance of research groups exploring this topic and becoming relevant study centers in the world scenario.

4.1.4 Work by Fonseca et al. (2019)

Fonseca et al. (2019) presents a systematic review of the literature on educational games for the elderly, with the aim of identifying current research on the topic and answering three research questions. The methodology used was adequate and well described, with the selection of articles performed through a search *string* and the application of quality criteria for the final selection of the works.

The results obtained from the analyses of the nine productions analyzed in the literature, and market, show that educational games can contribute to the learning of the elderly, if developed appropriately, taking into account their needs and interests. In addition, the work highlights the importance of considering the limitations of the elderly and the care that must be taken in the development so that educational games are accessible.

However, the work has some limitations. The review does not present a critical analysis of the results of the selected studies, but merely describes the main conclusions of each study. Another limitation is that the study does not present a more in-depth discussion about the practical implications of the results found. For example, it would be interesting to discuss how the results can be applied in practice, such as the development of specific educational games for the elderly, and what would be the best practices for the development of these games.

In summary, the work presents a systematic review of the literature on educational games for the elderly, with relevant results for the area. However, the work could be enhanced with a larger sample of selected articles, a more in-depth critical analysis of the results, and a more detailed discussion of the practical implications of the results found.

4.2 BENEFITS OF THE APPLICATION OF THE PRODUCTIONS FOUND

In this subsection, the benefits identified in the studies analyzed will be discussed. The positive impacts of digital games on the cognitive health of older adults will be presented, including improvements in memory, attention, logical reasoning skills and problem solving. The positive aspects related to motivation, entertainment and emotional well-being provided by the games will also be highlighted.

From the analyses, and as elucidated by the authors themselves: Cardoso et al. (2017), Bonfim et al. (2019), Santos et al. (2018) and Fonseca et. al (2019), affirm in their works, the use of digital games applied to the public of the third age potentiate the benefits to their quality of life. Aspects such as improvement in cognitive ability, hence involve elements such as memory, reasoning, and learning.

Also, in accordance with the line of reasoning of the other authors, in the work of Fonseca et al. (2019), the exposition is made that by aligning a good planning of *design* of game and *design* of level is noted in older adults positive effects on the cognitive system, but given the caveat that this is directly and proportionally related to the performance performed by the player.

The results of the studies show that digital games can be an effective tool to stimulate and exercise the mind of the elderly, contributing to the maintenance of cognitive health. In addition, games can provide fun, entertainment and a rewarding experience, promoting the emotional well-being and motivation of players.

These highlighted benefits reinforce the importance of considering the use of digital games as a strategy to promote healthy aging and quality of life of the elderly. However, it is essential to continue to conduct research and develop approaches that are appropriate to the specific needs and characteristics of this audience, always seeking to improve the benefits provided by digital games in the elderly.

4.3 GAPS AND DEFICIENCIES IDENTIFIED

In this subsection, the gaps and deficiencies found in the studies analyzed will be addressed, in relation to the production of digital games for the market, aimed at the public of the third age. Issues related to accessibility, usability and personalization of games for the elderly will be discussed. Aspects such as the lack of diversity in game options, technological limitations and difficulties in adapting to the individual needs of elderly users will also be highlighted.

One of the gaps identified is the issue of accessibility of digital games for seniors. Not all games available on the market are developed taking into account the needs and limitations of the elderly, such as vision, hearing or mobility problems. The lack of accessibility features can make it difficult for seniors to access and experience games.

In addition, the usability of digital games for seniors is also an area that requires attention. The game interface, commands, and controls are often not intuitive and can be challenging for seniors, who may struggle to cope with technology or have less familiarity with electronic devices.

The lack of care with the specifics of the niche, to meet the individual needs of the elderly is another gap identified. Each senior has different cognitive abilities and preferences, and games often do not offer customization options that allow them to tailor the level of difficulty, pace of play, or specific challenges to individual abilities, as discussed and presented in the previous sections.

Another gap highlighted is the lack of diversity in the gaming options available to seniors. Often, the games are aimed at a younger audience, with themes and plots that do not arouse the interest of the elderly. The lack of variety of games aimed at this audience limits the entertainment and learning options available to seniors.

The analysis of the gaps and deficiencies identified in the studies analyzed in relation to the production of digital games for the market aimed at the elderly public reinforces the need to explore research and develop more appropriate and inclusive solutions. The results highlighted the lack of accessibility, usability, and customization in existing games, as well as the lack of diversity in the options available. These limitations directly affect the experience of the elderly with the games and restrict the benefits that could be achieved. Given this scenario, it is essential to propose innovative solutions that fill these gaps, aiming to provide a satisfactory and beneficial experience for the elderly public. In this context, in the next section, a proof-of-concept proposal for a gaming device for the elderly based on the Arduino platform will be presented, with the aim of exploring opportunities for improvement and offer a more suitable alternative to the elderly in terms of accessibility, usability and customization of the games.

5 STUDY PROPOSAL

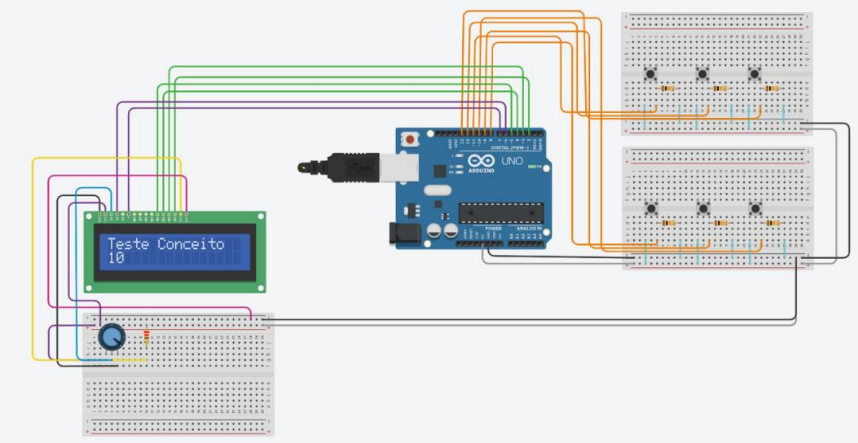
In this section will be presented some points regarding the target proposal of this article, which is to propose a portable device with digital games embedded in an Arduino board. The following topics will be highlighted and discussed: what the device is about, which games will be present and what are the justifications for choosing them, what were the prototypes initially carried out until conceiving a final model of the product, and finally the description of how the interaction of the person with the platform occurs.

5.1 DEVICE DESIGN

For this project was chosen as a resource for the development of such the arduino board because among several reasons of advantages the most notable was the fact that it has an economic cost that compares to other electronic development solutions as well as its portability and ease of acquiring both the board in se and its referred components. After choosing the board, the developers sought to research and analyze what resources would be used to develop such a project.

Based on this, pilot design proposals, both virtual and physical, were developed to explore and improve the proposed model. Among the design proposals, the third virtual proposal stands out, which proved to be the most promising and served as the basis for the evolution and progress of the project. Figure 1 illustrates a representation of this proposal, while Figure 3 outlines its main structural characteristics.

Figure 1. Third virtual circuit developed



For the development of the circuit presented in Figure 1, and also in a correlated way what is presented in Figure 2, the online platform Tinkercad was used, as presented by Bandeira et al. (2019), it is a *website* that allows to create and simulate electronic circuits in a virtual way. With this tool, developers were able to explore and test different configurations and electronic components prior to physical implementation.

The circuit in Figure 1 has 6 buttons of the *Push Button type*, which are used as interaction features with the platform. These buttons allow the user to perform different actions and commands while using the device. In addition, the circuit includes a display that enables the display of more primitive graphic and textual resources, providing visual information to the user. The entire circuit is integrated into an Arduino board, which stands out for the blue color in the figure and is responsible for the control and processing of the data, it also has a series of wire connections, which allow communication between the components of the circuit and the board itself.

Using Tinkercad as a virtual development platform allowed developers to test and validate the circuit before its physical implementation, providing a more efficient and cost-effective approach. Based on the results obtained in Tinkercad, the circuit was refined and adjusted to meet the needs of the project.

Figure 2. Listing of the Components Present in the Virtual Circuit in Figure 1

Nome	Quantidade	Componente
S5 S6 S7 S8 S9 S10	6	Botão
R5 R6 R7 R11 R13 R15	6	10 kΩ Resistor
UARD_02	1	Arduino Uno R3
U3	1	LCD 16 x 2
Rpot2	1	250 kΩ Potenciômetro
R1	1	220 Ω Resistor

For the elaboration of this design proposal, specific components were considered and used, as described in the list presented in Figure 2. This selection of components was carried out with the objective of creating a solid basis for the future realization of the proposed model. Before arriving at the final product model, testing steps were carried out to enhance and refine the final concept of the device.

This virtual design phase, using Tinkercad, was instrumental in ensuring that the circuit met the expected requirements and functionalities, before moving on to the physical implementation stage of the device.

Figure 3. Schematization of the Third Virtual Circuit Concept

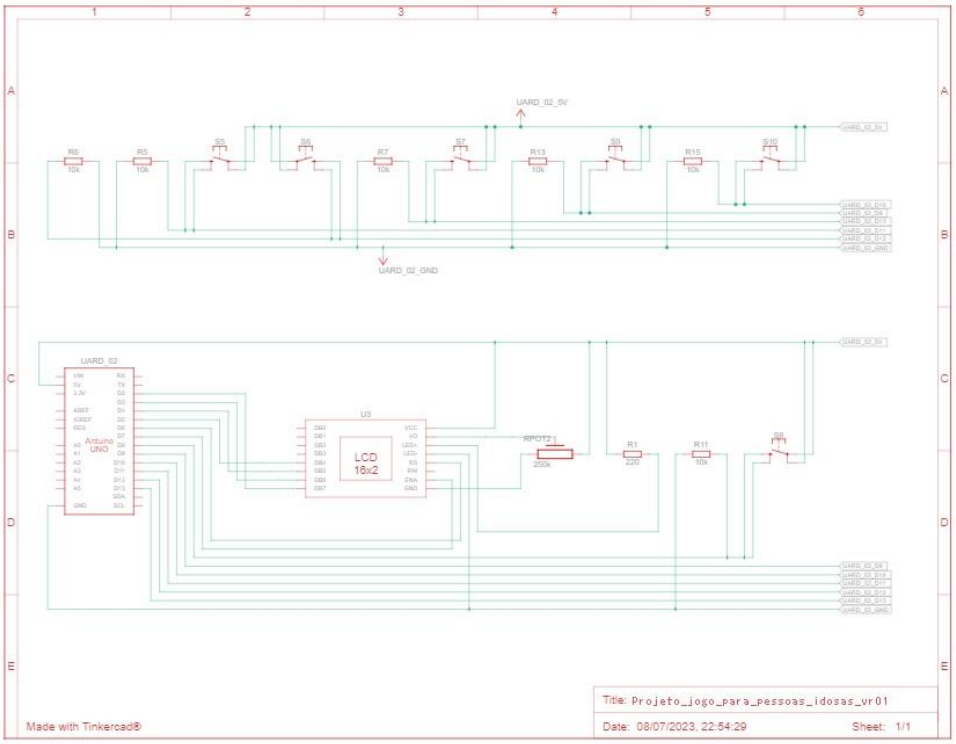
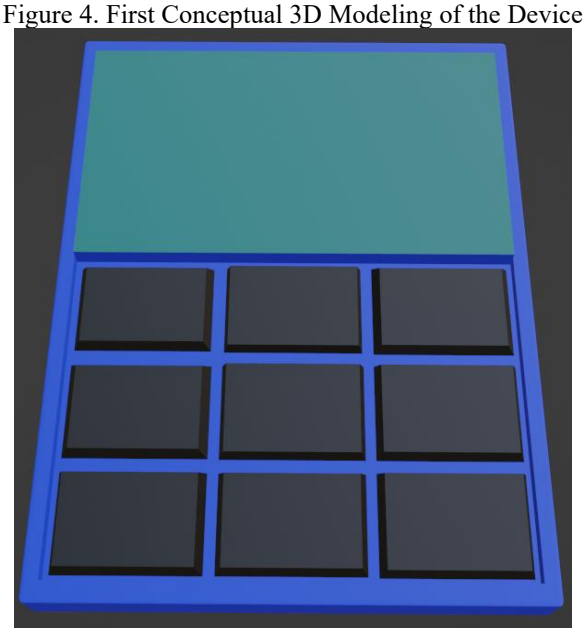


Figure 4. First Conceptual 3D Modeling of the Device



The model shown in Figure 4 shows a device with ergonomic format, designed to facilitate the interaction of elderly users. It has nine buttons arranged strategically, which would be used for interaction with the embedded games. These buttons were positioned taking into account aspects of accessibility and ease of use, seeking to meet the needs and abilities of the elderly.

In addition to the buttons, the device has a display where the information of the games and other interactions would be displayed in a clear and readable way. This display would be used to present instructions, scores, *feedback,* and other relevant information while using the device.

The conceptual 3D modeling of the device serves as an initial visual representation of the project, assisting developers in visualizing and refining the proposed features and functionalities. This modeling provided a visual reference for the development of the final concept of the device (which will be presented in later sections), allowing improvements and adjustments to be made throughout the design process.

5.2 NEXT STEPS AFTER INITIAL CONCEPTIONS

After the elaboration of the first virtual circuit and the realization of the first initial concepts, as mentioned earlier, the need to carry out some reformulations in the project was identified. One of these improvements consisted in the use of OLED display screens with inches greater than 3.5. These screens offer not only a larger size, but also provide much higher image quality, brightness, and colors compared to LCD-type displays. This update is especially relevant to meet the needs of people with vision limitations.

Another adaptation identified was the need to develop a custom "keyboard", since the existing keyboards on the market for Arduino did not meet the expectations of the developers. For this purpose, we opted for the use of Push Buttons, which are compact buttons, but which can be covered by a

special cover to increase their size. This approach has allowed developers to better customize and fit the project, resulting in significant improvements to the final model that will be presented in the following sections.

5.3 THE PROPOSED GAMES

In this subsection, the digital games proposed to stimulate the cognitive development of elderly users will be addressed. Each game will be described in detail, highlighting the main objectives, game mechanics and stimulated cognitive areas. The justifications for the choice of these games will be presented, considering their adequacy to the needs and abilities of the elderly, as well as the cognitive benefits expected from their use.

5.3.1 Overview of the games

The games embedded in the device were selected based on research on the games that are already used with the elderly, seeking to identify those that have the potential to stimulate cognitive development. Based on this research, different categories of games were created, each containing a variety of games related to the respective category. They have been designed in a way that addresses different cognitive skills such as memory, attention, logical reasoning and problem solving. Each category of games aims to exercise and strengthen these specific skills, providing challenges appropriate to the elderly audience.

For example, in the category of memory games, games are offered that require memorization of sequences, patterns, or specific information. These games stimulate short-term memory and the ability to concentrate.

In the category of logical reasoning games, challenges are presented that require the use of logical thinking and problem solving. Players are challenged to find patterns, make associations, and make decisions based on information provided by the game.

In addition, the games are designed taking into account the physical and perceptual limitations of the elderly. This includes adapting the game's interface, with clear visual elements, contrasting colors, and readable fonts, as well as the use of simplified, intuitive controls such as large, easy-to-trigger buttons.

The goal of these device-embedded games is to provide an enjoyable and challenging entertainment experience while promoting the cognitive development of aging users. Through these playful and stimulating activities, it is expected to improve memory, attention, logical reasoning and other cognitive skills important for the performance of daily activities and the quality of life of the elderly.

This approach of diversified games adapted to the needs and abilities of the elderly seeks to fill gaps identified in the existing solutions in the market, offering a more personalized and effective alternative to stimulate cognitive development in old age.

The sense of reward for satisfaction when performing a task can be nurtured when the elderly person can successfully complete a phase of the game, motivating him to continue playing, but to have a challenge and not end up generating monotonous perceptions regarding the experience of use, there are existing penalties such as restarting the progress of the game, or the loss of the current stage that the player is in.

5.3.2 Memorization games

Among the categories contained in the device, the player finds the category of memory game, in it the user can choose between some games whose focus are on exercising and stimulating memory, among the memory games contained in this category the player can play the game "Memorize the colors". In this game, the goal is to memorize the sequence of colors that appear on the screen, and replicas using the keyboard commands by pressing the keys corresponding to the colors in the order of the sequence to try to get it right.

5.3.3 Filling/Complementing games

In this category the user will have thematic games aimed at the proposal to complete and fill words or excerpts of things that are missing, such as filling words that are with some complete letters and others missing. With this, the user in addition to exercising the memory, he can still train the motor coordination, because he will have to type some letters, as well as also learn new words and even shapes and patterns.

5.3.4 Guessing games

Already in this category the player is faced with games aimed at divination, both in forms and patterns and even words. Here the player will have semi complete elements and will have the alternatives on what that is. Among the games contained in this category we have the guessing words, where you will already have the words without complete and some alternatives then the player will choose the right alternative on that word, thus exercising the user's cognition in addition to training and exercising memory and deduction capacity of the user, in addition to allowing him to learn new things in a playful way

5.3.5 Quiz games

In this category the player finds games with questions and answers of multiple choices, in it the player finds games with more playful questions and others with questions aimed at their safety and well-being, such as the game with questions regarding security measures. In it the player will have questions regarding the measures that should be taken about some situations experienced in the daily life of people with more advanced age, so he will choose the right answer regarding the measure that should be taken in the respective situation. In this way the player will learn by playing what should be done if he goes through such a situation.

5.4 THE FINAL PRODUCT

In this last subsection, the final design of the device with games integrated into an Arduino board will be described. You will be presented with the details of the device, including its appearance, functionalities and final components. The person's interaction with the platform will be discussed, describing how the device provides an engaging and stimulating experience for elderly users. The characteristics that differentiate and highlight the proposal in relation to existing solutions will be highlighted, evidencing the advantages and benefits offered by the device integrated with Arduino.

5.4.1 Human computer interface

As explained by Tavares et al. (2012), the advancement of technology has provided facilities in communication and interaction between people in different contexts. However, it is important to consider the diversity of users, especially when it comes to the interaction between seniors and technological devices. Many human-computer interfaces are designed based on users the author calls "typical" and young, which can make interaction difficult for older audiences.

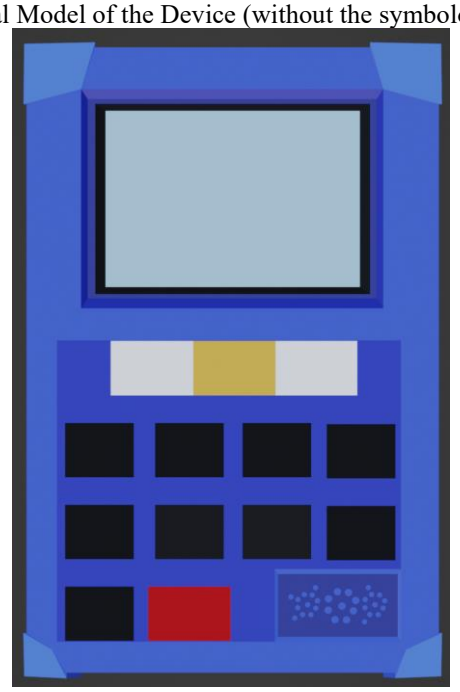
The lack of regulations to be followed for accessibility, and the lack of sensitivity to the specificities of this group may result in obstacles in the use of the devices, as previously mentioned. Making the environment accessible is critical to ensuring that seniors can access, and use, products and services easily and efficiently. In accordance with the ideas presented in the work of Santos (2022), it is admitted that it is necessary to develop interfaces that consider the specific needs of the elderly, providing an intuitive interaction and adapted to their abilities.

Assistive technology, understood as a group of artifacts available to people with special needs, plays an important role in offering solutions and resources that facilitate the interaction between the elderly and devices, promoting digital inclusion and ensuring a positive experience for this audience, and provides them with a more independent life, as Santos (2022) points out.

5.4.2 The final concept obtained

Given this contextualization, the final conception of the device that will have embedded in its system the games proposed in the previous sections was carried out. The following were taken into consideration: usability, portability, emotional response of the colors used for the entire making of the model from the graphical interface to the physical structure (this involves buttons, device housing, among other details to be perceived), there was also the concern regarding the fonts used in the screens in which the user will have to interact.

Figure 5. Conceptual Model of the Device (without the symbologies of the buttons)



After considering the criteria raised in topic 5.4.1, and from the initial conceptions of the device, presented in the previous sections, it was possible to arrive at the conceptual model represented by Figure 5. In it, a conformation is observed that contains:

- A blue carcass, which will possibly be made of plastic material, once it is physically developed (in order to reduce costs to become affordable in the financial aspect), but because it is a conceptual proof, no conclusive statement is made in this sense, because there will be research and validation to be carried out.
- A central screen where all the information regarding the games present on the device will be displayed. It is observed the presence of a black outline around the region of the viewfinder, to give prominence to the shape of it.
- Three top buttons being one yellow color and two side white, these buttons will be used for user navigation with the interface, in general.
- Nine buttons in black color, in which they will be used for the interaction of gameplay of the user, according to the occasion of the game in question.

- A button in red that will serve to turn the device on and off.
- A demarcated area in the lower right corner with small holes, referring to the sound output of the device. This output allows the device to emit sounds or *sound feedbacks during its use.*

Figure 6. Device Start Menus Interface

After having conceived an initial design of the form, and composition of the elements of the device, we set out to implement iconographic elements, which make up the interface to be manipulated by the target audience. Thus, the structure represented by Figure 6 was obtained.

5.4.2.1 Symbology of Physical Interface Elements

As cited by Costa et al. (2015), it is necessary to have concerns about the experience that players will have when interacting with the game produced, as they directly influence the understanding of the work. Something important to be observed, in Figure 6, is the choice to use alphanumeric characters in the black buttons, combining different options in a single button, based on what Falavigna (2015) points out, which takes into account the user experience, and aspects of the experience of the individual who will interact with the device.

By referring to the keys of old cell phones, prior to modern *smartphones*, this conformation brings a sense of familiarity to the elderly, as Falavigna (2015) addresses in relation to the user's experience, facilitating their experience of use. These characters have the function of representing the different options, or actions, available to the user. This approach allows users to identify and associate the available options with alphanumeric characters more intuitively.

Frontini (2023), brings in its publication a series of recommendations and expositions about the user experience, and construction of interfaces, among them stands out the importance of colors as

informational messengers, through the feelings generated by them. Colors such as blue can give the feeling of calm and tranquility, white can be neutral, and black can be used to contrast or give seriousness to the element depending on how the arrangement of the environment is, while the color red indicates the feeling of alertness, urgency, importance. Also evidenced by Frontini (2023), the order of information through the selection of colors can directly impact the experience of use, in line with what Falavigna (2015) brings in his study.

On the white buttons, the symbols "<" and ">" are observed, which are widely used to represent left and right navigation movements, or rewind and forward, respectively. These symbols are intuitive and recognizable, making it easy for the user to understand how to move around within the device interface.

In the center of the devices, represented in Figure 6, is the "OK" button. This symbology is commonly used to indicate confirmation or selection of an option. Its presence on the device seeks to provide a clear and easy interaction for the elderly user, allowing him to perform confirmation or acceptance actions.

It is also presented, highlighted by the red color, the button responsible for turning the device on and off. The symbology adopted to represent the power button is one of the important features of the device interface. An icon of a hollow circle with a vertical stroke in the middle is widely recognized as an on/off symbol. The adoption of this symbolic representation seeks to facilitate the use of the device, allowing the user to easily identify the power control button.

The spacing between the buttons is designed to prevent accidental touches and provide a comfortable tactile experience. In addition, the colors chosen, such as black for the interaction buttons and white for the navigation buttons, were selected to provide contrast and readability, making it easier for the elderly public to identify the functions.

5.4.2.2 Arrangement of Digital Interface Elements

Concepts such as the hierarchy of information, served as guidance to define how to convey the main message of each screen, clearly, configure the order of importance of the elements, either by size, color or positioning, to guide the understanding of the target audience, as well as elucidates Frontini (2023). This hierarchy of information allows the creation of an environment of clarity, assertiveness and impact on communication with the end user. In this sense, it is possible to observe the presence of these techniques applied in the screens shown in Figure 6 and Figure 7, whose emphasis is given to the game screens.

Figure 7. Interfaces in two game scenarios

As for the visual interface presented in Figure 6, ditto for Figure 7, a careful selection of the text font was made. The Trebuchet font was chosen based on studies presented by Farias et al. (2019) that identified its high readability, especially for the elderly public. It was also evidenced by Farias et al. (2019) that the use of bold gives greater prominence to the information displayed, drawing the user's attention to the important elements. These visual choices were made with the aim of ensuring a more accessible and satisfying user experience for the elderly audience.

6 DISCUSSIONS

When analyzing the results of the literature review, it is evident that the application of digital games in the elderly tends to bring significant impacts and benefits to the cognitive health of the elderly. The literature reviewed points to the relevance of these interventions as cognitive stimulation tools, capable of promoting the development and maintenance of mental skills, such as memory, attention, logical reasoning and problem solving.

The proposal of the embedded device with games based on the Arduino platform is a conceptual model that aims to address the gaps and deficiencies identified in the existing solutions in the market. Through the personalization of the games and the adaptation to the skills and needs of the elderly, we seek to create a more appropriate and stimulating gaming experience for this specific population.

The possible impacts and benefits of the proposed device are diverse. First, it is expected that the games embedded in the device promote cognitive health, contributing to the maintenance and improvement of the mental abilities of the elderly. This can result in greater autonomy and quality of life, allowing the elderly to remain active in intellectually stimulating activities, and to experience their daily lives as normally as possible.

In addition, the proposed device has the potential to promote the digital inclusion of older people by providing them with access to technology in an accessible way adapted to their needs. The Arduino integration allows for the creation of simplified interfaces and controls, ensuring that the device is intuitive and easy to use, even for those with physical or perceptual limitations.

However, it is important to consider some possible limitations or challenges in the implementation and acceptance of the proposed model. One of the challenges may be the resistance or reluctance of the elderly to adopt and use digital technologies. It is necessary to ensure a user-friendly interface, with clear instructions and adequate support, in order to facilitate the familiarization and engagement of the elderly with the device, as was discussed in the study done by Tavares et al. (2012).

Another possible limitation is related to the accessibility of the device in terms of cost and availability. It is essential to seek alternatives that make the device accessible and viable for a greater number of elderly people, considering the different socioeconomic realities and access to technology. In this initial stage of the conceptual elaboration of the device, there were concerns as issues of interaction of the human being with the interface, the use of colors, product design, but it is necessary to keep in mind that there will be costs when the construction of a physical, real product is carried out, and this should be addressed in future projects, not in this one in question, Because as mentioned in previous sections this article does not propose to solve any problems, however based on the systematic review carried out it is possible to present a proof of concept that tends to remedy gaps left by existing market solutions.

In addition, it is important to highlight that the proposal of the device and its effectiveness need to be evaluated through field research and validations with the target audience, that is, with people between 60 and 75 years old. These surveys should consider indicators of cognitive performance, user satisfaction, and impacts on quality of life in order to provide a solid foundation for continued device development and enhancement.

In short, the conceptual proposal of the device embedded with games based on the Arduino platform presents potential benefits for the cognitive health of the elderly. However, it is necessary to face challenges related to the acceptance, accessibility and validation of the model presented. From these discussions, it is possible to direct future research and development in the field of digital games aimed at the elderly, contributing to the promotion of healthy and active aging.

7 FINAL CONSIDERATIONS AND FUTURE WORK

Throughout this article, several aspects related to the application of digital games as cognitive stimulation tools for the elderly were addressed. The importance of cognitive health in the quality of life of the elderly and the growing relevance of digital games as a promising approach to promote cognitive development in this population were highlighted.

The proposal of the conceptual study presented in this work seeks to fill gaps and overcome challenges identified in the existing solutions of digital games aimed at the elderly. The device integrated with an Arduino board, containing a set of specially designed digital games, aims to stimulate cognitive development in a personalized and accessible way for the elderly. The relevance of this proposal lies in the search for technological alternatives that meet the specific needs of the elderly, promoting cognitive health and contributing to the improvement of the quality of life of this population. In addition, the creation of this device will make it possible to conduct field research with the target audience, providing a more in-depth validation of the cognitive stimulation strategies adopted.

As future works, it is intended to advance in the development and manufacture of the proposed device, performing tests and validations with elderly in the age group of 60 to 75 years. This field research will be instrumental in evaluating the device's effectiveness, collecting user feedback, and enhancing cognitive stimulation strategies. In addition, it is important to continue scientific research in this field, exploring new approaches, evaluating other aspects of cognitive health, and improving technological solutions aimed at the elderly.

In short, this conceptual study represents an initial step in the search for innovative solutions that promote the cognitive health of the elderly through digital games. With the making of the device and conducting field research, it is expected to contribute effectively to the improvement of the quality of life and well-being of this population. The continuous improvement of technology and the deepening of research in this area are fundamental to promote digital inclusion and offer increasingly effective interventions for cognitive stimulation in the elderly.

REFERENCES

Banco Nacional de Desenvolvimento Econômico e Social (BNDES). (2017). “Envelhecimento e transição demográfica | Marca-texto”. Disponível em: https://www.bndes.gov.br/wps/portal/site/home/conhecimento/noticias/noticia/envelhecimento-transicao demografica#:~:text=O%20envelhecimento%20populacional%20pode%20ser,era%20de%2046%2C8%20anos. Acesso em 04 de Abril de 2023.

Bandeira, L. M. S. A., et al. (2019). "Instrumento de Avaliação do Software Educacional TinkerCad: uma visão fundamentada na BNCC”. In: Anais do XXV Workshop de Informática na Escola. SBC, p. 1324-1328.

Bonfim, C., Santana Pereira, J. V., Cerqueira, L. de C., & Luciano, M. de F. D. (2019). “Usabilidade de jogos digitais para idosos: dados preliminares de um estudo quase experimental com idosos de uma Universidade Aberta da Terceira Idade”. In XVIII Simpósio Brasileiros de Jogos e Entretenimento Digital (pp. 316-322).

BRASIL. (2003). “Lei nº 10.741, de 1º de outubro de 2003”. Dispõe sobre o Estatuto da Pessoa Idosa e dá outras providências. Diário Oficial da União, Brasília, DF. Disponível em: https://www.planalto.gov.br/ccivil_03/leis/2003/l10.741.htm. Acesso em 9 de Junho de 2023.

Caetano, L. A. O., Silva, F. S. da, & Silveira, C. A. B. (2017). “Alzheimer, sintomas e grupos: uma revisão integrativa”. Vínculo, 14(2), 84-93. Disponível em:http://pepsic.bvsalud.org/scielo.php?script=sci_arttext&pid=S1806-24902017000200010&lng=pt&nrm=iso. Acesso em: 23 de Abril de 2023.

Cardoso, N. de O., Landenberger, T., & Argimon, I. I. de L. (2017). “Jogos Eletrônicos como Instrumentos de Intervenção no Declínio Cognitivo - Uma Revisão Sistemática”. Rev. Psicol. IMED, 9(1), 119-139. Disponível em: http://pepsic.bvsalud.org/scielo.php?script=sci_arttext&pid=S2175-50272017000100009. Acesso em 05 de Maio de 2023.

Carreiro, M. V. H. da S., Teruya, V. T., Faria, M. H. V., Kasperavicius, V. B., Carvalho, R. A. F., & Barboza Junior, A. T. (2018). "Remember – Uma proposta de jogo para cuidadores de portadores de Alzheimer." In XVII Simpósio Brasileiros de Jogos e Entretenimento Digital (pp. 1432-1435).

Clínica Jequitibá Saúde Mental. (2020). "Comprometimento Cognitivo em Idosos." Disponível em: https://saudementalatibaia.com.br/blog/%EF%BB%BFcomprometimento-cognitivo-em-idosos/. Acesso em 16 de Junho de 2023.

Chagas, N. S., Souto, G. M. S., & Caminha, I. D. O. (2022). “A construção social do envelhecimento através da participação no trabalho social com idosos do Sesc – CE”.Disponível em:http://sevenpublicacoes.com.br/index.php/ISJHR/article/view/1621/2266. Acesso em: 10 de Maio de 2023.

Chaimowicz, F., & Chaimowicz, B. F. (2022). “Por quais razões adoecem e morrem os idosos no Brasil?”. PISTA: Periódico Interdisciplinar [Sociedade Tecnologia Ambiente], Puc Minas, ISSN 2674-6727. Disponível em: http://periodicos.pucminas.br/index.php/pista/article/view/29831. Acesso em: 11 de Maio de 2023.

Costa, A. F. & Nakamura, R. (2015). Experiência de usuário e experiência de jogador: discussão sobre os conceitos e sua avaliação no projeto de jogos digitais. In Anais do XIV Simpósio Brasileiro de Jogos e Entretenimento Digital (pp. 512-517).

Darin, T., 2020. “Jogos sérios: desenvolver habilidades cognitivas pode ser divertido!”. SBC Horizontes. ISSN: 2175-9235. Disponível em: http://horizontes.sbc.org.br/index.php/2020/05/08/o-papel-essencial-da-universidade-publica-no-combate-ao-covid-19. Acesso em: 05 de Junho de 2023.

Domingos, G. B., Miura, B., Pas, Á., Carthery-Goulart, M. T., & Brandão, A. L. (2018). “Desenvolvimento de um Protótipo de Jogo com Design Participativo para Treino Cognitivo de Pessoas Idosas”. In Anais do XVII Simpósio Brasileiro de Jogos e Entretenimento Digital (pp. 97-106).

Falavigna, V. D. (2015). “Experiência do usuário: análise e aplicação de métodos de avaliação”. Disponível em: https://repositorio.ucs.br/handle/11338/1340. Acesso em: 21 de Maio de 2023.

Farias, B. S., & Landim, P. da C. (2020). “Tipografia Inclusiva para Terceira Idade | Inclusive Typography for Seniors”. InfoDesign - Revista Brasileira De Design Da Informação, 17(2), 99–116. https://doi.org/10.51358/id.v17i2.817

Ferreira, P. S., Tolentino, J. A. G., & Faustino, A. M. (2022). “Avaliação da acessibilidade de jogos digitais voltados para idosos / Assessment of the accessibility of digital games aimed at the elderly”. Brazilian Journal of Development, 8(7), 50567–50579. https://doi.org/10.34117/bjdv8n7-124.

Funcionalitá. (2021). "Avaliação neuropsicológica no declínio cognitivo de idosos." Disponível em: https://www.funcionalita.com.br/avaliacao-neuropsicologica-no-declinio-cognitivo-de-idosos. Acesso em 23 de Junho de 2023.

Frontini, N. H. (2023). Hierarquia da informação: a chave para uma comunicação assertiva. Disponível em: https://insights.allidem.com/hierarquia-da-informacao-comunicacao-assertiva. Acesso em: 17 de Junho de 2023.

Fonseca, G., & Ishitani, L. (2019). “Jogos educacionais para idosos: uma revisão sistemática da literatura”. In XVIII Simpósio Brasileiros de Jogos e Entretenimento Digital (pp. 1180-1183).

McRoberts, M. (2018). Arduino básico. Novatec Editora. Miranda, G. M. D., Mendes, A. C. G., & Silva, A. L. A. (2016). “O envelhecimento populacional brasileiro: desafios e consequências sociais atuais e futuras”. Disponível em: https://www.scielo.br/j/rbgg/a/MT7nmJPPRt9W8vndq8dpzDP/?lang=en#. Acesso em: 12 de Maio de 2023.

Moreno, I. & Reyes, J. A. (2021). “Ocho claves para distinguir el envejecimiento normal del alzhéimer”. Disponível em: https://theconversation.com/ocho-claves-para-distinguir-el-envejecimiento-normal-del-alzheimer-168128. Acesso em: 23 de Abril de 2023.

Ministério da Saúde. (2022). “Boletim Temático da Biblioteca do Ministério da Saúde”. Disponível em: https://bvsms.saude.gov.br/bvs/boletim_tematico/saude_idoso_outubro_2022-1.pdf. Acesso em: 09 de Maio de 2023.

Ministério da Saúde. (2021). “Conhecer a demência, conhecer o Alzheimer: o poder do conhecimento – Setembro, Mês Mundial do Alzheimer”. Disponível em:https://bvsms.saude.gov.br/bvs/boletim_tematico/saude_idoso_outubro_2022-1.pdf. Acesso em: 16 de Maio de 2023.

Ministério da Saúde. (2023). "Saúde da pessoa idosa." Disponível em: https://www.gov.br/saude/pt-br/assuntos/saude-de-a-a-z/s/saude-da-pessoa-idosa. Acesso em: 10 de Maio de 2023.

Organização Mundial da Saúde (OMS). (2022). “Ageing and health”. Disponível em: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. Acesso em 08 de Maio de 2023.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). “The PRISMA 2020 statement: an updated guideline for reporting systematic reviews”. BMJ, 372, n71. doi: 10.1136/bmj.n71.

Pereira, T. (2019). “A função cognitiva no envelhecimento. Instituto Politécnico de Coimbra IPC | Inovar Para Crescer”. Disponível em: http://hdl.handle.net/10400.26/32920. Acesso em: 17 de Maio de 2023.

Santos, L. C. M. (2022). “O mundo não acessível dos jogos digitais: É necessário falar sobre isso!”. Atena Editora, p. 76-88. Disponível em:https://www.atenaeditora.com.br/catalogo/post/o-mundo-nao-acessivel-dos-jogos-digitais-e-necessario-falar-sobre-isso. Acesso em: 20 de Maio de 2023

Santos, F. de S., Salgado, A. de L., & Fortes, R. P. de M. (2018). “Um Mapeamento Sistemático sobre Acessibilidade e Usabilidade no Desenvolvimento de Jogos Digitais para Idosos”. ISys - Brazilian Journal of Information Systems, 11(2), 63-90. Disponível em: http://seer.unirio.br/isys/article/view/6957. Acesso em: 12 de Abril de 2023.

Santos, L. G. N. de O.; Ishitani, L.; Nobre, C. N. (2013). “Uso de jogos casuais em celulares por idosos: um estudo de usabilidade”. Revista de Informática Aplicada, v. 9, p. 24–44.

Tavares, M. M. K., & Correa de Souza, S. T. (2012). “Os idosos e as barreiras de acesso às novas tecnologias da informação e comunicação”. Revista Novas Tecnologias na Educação, 10(1). doi: 10.22456/1679-1916.30915. Disponível em: https://seer.ufrgs.br/index.php/renote/article/view/30915. Acesso em: 22 de Maio de 2023.