TEKA teaching: contributing to increasing the vocabulary of autistic children

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Ensino TEKA: contibuindo para o aumento do vocabulário de crianças autista

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TEKA teaching: contribuyendo a aumentar el vocabulario de los niños autistas

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Resumo: Este artigo apresenta o game intitulado "ENSINO TEKA" como estratégia para expansão do repertório de linguagem das crianças com Transtorno do Espectro Autista (TEA) no contexto formal e não formal de aprendizagem, associadas as funções executivas relacionadas à percepção de estímulos visuais e auditivos. A metodologia adotada foi a Applied Behavior Analysis (ABA) baseada cientificamente nos princípios fundamentais da promoção de atitudes desejadas por meio de reforços positivos, seguindo as especificações do Guia de Acessibilidade de Interfaces para Autismo (GAIA). Sua aplicação foi realizada pelos os professores do Atendimento Educacional Especializado (AEE) da Unidade Integrada Monteiro Lobato, localizada no município de Paço do Lumiar - MA, tendo como público-alvo as crianças do primeiro ciclo de alfabetização, demonstrando a eficácia do aplicativo para o enriquecimento do vocabulário das crianças com TEA e a necessidade da intervenção pedagógica como forma de atender suas especificidades, corroborando com Meyer et al. (2006) os quais afirmam a importância da individualização dos programas de intervenção, levando em conta as habilidades e limitações específicas de cada indivíduo com o referido transtorno. A pesquisa explicitou que o grau do transtorno das crianças com TEA influencia na proficiência das habilidades exigidas pelo aplicativo, entretanto, com o acompanhamento adequado é possível melhorar a capacidade de reconhecimento e associação de imagens e sons, tais evidências demonstram a necessidade de pesquisas futuros contendo maiores variedades de blocos de palavras e recompensas de estímulos visuais e sonoros objetivando a melhoria da usabilidade do game.

Palavras-chave: *Autismo. Estímulos visuais. Estímulos sonoros. TEA. Transtorno.*

Abstract*: This article presents the game entitled "TEKA TEACHING" as a strategy for expanding the language repertoire of children with Autistic Spectrum Disorder (ASD) in the formal and non-formal learning context, associated with executive*

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functions related to the perception of visual and auditory stimuli. The methodology adopted was the Applied Behavior Analysis (ABA) scientifically based on the fundamental principles of promoting desired attitudes through positive reinforcement, following the specifications of the Interface Accessibility Guide for Autism (GAIA). Its application was carried out by the teachers of the Specialized Educational Service (AEE) of the Monteiro Lobato Integrated Unit, located in the municipality of Paço do Lumiar - MA, having as target audience the children of the first literacy cycle, demonstrating the effectiveness of the application for the vocabulary enrichment of children with ASD and the need for pedagogical intervention as a way to meet their specificities, corroborating Meyer et al. (2006) who affirm the importance of individualizing intervention programs, taking into account the specific abilities and limitations of each individual with the referred disorder. The research explained that the degree of the disorder of children with ASD influences the proficiency of the skills required by the application, however, with proper monitoring it is possible to improve the ability to recognize and associate images and sounds, such evidence demonstrates the need for future research containing greater varieties of word blocks and rewards of visual and sound stimuli aiming at improving the usability of the game.

Keywords*: Autism. Disorder. Sound stimuli. TEA. Visual stimuli.*

Resumen: *Este artículo presenta el juego titulado "TEKA TEACHING" como estrategia para ampliar el repertorio lingüístico de niños con Trastorno del Espectro Autista (TEA) en el contexto de aprendizaje formal y no formal, asociado a funciones ejecutivas relacionadas con la percepción de estímulos visuales y auditivos. . La metodología adoptada fue el Análisis de Comportamiento Aplicado (ABA) basado científicamente en los principios fundamentales de promover las actitudes deseadas a través del refuerzo positivo, siguiendo las especificaciones de la Guía de Accesibilidad de Interfaz para el Autismo (GAIA). Su aplicación fue realizada por los docentes de la Asistencia Educativa Especializada (AEE) de la Unidad Integrada Monteiro Lobato, ubicada en el municipio de Paço do Lumiar - MA, teniendo como público objetivo a los niños del primer ciclo de alfabetización, demostrando la efectividad de la la aplicación para el enriquecimiento de vocabulario de niños con TEA y la necesidad de intervención pedagógica como forma de atender sus especificidades, corroborando Meyer et al. (2006) quienes afirman la importancia de individualizar los programas de intervención, teniendo en cuenta las capacidades y limitaciones específicas de cada individuo con el referido trastorno. La investigación explicó que el grado del trastorno de los niños con TEA influye en el dominio de las habilidades requeridas por la aplicación, sin embargo, con un seguimiento adecuado es posible mejorar la capacidad de reconocer y asociar imágenes y sonidos, tal evidencia demuestra la necesidad de investigaciones futuras que contengan mayores variedades de bloques de palabras y recompensas de estímulos visuales y sonoros con el objetivo de mejorar la usabilidad del juego.*

Palabras clave: *Autismo. Estímulos sonorous. Estímulos visuals. TEA. Trastorno.*

1 INTRODUÇÃO

Autistic Spectrum Disorder (ASD) encompasses a series of complex brain development disorders, which manifest before, during or shortly after birth. And it is characterized by difficulty in social communication, associated with repetitive behaviors and restricted interests (BRENTANI et al., 2013).

The APA (American Psychiatric Association) lists in its diagnostic and statistical manual a series of criteria, characteristics, specifiers, intensities and levels of severity for the identification of the autistic spectrum and defines the disorder as a group of diseases characterized by deficiencies in the reciprocal interaction social, communication, repetitive and stereotyped patterns of behavior, interests and activities. Its manifestation frequency for every 10,000 people is around 2 to 5 individuals within the world population (APA., 2014).

Figure 1- ASD prevalence graph in countries around the world

Prevalence of autistic spectrum disorder, 2019
Share of the total population with autistic spectrum disorder, which is inclusive of autism and Asperger Syndrome.
This prevalence is age-standardized to compare between countries and with time.

No data 0% 0.2% 0.4% 0.6% 0.8% 1% 1.2%
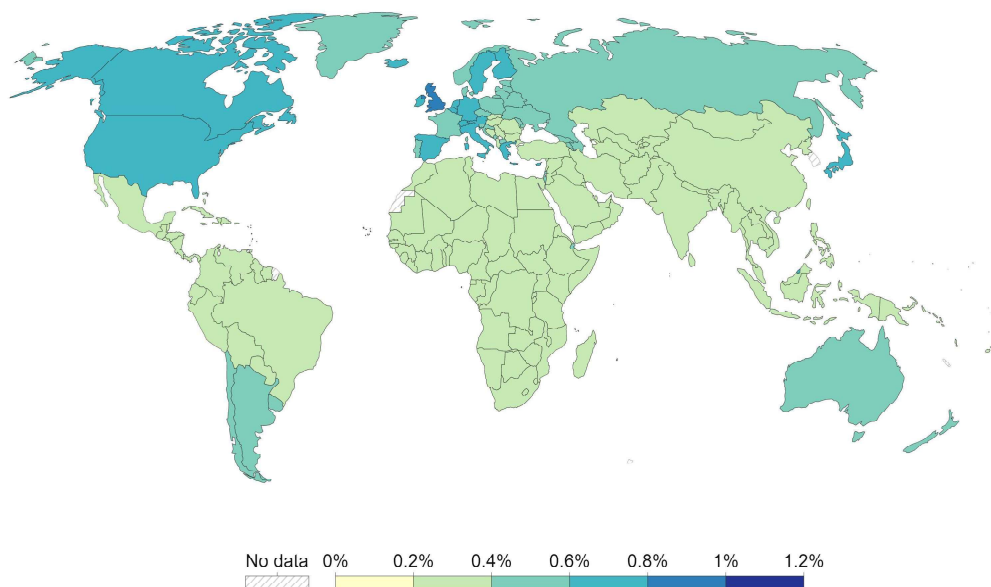
The Figure 1 presents a graph of the prevalence of ASD in different countries around the world. It is important to note that the data may be affected by each country's ability to identify people with ASD, which may lead to differences in reported frequency. However, the figure provides an overview of the global distribution of ASD and may be helpful in understanding the recurrence of the disorder worldwide.

In the Brazilian population, the disorder affects about 1% of the Brazilian population, that is, for every 10,000 births, this syndrome affects 20 people, manifesting itself four times more in males than in females in the first years of life (ANDRADE; BRITO, 2022).

Although all people with ASD share these difficulties, they present themselves in different intensities, as these characteristics can be clear after birth, facilitating identification by the family nucleus; or they may be more subtle and become more noticeable during development. Thus, understanding these specificities becomes relevant for any planning and adequate intervention for these subjects (ANDRADE; BRITO, 2022).

According to the Diagnostic and Statistical Manual of Mental Disorders, 5th edition, persistent deficits in social communication and in restricted and repetitive patterns of behavior, interests or activities characteristic of ASD

cause significant impairments in visual processing and important social functioning for the acquisition of increasingly complex skills such as the process of reading and writing.

The inclusion of children with ASD in early childhood education is not merely due to access to school and insertion in the classroom, people affected by ASD have a unique perception in the learning process, in the way of expressing themselves and especially in the way of assimilating information. Considering Vygotsky's historical-cultural approach, language and child development are linked, because, from the moment the child develops physically, he also improves his language and, consequently, his thinking.

Since the beginning of the 21st century, education systems around the world have been challenged by this growing demand for an Inclusive Education model, during the 1990 World Conference on Education for All, organized by UNESCO, the declaration that would guide the global objective in the efforts for an education system more accessible to the entire population in its various levels of aptitude in learning (TODOS, 1990).

The guidelines for the formation of these inclusive educational systems were elaborated years later at the World Conference on Special Education (EE), held in Spain in 1994, through the Declaration of Salamanca, which received the name of its city of creation, establishing a set of parameters and reforms on the education model practiced at the time, in addition to reframing the concept of "special educational needs" which began to encompass not only children with disabilities, but also those who would be experiencing any type of difficulty in learning , whether temporary or permanent, for psychological, socioeconomic reasons or even those that for some reason are outside the educational system (BREITENBACH; HONNEF; COSTAS , 2016).

In the last decade in Brazil, EE has become a point of convergence for the Ministry of Education marked by the creation of the Special Education Secretariat (Law No. 8069/90), however it is observed that EE in Brazil is still very restrictive and little targeted, because despite

being present in all regions of Brazil, it is only publicly available in Undergraduate and Postgraduate courses in a few public Higher Education Institutes (HEIs) (BRANCO; ALMEIDA, 2019).

Among the efforts to achieve an inclusive education project, the use of pedagogical methodologies that make the learning activity more attractive and playful for special students stands out, carrying out activities often based on the Applied Behavior Analysis (ABA) method, which seeks to reward the reproduction of the desired behaviors, increasing the probability of their recurrence, this technique is easily schematized in the format of a practical game or play (BANDIM, 2011).

Among the various tools to help these pedagogical methodologies is Gamification, a Brazilianized translation of Gamification, a term created by researcher and programmer Nick Pelling in 2002, which refers to the use of game design elements in cases where their application is not a game, a method applied in the most diverse areas, from marketing to education, the emergence of this method accompanied the growth of the games industry in recent years.

"Gamification consists of using game elements, strategies and thoughts outside the context of a game, an example is the growing interest in its use in training, qualification and corporate training processes" (REZENDE; MESQUITA, 2017).

Gamification in Education is nothing new and is already adopted in the EE context with tangible results, according to Minuzzi, gamification is one of the ways to reach students today , when carrying out innovative practices (MINUZI et al., 2018).

There are several studies, metrics and recommendation guides that intend to define how the interactions of an application fruit of gamification should be as a user with ASD in order to respect the behavioral reactions of this group, among them is GAIA, a guide that was designed to help not only IT professionals, but therapists, educators to better understand how to develop visual interfaces that are more adequate to the needs of people with ASD, es-

pecially children, focusing on WEB-based applications (BRITTO; PIZZOLATO, 2018).

This research presents a case study that investigated the application of gamification techniques in kindergarten children with ASD through an application, with the objective of evaluating its effectiveness in expanding vocabulary and improving other executive functions related to the perception of visual and auditory stimuli.

2 METHODS

From the objective of creation, implementation and technological transfer of a computational tool, together with institutional management processes, the research begins with: a) bibliographic survey; b) search for research related to the topic; c) definition of the programming language to be used in the project; d) development of the protocol to be applied to the data studied; e) analysis and development of the application prototype that simulates the process patterns; f) adequacy of the system and evaluation of the results obtained, with the test of the coherence of the model.

The development of the game was based on the platforms: Unity, Visual Studio and Corel Draw 9. Unity is an IDE that makes it possible to directly create the game through creation and formatting tools in the structure of the application under development. Also, it is responsible for supporting layout management and interpreting code in C# language, so that it can be used as an additional resource in the creation of the same, being responsible for providing the development of applications for mobile devices, making it possible to control build versions for different operating systems.

4 THEORETICAL FOUNDATIONS

Individuals with ASD have clinical specificities, in general they have a convergence with deficits in executive functions, correlated with changes in the prefrontal cortex, among the skills that can be affected are attention, cognitive flexibility, working memory and planning (DE FREITAS et al. , 2016), these skills associated with language must be developed in early childhood education and are essential in the teaching-learning process as they accompany the individual throughout adult life.

Behaviors that negatively interfere with the schooling process may be related to difficulties in sensory processing. This relationship is discussed in the Theory of Sensory Integration developed by Ayres, which states that difficulties in sensory processing skills can compromise development and learning. Whether in the form of apathy or agitation, children who have some degree of neurodevelopmental disorder may have inappropriate neural activation that may be conditioned by sensory experience. This connection between the senses, the brain and behavior can directly affect a child's cognitive abilities. Therefore, it is important to identify and treat difficulties in sensory processing, so that we can provide the student with all the support and care necessary to achieve maximum success in schooling (MATTOS, 2019).

Antisocial behavior is common in people with ASD and it is important for healthcare professionals to understand its causes and characteristics in order to provide appropriate intervention. Understanding antisocial behavior can help identify the specific needs of each individual and guide interventions to improve their quality of life. In addition, collaboration with the family and the school is essential to obtain a more effective intervention (FERNANDES; AMATO, 2013).

> According to Fernandes, the learning of children with ASD is a process that involves the family and the school, and should not be restricted to the school environment. The participation of the family is essential, since it is in the family that the child spends most of his time. The author points out that it is important for the family to be engaged and involved in the learning process, following the activities developed by the school and always looking for new ways to stimulate the child's development at home (VARANDA; FERNANDES, 2011) .

With the diagnosis of Autistic Spectrum Disorder (ASD) increasingly present in schools,

it is important to bear in mind that meeting the specific needs of children affected by this condition is essential. It is necessary to develop skills and adaptations for conducting restricted and stereotyped behaviors, as well as engaging children in tasks for the development of essential skills for an autonomous and independent life. Thus, there is the importance of advancing in treatments and strategies for the well-being of individuals with ASD (FRANÇA et al., 2022).

The importance of taking into account the individual needs and difficulties of each child with autism in the early intervention process is highlighted by Cibelle Albuquerque de la Higuera Amato. For the author, it is crucial for the professional to carry out a comprehensive assessment of the child's abilities in different areas of development, such as language, cognition, social and motor skills, in order to identify their needs and draw up an adequate intervention plan (FERNANDES; AMATO, 2013).

Mundy and Sigman point out that understanding the differences in the communication of people with ASD is essential so that health professionals can adapt their therapeutic approaches and help in the development of adequate communication skills. In this sense, they emphasize the importance of individualizing intervention programs, taking into account the specific abilities and limitations of each individual with ASD (MEYER et al., 2006).

In the context of ASD, different theories of language and learning have been discussed, including behavioral, cognitive, and social theories. Behavioral theories emphasize the importance of the environment in learning, while cognitive theories consider cognition and perception as central factors in learning. Social theories, on the other hand, focus on social interactions and communication. Each theory has its own teaching-learning strategies and methods that can be applied in interventions for children with ASD.

5 DEVELOPMENT OF APPLICATION

Gamified digital game went through a series of technical choices that are raised in the requirements gathering stage, the main choices to be decided are: choice of publishing platform; the programming language; the Game Engine adopted, the Level Design and the mechanics.

5.1 APPLICATION PLATFORM

Android was the platform chosen by an operating system that meets accessibility criteria that facilitate application in the classroom. This platform is massively used in smartphones that enables easy distribution and portability of the software, the application of the project in loco requires a portability of the application that is only achieved in mobile hardware.

5. 1.2 Game Engine and Programming Language

As Game Engine, Unity was chosen, a free game engine widely used by independent developers together with the programming language C# (pronounced C Sharp) for writing scripts.

5.1.3 Level Design

The game aims to be a resource to help expand the vocabulary of children with ASD following the GAIA model. The teaching-learning methodology adopted was the ABA methodology with positive reinforcement dynamics. As a learning object, a list of words and images schematized following the PECS system will be used.

5.1.4 Mechanics

The proposed mechanic is inspired by an activity already applied in the institution where the game will be used. In the game phase, names and images of objects will be presented that will be the collection of terms to be added to the user's vocabulary, these terms are chosen and grouped in blocks of three words that have a similarity in writing. The groups of three words form the organized blocks, each block works the syllabic family of a letter, so BEBE, BOI and BÓIA belong to the syllabic block with the letter B for example (Figure 2).

Figure 2- Word Blocks

Família Silábica da Letra	Palavra Escrita 1 (C1) + Figura 1 (B1)	Palavra Escrita 2 (C2) + Figura 1 (B1)	Palavra Escrita 3 (C3) + Figura 1 (B1)
B	BOIA	BEBE	BOI
M	MEIA	MÃO	MAMAO
L	MALA	BOLO	LIMAO
D	DAMA	DADO	BOLA
N	BONÉ	BANANA	DANONE
C (a,o,u)	BONECA	CUCO	COLA
S	SUCO	SINO	SACO
P	PÃO	SOPA	PIPINO
T	PETA	LEITE	TOMATE
F	SOFÁ	CAFÉ	FITA

Source: Own elaboration inspired by the activities of the CRIAR RECRIAR ENSINAR project (2023).

The order in which they are worked on is in accordance with the chosen teaching script, so that learning the words in a block naturally facilitates the absorption of the words in the next block. In the gameplay of the game, a cabinet with three spaces is presented, each space is associated with a label with one of the words in the block (Figure 03).
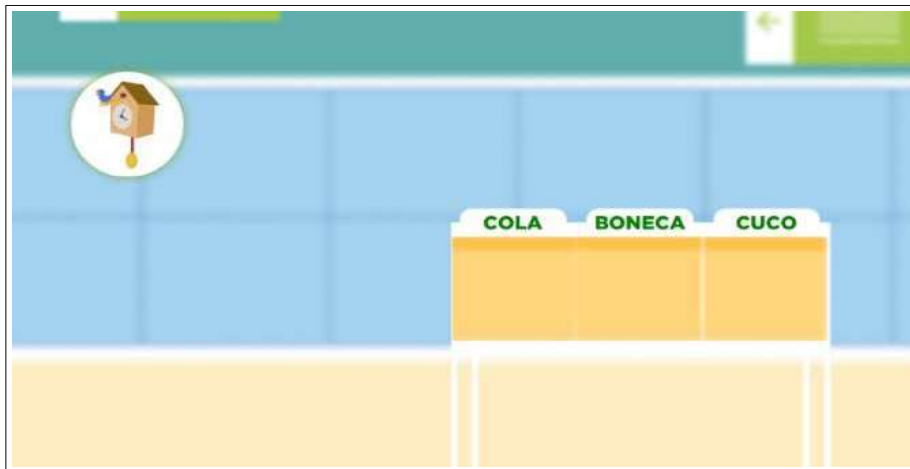
Figure 3- Spaces with label
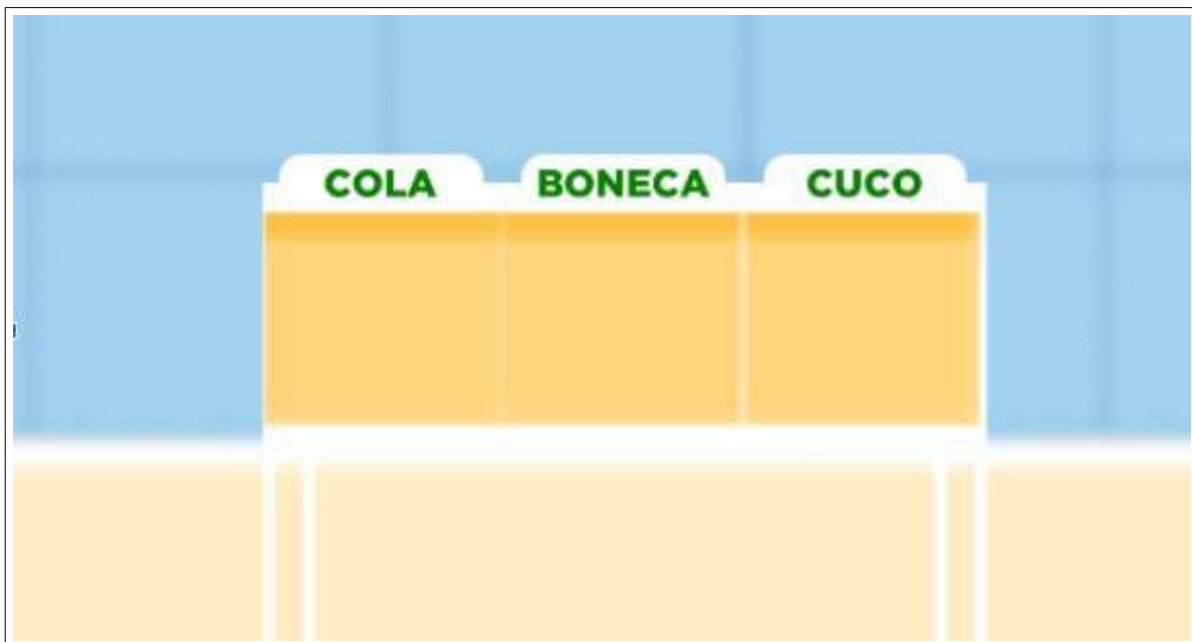
Source: Authors (2023).

In the same scene, the image of the object corresponding to one of the labels is displayed, the user must use the DRAG AND DROP feature of the smartphone, pressing and dragging the object to the correct space, in which the name of the object is being presented (Figure 4).

Figure 4- Drag and Drop system

Source: Authors (2023).

The flow of phases follows the player's progress in the game, they are divided into three categories with different purposes:

a)   Block Probing Phases (FSB), this phase is responsible for analyzing the user's proficiency with the current block of words.

b)   Immediate cue teaching phases (FEDI), this phase works with inducing the correct answer through visual cues, and positive reinforcement following the ABA methodology.

c)   Teaching phases with delayed cue (FEDA), is responsible for intermediating teaching and probing, maintaining positive reinforcement, but inducing a response only if there is no response within 5 seconds.

The choice of the current phase type is made by a flow that takes into account the percentage of correct answers (PA) of the previous block (Figure 5).

Figure 5 - Phase Flowchart
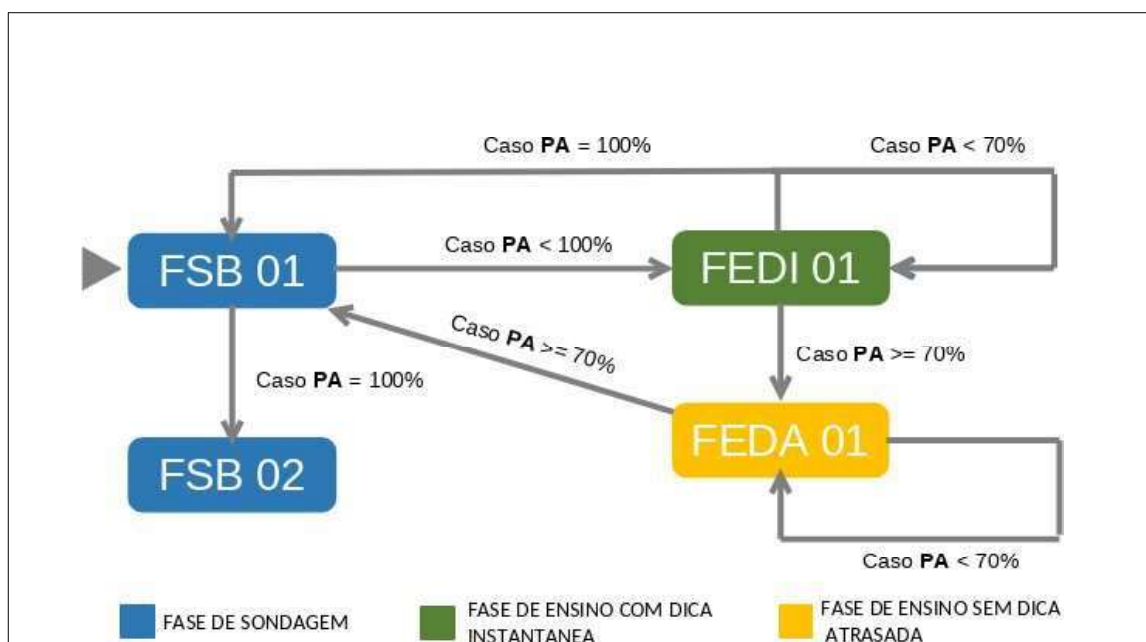
Source: Authors (2023).

The phase flow is repeated in all FSBs and ends when all blocks are completed with 100% PA, that is, when proficiency in recognizing and associating all objects with their respective names is proven.

5.2 Application and Data Collection

The application was carried out at the Monteiro Lobato Integrated Unit, located in the municipality of Paço do Lumiar - MA. The Multifunctional Resource Rooms were the place chosen as the scenario for the application of the study, with the target audience being children in the first literacy cycle and teachers of Specialized Educational Assistance (AEE).

For the application of the field research, there was a partnership with a student of the Master's Degree in Professional and Technological Education (ProfEPT) with IFMA as an associated institution, she carried out the single-subject design, five to ten sessions of 50 min were made each, and can be extended to each participant one of the 5 participants. A Social Story (adapted Social History) will be used for data collection with the participating students, initially for their understanding and initiation of the research, and then their assent.

Right after this step, the game starts with the help of the researcher/applicator of the experimental research for the selection of the block of words and selection of animations (reinforcing stimuli of gamified teaching) together with the student.

The data will initially be collected through an application's internal match history that automatically captures and records materials related to user interaction, the information will be organized into three tables (Figure 6):

a) Players, which contains the identifier (ID) and the player's fictitious name (Name);

b) Matches, which lists the following information for each match: the match identifier (ID); the player identifier (PlayerID); The letter of the syllable family (LetterFamily); The hint level, which can be with hint, hint with delay or without hint (SupportLevel); The phase type, which can be FSB, FECD, or FESD (MatchType); Match start time stamp (StartMatchTime);

c) Attempts, records the data of each attempt in all phases, presents the following fields: The attempt identifier (ID); The match identifier (MatchID); The result which can be "0" for failure and "1" for success (Result); The time in seconds since the last attempt (DelayToAttempt); The number of tips used (TipsCount).

Figure 6- Match history UML

Source: Authors (2023).

5.2.1 Data Grouping

To group and store the data, an API was created using the FastAPI framework (Python3) that updates the database with the results of new matches at each synchronization. This architecture is designed to provide fast access to application data without compromising offline functionality. This means that synchronization can be done later in environments without an internet

connection, in addition to centralizing the density of data in a CSV file (comma-separated values) in the Google Drive public folder, facilitating access for all researchers involved (Figure 07).
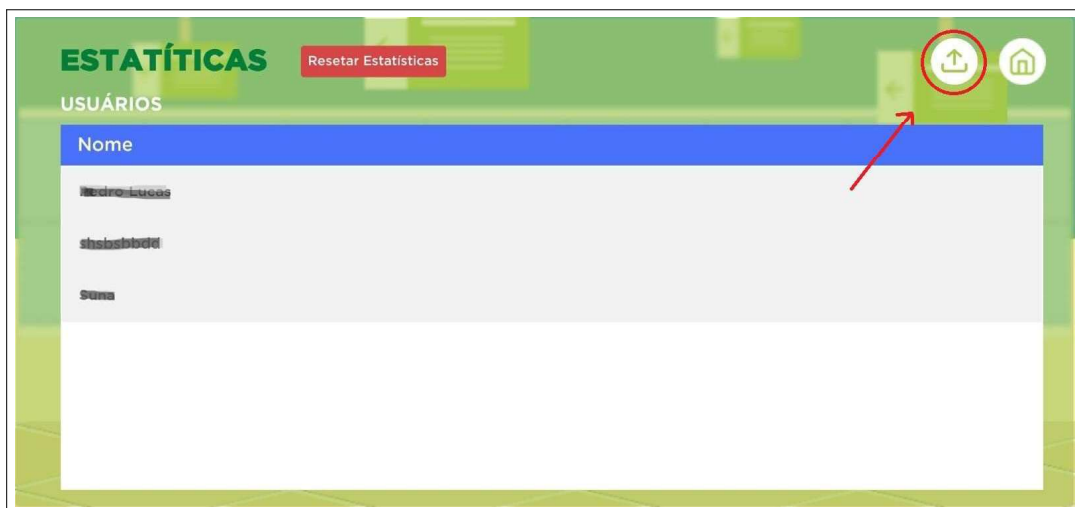
Figure 7- Data collection flow
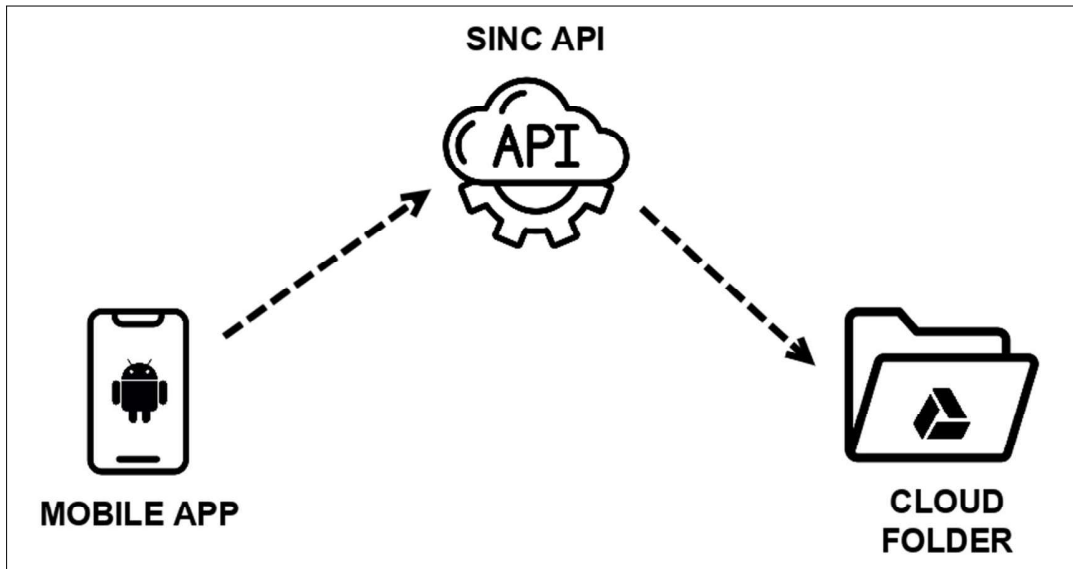
Source: Authors, 2023.

To perform data synchronization, a button was implemented in the application's graphical interface that triggers a function responsible for sending data to the API and subsequent synchronization with the centralized database (Figure 8).

Figure 8- Sync button

Source: Authors (2023).

5.3 Creating individual progress charts

The analysis presented by means of a graph offers a broad perspective of the users' performance in relation to each block of words from the first session, contemplating the percentage of correct answers obtained in the survey stages. It is possible to detect usability problems or flaws in the application's goal, in addition to quantifying the

progress of users in recognizing stimuli over time.

Statistical graphs were prepared by compiling the collected raw data, using the Pandas framework for data analysis and processing, combined with the Matplotlib library to create the visual presentation of the graphs. The entire process was performed through the Python3 interpreter.

And finally, the elaboration of the graph of average response time per attempt helps to identify which players spent more time to select an option and, consequently, had more difficulty in assimilating the stimuli.

6 RESULTS AND DISCUSSIONS

The application is available for free download from the Google PlayStore (https://play.google.com/store/apps/details?id=com.ifma.ensinoteka&pli=1) and can be installed on devices with the Android operating system. For tests, six children students of the Monteiro Lobato Integrated Unit in the municipality of Paço do Lumiar , located in the State of Maranhão - Brazil, were selected, which were divided into two groups containing three components each group and were accompanied by the multidisciplinary team of the Federal Institute of Education , Science and Technology of Maranhão. Players in the first group had a maximum hit rate and maintained this percentage with little margin for error during all probing games, with the average response time of each attempt between 3 and 4 seconds without demonstrating difficulty in assimilating the stimuli, whereas the second group presented low initial success rates and difficulty in recognizing objects in the first phases. However, with the help of the multidisciplinary team in the learning phase, there was a significant improvement in hit rates and a notable reduction in the average response time. Although they still have difficulties compared to the first group, this indicates a deficiency in the ability to recognize and associate images and sounds.

7 CONCLUSION

The results showed that the application is effective and can be characterized as a tool for didactic-pedagogical support useful for learning visual and sound stimuli in children with ASD. The study confirmed the existence of different outcome profiles among the selected children. Some showed high success rates right from the start, while others needed learning phases and help from the company to improve. It is important to highlight that the selected children have different degrees of ASD, which proved to be relevant to assess differences in their ability to use the application. During the evaluation process, it was observed that the children showed a significant improvement in the skills required by the game, such as image recognition and sound association. The hit rate increased and the average response time was reduced, indicating an improvement in the ability to recognize and assimilate stimuli.

The importance of pedagogical monitoring by the multidisciplinary team was an undeniable catalyst in the evolution of children's learning. Because he was responsible for guiding and helping in the understanding of the material, in addition to defining the needs and aptitude of the children, deciding what should be applied for the personalized service. This is because the effectiveness of the software depends on the ability to meet the individual demands of each student. It is important to understand if the child has specific difficulties in the area of perception, object identification, memory, among others, so that it can be decided whether the application will be really effective and beneficial for the child.

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