LED Strike: Educational Robot to Help Children with ADHD Improve Their Attention

***Abstract*—Attention Deficit Hyperactivity Disorder (ADHD) is a condition that significantly affects children's learning due to difficulties in maintaining attention, controlling impulses, and regulating motor activity. These limitations highlight the need for innovative tools to effectively and educationally address these challenges. This project aims to develop an interactive prototype inspired by the Cyclone game, specifically designed for children with ADHD. This device aims to capture attention through visual and auditory stimuli, promoting playful and educational focus. The methodology involved designing and assembling a circuit based on an Arduino Mega 2560 R3, LEDs, an LCD screen, and two sound buzzers. The LEDs are controlled using shift registers, generating dynamic light patterns. The prototype includes an interactive system where the child must immediately press a button to stop the light. If the child succeeds, they advance to the next level, progressively increasing speed and challenge. The LCD screen displays the achieved level, while the buzzers emit sounds as a reward, reinforcing user motivation. The 3D design, which simulates Mickey Mouse's head with a circle of LEDs around it, makes it visually appealing and suitable for children. The results show that the prototype effectively captures and maintains the attention of children with ADHD. Its user-friendly design and simple interaction motivate users to continue using the device, promoting the development of attention, concentration, and self-control skills. In conclusion, this prototype combines technology, didactics, and attractive design, providing an effective and accessible tool that fosters attention, motivation, and retention capacity in children with ADHD. Its simplicity and effectiveness position it as an innovative resource for supporting children's learning.**

Keywords—ADHD, attention, Arduino MEGA, dynamic pattern, educational robot.

I. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neurobiological condition that affects approximately 5% to 10% of school-age children [1] [2]. This disorder is characterized by persistent difficulties in maintaining attention, controlling impulses, and regulating motor activity, which can significantly impact academic performance and interpersonal relationships [3] [4]. These limitations underscore the necessity for pedagogical and therapeutic strategies that foster the cognitive, emotional, and social development of affected children, thereby ensuring an effective intervention tailored to their specific needs [5] [6]. In this context, digital resources have emerged as innovative and versatile tools for addressing the needs of children with ADHD. These resources incorporate personalized approaches that combine playful and educational elements, enhancing sustained attention and promoting meaningful learning. Mobile applications, interactive video games, and academic platforms help capture attention, maintain interest, and improve executive skills, including memory, attention, and self-control [7]. AI-based platforms offer programs adjusted to the child's progress, promoting intrinsic motivation through interactive and engaging environments [8].

Technological devices, such as smartwatches and organizational applications, are also helpful for setting reminders and managing daily activities, encouraging autonomy, and reducing stress [9-11]. Recent studies highlight how these technologies enhance cognitive abilities and boost children's active participation in their learning process [12] [13]. Additionally, their implementation can be complemented with therapeutic support and the involvement of parents and caregivers, creating a comprehensive approach that promotes well-being and social development [14]. Combining traditional strategies with innovative digital tools is key to ensuring more effective interventions [15] [16]. An inclusive environment and resource personalization can make a significant difference in the lives of children with ADHD, helping them overcome barriers and reach their full potential [17] [18].

LED Strike is presented within this framework. It is an interactive prototype developed with Arduino technology, designed to capture children's attention through visual and auditory stimuli. This device uses dynamic LED patterns, an LCD screen to display progress, and a button system for direct user interaction. Its design combines technology with a therapeutic approach, providing a playful and educational tool that contributes to the cognitive and emotional development of children with ADHD [19-21].

II. Background

Educational robots are increasingly being used to support children with Attention Deficit Hyperactivity Disorder (ADHD) in both academic and therapeutic settings, where they aim to improve attention, learning, and social skills through interactive, engaging, and adaptive activities tailored to individual needs [22]. These robotic assistants can help children stay focused during homework, correct misbehavior, and provide real-time feedback, enabling therapists to monitor sessions remotely and adjust interventions accordingly, which enhances engagement and performance for children with and without ADHD [23]. Furthermore, robots are employed to train cognitive skills such as selective attention, memory, and constructive learning. Additionally, social robots can mediate therapy sessions by helping children practice social behaviors and nonverbal communication [24].

Research has identified innovative projects that employ interactive technology to support children with ADHD. Among them is the development of an interactive electronic toy designed to teach basic addition in a fun and engaging manner, specifically targeting children with hyperactivity. Using a ball-based game, the prototype aims to enhance logical thinking and support teacher guidance. Through exploration and descriptive research, effective didactic strategies for addressing hyperactivity were identified to inform the design of the toy. Functional testing showed increased interest and knowledge retention among participants, with success rates reaching 86%, demonstrating the toy’s positive impact on learning [19].

Additionally, improving children's concentration is a challenging task for both parents and teachers. This game addresses that challenge by creating increasingly demanding environments to enhance focus. It features four types of interactive boxes: a green box as the primary target, a yellow box that represents a distraction to avoid, a white box that adds extra time, and a red box that appears briefly and requires high concentration to hit. The game's narrative, where the hero seeks to rescue his kidnapped girlfriend and save the planet, adds an engaging storyline that motivates children to stay attentive and immersed [20].

Complementing these efforts, Rey Juan Carlos University has created an intelligent robot that, using artificial intelligence algorithms and haptic response devices, adapts its interaction to encourage concentration and self-control in children with ADHD [21]. These projects highlight the crucial role of interactive technologies in cognitive development and improving the quality of life for these children.

III. Methodology

The project development began with research and the identification of similar projects that could assist children with ADHD. A circuit simulation was then created in TinkerCAD to validate its functionality. Once the simulation was completed, the 3D model was designed, serving as the basis for the final prototype implementation.

A. Project Description

The final project presents an interactive LED roulette shaped like Mickey Mouse’s head, equipped with an LED light system, an LCD screen, and two buzzers. This device is designed to capture children's attention, especially those with ADHD, using visual and auditory stimuli. The LED lights spin sequentially, simulating a roulette movement, while the blue LED indicates the "winning point." The buzzers emit motivational sounds upon success, and the LCD screen displays achieved levels or personalized messages, offering multisensory feedback that encourages interaction and learning.

The design, focused on the child's experience, integrates a 3D-printed casing that encapsulates all electronic components, ensuring both functionality and aesthetics. An Arduino Mega 2560 R3 controls the prototype, guaranteeing efficient and dynamic operation. Additionally, the device utilizes vibrant colors and playful elements that make the experience more engaging and motivating for children, promoting their active participation and helping to develop coordination skills.

B. Component Description

The project has fundamental elements that are crucial for its optimal functioning. Key components include the Arduino Mega 2560 R3 (1 piece), which acts as the central brain, two buzzers (2 pieces) to generate acoustic signals, a 16x2 LCD screen (1 piece) to display information, an I2C inter-integrated circuit (1 piece) for the operation of the LCD screen, green LEDs (23 pieces) to generate light patterns, a blue LED (1 piece) that indicates the winning level, 330 Ω resistors (31 pieces) to regulate current control, male-male cables (24 pieces) to connect the components, female-male cables (72 pieces) to connect the components to the Arduino, female-female cables (12 pieces) to connect the components, a slide switch (1 piece) that indicates the on or off of the system, a 9V battery (1 piece) for power, a plastic snap connector (1 piece) for battery operation, a large breadboard (2 pieces) for connecting the components and cables, a medium breadboard (1 piece) for the connection of components and cables, three buttons (3 pieces) to control the interaction of the game and three 74HC595 integrated circuits (3 pieces) for the best functioning of the prototype.

C. Design Description

The design of this project is based on Mickey Mouse's head, with adaptations that create a friendly and attractive model for children. Inspired by Mickey's popularity, this prototype aims to capture attention through its visual aesthetics and provide comfort by utilizing a 3D-printed design, fostering a fun and effective connection with users. This model seeks to provide a multisensory experience that encourages learning in an entertaining and accessible manner for children with attention and calculation difficulties, promoting an inclusive and practical approach.

2D Design: The measurements of the Mickey Mouse-shaped object are divided into two parts: the lid and the base (Figure 1). The lid measures 259.464 mm in length and 233.597 mm in width, while the base measures 255.535 mm in length and 228.624 mm in width, ensuring a secure fit when assembled. The screen areas, designed to display interactive content, measure 24.3 mm in width by 71.2 mm in length, providing adequate space for visual feedback during gameplay. LEDs are arranged in a circular pattern with 5 mm spacing between each, contributing to a dynamic and engaging visual experience for children. Below the screen, the start, level, and pause buttons—each with a radius of 10 mm—are ergonomically placed for easy access, especially for young users. The laser-cut openings for these buttons are rectangular, measuring 10 mm in width by 30 mm in length, allowing for precise placement and smooth mechanical operation. This configuration was designed to ensure both functionality and an appealing user experience in educational or therapeutic gaming contexts.

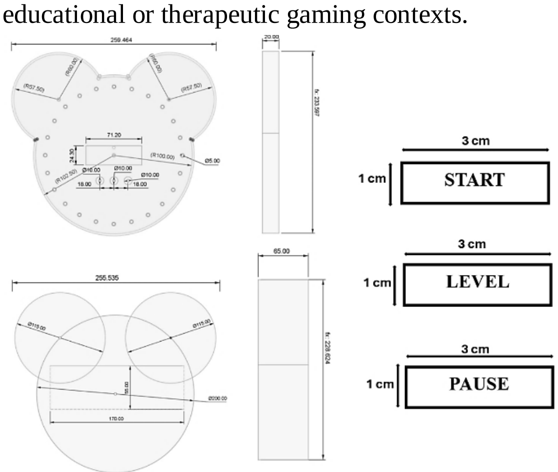

Fig. 1. 2D Model design.

3D Design: Inspired by the iconic shape of Mickey Mouse (Figure 2), the three-dimensional design was developed from initial sketches and transformed into a solid model optimized for 3D printing. The final design includes a prism-like structure with precisely positioned slits to accommodate electronic components, LED indicators, and decorative buttons. The main box and its cover were printed separately, taking 32 and 18 hours, respectively, using additive manufacturing techniques that ensured dimensional accuracy, structural integrity, and full compliance with the technical specifications. This process yielded a functional and visually appealing prototype suitable for educational or therapeutic purposes.

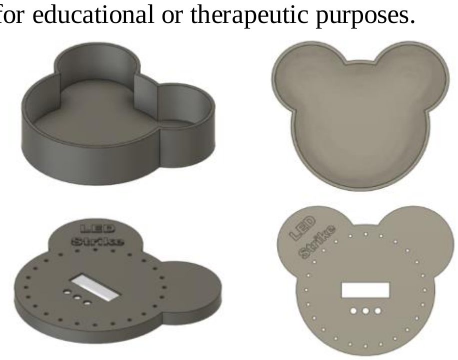

Fig. 2. 3D model design.

D. Programming Description

Due to the differences between the circuits, the code has slight variations for each version. Therefore, a general explanation of the code will be given, and specific differences will be noted where applicable (Figure 3). The code begins by including the necessary libraries for the LCD screen, utilizing *LiquidCrystal.h* in TinkerCAD and *Wire.h*, along with *LiquidCrystal_I2C.h* in the implemented version due to the I2C module. This modifies the configuration: in TinkerCAD, the pins RS, E, DB4, DB5, DB6, and DB7 are declared, while in the implemented version, only the I2C module and the screen size are configured. The LEDs are also declared differently: in TinkerCAD, shift modules are used, while in the implemented version, they are mapped directly to the Arduino pins. The pin assignments vary; for instance, the buttons in TinkerCAD are located at A0, 2, and 13, whereas the implemented versions are at 9, 10, and 11. Additionally, variables are created to store the game's melodies. The configuration differs: in TinkerCAD, the buttons are inputs with INPUT logic, the shift register pins are OUTPUT, and the LCD screen initializes by displaying "Welcome." In the implemented version, the 24 LEDs are configured as OUTPUT through a loop, the buttons use INPUT_PULLUP logic, and the LCD also displays "Welcome."

In both versions, the main loop shows the selected level and "Start..." with conditions to level up or start the game. Updating LEDs varies depending on the implemented version; simple logic is used to turn them on, while in TinkerCAD, the corresponding register (first, second, or third) is identified, and the data is sent to update the LEDs. When starting the game, a loop lights up LEDs according to the level's pattern, with conditions to verify the correct buttons, pause the game, and refresh the LCD screen. Finally, the code includes additional loops: one for playing tunes, one for victory events that advance to the next level, and one for defeats that restart the game. The differences in LOW and HIGH logic affect input and output management in both versions.

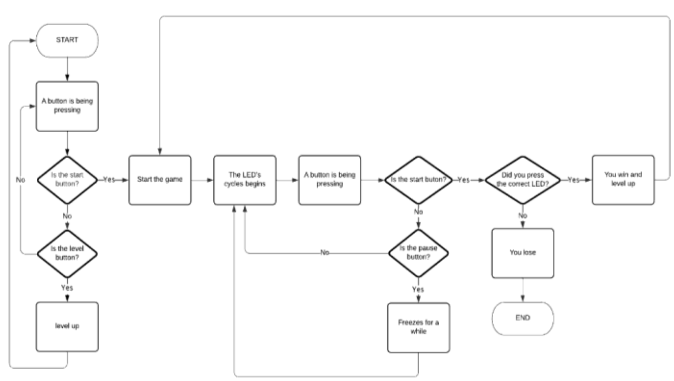

Fig. 3. Flowchart of the algorithm.

E. Circuit configuration

For greater versatility in the implemented version, the LEDs were mounted on a breadboard, allowing easy modification and testing. All components, including sensors, buttons, and indicators, were interconnected on the breadboard, simplifying integration with the Arduino. Additionally, an I2C module was incorporated to streamline communication with the LCD screen, reducing the number of required pins and improving the efficiency of data transmission and system organization. This setup facilitated rapid prototyping and ensured flexible adjustments during development.

With the above clarified, we proceed to describe the implementation of the designed circuit (Figure 4), which is:

- Arduino UNO R3 (1) to connect six main components.
- Three pushbuttons (2) have their lower right terminals connected to 5V, the lower left ones to GND, and the upper left ones to input A0 (left), 2 (center), and 13 (right).
- Two buzzers (3) relate their positive inputs to pins 3 and 4 and their negative inputs to GND. An LCD screen (4) connects to pins 8 (RS), 9 (E), 10 (DB4), 11 (DB5), 12 (DB6), and 13 (DB7), with a 5V supply for power and LED anode, and GND connected to the contrast, the cathode LED and the GND of the display.

Additionally, an 8-bit shift register module (5) is incorporated to expand the Arduino's output and enable the interconnection of other similar modules. This module is configured with inputs on pins 0 (data), 1 (output register), and 5 (shift register), with 5V power for both the module and register clearing. Eight LEDs (six of which are connected to their respective outputs using 220Ω resistors) are controlled by the Arduino, with the GND of the Arduino connected to the output activation pin of the module. To further expand the outputs, the inverted output of the first module is connected to the power input of the next module, replicating this process once again and thus achieving a total of 24 outputs to control 24 LEDs. Finally, 10 kΩ resistors were used for the buttons and the anode of the LCD screen, while 220 Ω resistors were used for each LED.

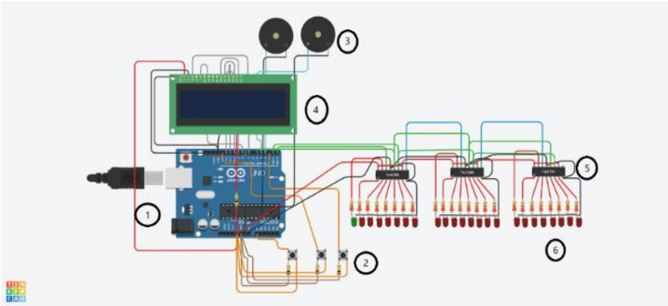

Fig. 4. Electronic circuit in TinkerCAD.

F. Deployment Description

The project began with the assembly of each circuit component (Figure 5). During this process, minor modifications were made to adapt the layout to the dimensions of the 3D-printed case. Initially, the LEDs were connected using wires; however, they frequently became loose and detached from their positions. To resolve this issue and ensure stability, the LEDs were soldered directly into place, preventing displacement during use. The accompanying figure illustrates the soldering process applied to secure the LEDs and other components, significantly improving the structural integrity and durability of the system during gameplay.

Fig. 5. Union and Connection of Components with Soldering

Once it was verified that the system was working correctly as expected, all the assembled components were carefully installed inside the casing to ensure proper alignment and secure positioning (Figure 6). A test assembly was performed to verify the welding quality and the precise location of each part, with particular attention paid to the correct seating of the components to prevent any issues later in the process. This stage enabled us to assess the effectiveness of the soldering work, particularly on the LEDs, which had previously presented challenges in maintaining adequate connections. Additionally, the wiring of the LEDs was a significant concern, as the connections were difficult to manage due to the tight space within the casing. The figure illustrates the early implementation phase, showing the arrangement of parts and highlighting the difficulties encountered with the wiring, which required further adjustments before achieving a functional setup. Despite these challenges, the test assembly provided valuable insights into the integration process, ensuring the system was robust and ready for further testing and refinement.

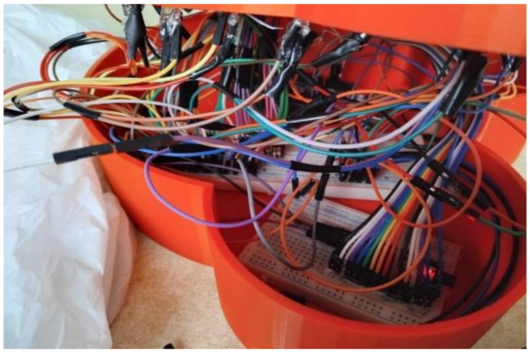

Fig. 6. Integration of Components and Final Pre-assembly

The system integration involved installing all the assembled components inside the casing, ensuring that each part was adequately positioned and connected. During the initial functionality tests, it was verified that all electrical and mechanical connections were operating as expected, with special attention paid to the stability of the LEDs, which initially had issues staying in place. After performing the necessary soldering and adjusting the wiring, the buttons, LED lighting, and the LCD screen operation were tested, confirming that all components responded correctly. These initial tests (Figure 7) enabled the identification of potential improvements in the assembly. They ensured that the integration of the parts was carried out effectively, thereby achieving optimal device functionality before proceeding to subsequent phases of the project.

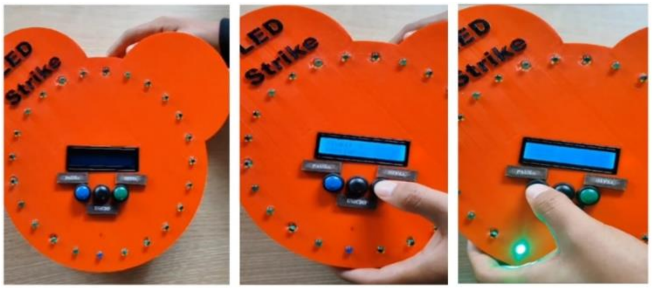

Fig. 7. Component function tests

Functionality tests were conducted with users, particularly children, to gather direct feedback on their interaction with the system. Participants used the device under real-world conditions, allowing for the observation of how they engaged with the buttons, LEDs, and LCD screen during educational tasks, such as solving math problems or responding to visual stimuli. These sessions not only measured the technical performance of the system but also assessed children's levels of attention, motivation, and engagement. Evaluators paid special attention to how intuitive the device was for first-time users, noting whether the children could navigate the interface without assistance and how quickly they adapted to the game's rules.

Fig. 8. Functionality tests with users.

This testing phase was essential for identifying areas of improvement in usability. Feedback from children provided valuable insights into interface clarity, ergonomic comfort, and the effectiveness of visual feedback, such as color-coded LEDs and animated messages on the screen. Children's spontaneous reactions—such as smiles, frustration, or excitement—also served as behavioral indicators of the quality of user experience. Moreover, this phase helped validate the educational value of the system, as children demonstrated improved concentration and problem-solving confidence after multiple interactions. Their participation revealed usability challenges that were not evident during internal testing, ensuring the final prototype was not only technically functional but also appealing, safe, and effective for its intended audience.

Functionality testing was conducted during the Arduino Day university competition, where the project was presented to both the jury and the general public. Approximately 83 people tested the game, including around 40 children and the rest, young adults and adults. In total, more than 90 games were played, each lasting an average of 2 to 5 minutes. This real-life context provided valuable information on how participants interacted with the system.

Approximately 30 children responded enthusiastically to the attractive design and simple rules, allowing them to quickly understand the game and enjoy it on multiple attempts. Among young adults and adults, approximately 60% repeated the experience two to three times to complete the levels, highlighting the immersive and entertaining nature of the project. Observations revealed that more than 80% of participants expressed satisfaction and shared positive comments, highlighting that the game was not only fun but also easy to understand and appealing to all age groups. Some parents even suggested an educational value, as the experience promoted concentration and perseverance.

IV. Conclusions

In conclusion, the LED Strike project fulfills its primary objective of offering an interactive tool that captures the attention of children with ADHD through visual and auditory stimuli, playfully promoting focus. A functional prototype was developed using Arduino, an LCD screen, shift registers, buzzers, and LEDs that combine entertainment and learning. The device's design, inspired by friendly shapes such as Mickey Mouse's head, ensures an approach that is both accessible and attractive to children. In addition, the game's dynamics, with progressive levels and options such as "warp," allow the experience to be tailored to each user's rhythm. This project demonstrates the positive impact of technology on learning and education. It opens the door to future improvements and implementations that could further enhance its effectiveness in educational and therapeutic settings.

In future revisions, it is proposed that the LED Strike prototype be enhanced by polishing and refining the game algorithm to provide users with a better experience. Additionally, there is the idea of conducting tests with a more extensive and diverse sample of children with ADHD to evaluate the effectiveness of Led Strike. Integrating new elements, such as haptic feedback modules or enhancements to customization of light and sound patterns, is also considered to increase the device's interactivity and attractiveness. These improvements aim to enhance functionality and expand the prototype's scope, solidifying it as a valuable tool in supporting children with ADHD.

REFERENCES

[1] T. N. Willig, et al., “Healthcare pathways and practitioners’ knowledge about ADHD in children,” *L'encephale*, vol. 50, no. 4, pp. 363-372, 2024.

[2] J. G. García & J. M. G. Calleros, “Videojuegos en educación especial: niños con TDAH,” *Revista de la Asociación Interacción Persona Ordenador (AIPO)*, vol. 2, no. 1, pp. 48-59, 2021.

[3] G. Español-Martín, et al., “The impact of attention-deficit/hyperactivity disorder and specific learning disorders on academic performance in Spanish children from a low-middle- and a high-income population,” *Frontiers in Psychiatry*, vol. 14, pp. 1136994, 2023.

[4] J. M. Torres, M. O. Amorós, and M. S. Barceló, “El TDAH en la etapa preescolar: Una revisión narrativa,” *Revista de Psicología Clínica con Niños y Adolescentes*, vol. 9, no. 3, pp. 1-6, 2022.

[5] V. N. Vahia, “Diagnostic and statistical manual of mental disorders 5: A quick glance,” *Indian Journal of Psychiatry*, vol. 55, no. 3, pp. 220-223, 2013.

[6] V. A. J. Galarza, and M. P. S. Hidalgo, “Trastorno de Atención por Hiperactividad (TDAH): caracterización, evolución teórica y estrategias pedagógicas para su superación,” *Revista de la Universidad del Zulia*, vol. 12, no. 35, pp. 466-483, 2021.

[7] A. Thapar, et al., “Practitioner Review: What have we learned about the causes of ADHD?” *J. Child. Psychol. Psychiatry*, vol. 54, no. 1, pp. 3–16, 2013.

[8] J. A. García Conforme, and E. K. Aguilar Morocho, “Efectos de las actividades lúdicas en la reducción de la hiperactividad en niños con TDAH,” *Ciencia y Educación*, vol. 5, no. 8, pp. 98 – 112, 2024.

[9] J. Huaytalla-Pariona, et al., “Discalcu: Mathematical Device for Children with Dyscalculia,” *International IOT, Electronics and Mechatronics Conference,* Singapore: Springer Nature Singapore, vol. 1, pp. 277-290, 2024.

[10] H. Valcarcel-Castillo, et al., “Proposal for a Technological Model to Manage Dyslexia in Childhood with 'Rodolfo’,” *International IOT, Electronics and Mechatronics Conference*, Singapore: Springer Nature Singapore, vol. 1, pp. 261-275, 2024.

[11] J. Huaytalla-Pariona, et al., “Dave Octopus Prototype to Relieve for Children with Asperger’s Syndrome,” *International IOT, Electronics and Mechatronics Conference*, Singapore: Springer Nature Singapore, vol. 1, pp. 247-259, 2024.

[12] P. Cornellà, M. Estebanell, and D. Brusi, “Gamificación y aprendizaje basado en juegos,” *Enseñanza de las Ciencias de la Tierra*, vol. 28, no. 1, pp. 5-19, 2020.

[13] J. O. Verastegui-Santiago, et al., “Use of 2D/3D Video Games in Digital Platforms for Basic Education: A Technological and Systematic Review,” *2023 IEEE Colombian Caribbean Conference (C3)*, Barranquilla, Colombia, pp. 1-6, 2023.

[14] E. Chan, J. M. Fogler, and P. G. Hammerness, “Treatment of attention-deficit/hyperactivity disorder in adolescents: A Systematic Review,” *JAMA*, vol. 315, no. 18, pp.1997-2008, 2016.

[15] J. Huaytalla-Pariona, et al., “‘Tony’ Glove: Facilitating Interaction with the Environment for Children with Visual-Spatial Deficit,” *International IOT, Electronics and Mechatronics Conference*, Singapore: Springer Nature Singapore, vol. 1, pp. 233-246, 2024.

[16] V. Rivera, y G. Alicia, “Impacto del TDAH en el aprendizaje de estudiantes en edad escolar: una revisión sistemática,” *Revista San Gregorio*, vol. 1, no 57, pp. 199-219, 2024.

[17] J. Quintero, y C. Castaño de la Mota, “Programa de Formación Continuada en Pediatría Extrahospitalaria,” Pediatría Integral, vol. 18, no. 9, pp. 595-697, 2014.

[18] J. A. Rabadán y A. M. Giménez-Gualdo, “Detección e intervención en el aula de los trastornos de conducta,” *Facultad de educación*, vol. 15, no. 2, pp. 185-212, 2012.

[19] D. Toca, et al., “Juguete electrónico para niños con trastorno de hiperactividad en la educación inicial,” *Maskay*, vol. 11, no. 2, pp. 1-6, 2021.

[20] R. Salama, and M. Elsayed, “Practical study on the effect of Educational Games on ADHD students,” *New Trends and Issues Proceedings on Humanities and Social Sciences*, vol. 6, no. 6, pp. 48-57, 2019.

[21] J. Berrezueta-Guzman, et al., “Assessment of a Robotic Assistant for Supporting Homework Activities of Children With ADHD,” *IEEE Access,* vol. 9, pp. 93450-93465, 2021.

[22] A. L. H. Poma, A. C. M. Puris, and J. A. Del Aguila Ramos, "Proposal for the Design of an Educational Robot to Enhance Learning and Support Children with attention Deficit Hyperactivity Disorder from the Fifth Year of Age at Low Cost-Nubox," *2024 4th International Conference on Robotics, Automation and Artificial Intelligence (RAAI)*, Singapore, Singapore, pp. 11-16, 2024.

[23] Z. Telisheva, et al., "The Quantitative Case-by-Case Analyses of the Socio-Emotional Outcomes of Children with ASD in Robot-Assisted Autism Therapy," *Multimodal Technologies and Interaction*, vol. 6, no. 6, pp. 46, 2022.

[24] A. Sandygulova, A. Amirova, Z. Telisheva, A. Zhanatkyzy, and N. Rakhymbayeva, "Individual Differences of Children with Autism in Robot-assisted Autism Therapy," *2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, Sapporo, Japan, pp. 43-52, 2022.