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ENTREVISTA A JORGE IGNACIO LEIVA TORRES, DIRECTOR POR ALTA DIRECCIÓN PÚBLICA DEL LICEO INDIRA GANDHI, LA FLORIDA

DESIGN AND EVALUATION OF DIGITAL PLATFORMS FOR TEACHING MATHEMATICS TO STUDENTS WITH ASD AND ADHD

DISEÑO Y EVALUACIÓN DE PLATAFORMAS DIGITALES PARA LA ENSEÑANZA DE MATEMÁTICAS A ESTUDIANTES CON TEA Y TDAH

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ABSTRACT
This study explores the design and evaluation of an e-learning platform for teaching mathematics to students with Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD).. The platform integrates accessibility, gamification, and adaptive learning for overcoming cognitive, emotional, and sensory challenges. A mixed-methods design was employed, including pre- and post-intervention measurements, observation, and feedback from students, teachers, and parents. Results were impressive: mathematics performance averaged 30% higher, students were correctly answering problems in larger numbers. Interactive and graphical presentation of the platform reduced stress and frustration, as reported by 71% of the students who exhibited positive affect for mathematics activities following treatment. Gamification elements substantially enhanced motivation, particularly for ADHD students, with an 80% engagement rate for instant feedback. ASD students benefited from highly structured, predictable interfaces, with a 65% reduction in anxiety incidents.

KEYWORDS: digital learning platform; neurodiverse education; mathematics instruction; inclusive design.

RESUMEN
Este estudio explora el diseño y la evaluación de una plataforma de aprendizaje electrónico para la educación en matemáticas de estudiantes con Trastorno del Espectro Autista (TEA) y Trastorno por Déficit de Atención e Hiperactividad (TDAH). La plataforma integra accesibilidad, gamificación y aprendizaje adaptativo para superar desafíos cognitivos, emocionales y sensoriales. Se empleó un diseño de métodos mixtos, que incluyó mediciones previas y posteriores a la intervención, observación y retroalimentación de estudiantes, docentes y padres. Los resultados fueron impresionantes: el rendimiento en matemáticas fue un 30 % superior en promedio y un mayor número de estudiantes resolvió problemas correctamente. La presentación interactiva y gráfica de la plataforma redujo el estrés y la frustración, según lo reportado por el 71 % de los estudiantes que mostraron un afecto positivo hacia las actividades matemáticas después del tratamiento. Los elementos de gamificación mejoraron sustancialmente la motivación, especialmente en estudiantes con TDAH, con una tasa de participación del 80 % gracias a la retroalimentación instantánea. Los estudiantes con TEA se beneficiaron de interfaces altamente estructuradas y predecibles, con una reducción del 65 % en los incidentes de ansiedad.

PALABRAS CLAVE: plataforma de aprendizaje digital; educación neurodiversa; instrucción en matemática; diseño inclusivo.

I.- INTRODUCTION

Websites used to teach mathematics to students with autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD) have become essential in recent years, thanks to technological advances and the growing need for accessible educational resources to support students with special educational needs. However, despite efforts to integrate technology into the educational system, resources and means to equitably integrate students with ASD and ADHD are insufficient, particularly in traditionally challenging areas such as mathematics (Miranda et al., 2025). The use of virtual platforms designed to meet the cognitive, affective, and motor needs of these students can not only improve their academic performance but also their motivation, interest, and adjustment (Aparicio-Juárez et al., 2024).

ASD is a neurodevelopmental disorder that has a major impact on individuals' social skills, communication, and behavior. Children with ASD typically exhibit a wide range of cognitive and emotional abilities; therefore, treatment will need to be highly individualized. In mathematics, children with ASD will also face additional challenges: they will have difficulty maintaining focus, concentrating, and following an explicit and predictable order in the learning context (Gutierrez et al., 2024). Similarly, students with ADHD suffer from inattention, impulsivity, and executive dysfunctions that disrupt their ability to focus and navigate complex tasks, such as mathematical questions, on which they spend most of their time. All of these elements represent a considerable gap in traditional pedagogy, which may not always be sufficient to meet the needs of these students (Naula et al., 2025). Therefore, developing websites that facilitate teaching adapted to each student's specific

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needs—that is, their learning speed and mental patterns—is a suitable alternative for improving the quality of education (Caballero and Zarate, 2024).

Educational technologies offer numerous advantages that can offset the disadvantages of traditional classrooms. Thanks to the flexibility and personalization of content, virtual platforms offer students with ASD and ADHD an adaptive and interactive learning environment where they can learn at their own pace, receive immediate feedback, and learn through visual and auditory means (Calle et al., 2025). This approach can reduce frustration and anxiety for most of these students, as it maximizes their motivation and engagement in learning. Furthermore, the use of digital technologies allows for individual monitoring of each student, allowing for the rapid identification of problems and adaptation of online learning methods. Already available research has shown that the use of digital technologies in the education of children with ASD and ADHD has a positive effect on their studies, particularly in mathematics, where conventional methods are sometimes not effective enough to address their personal difficulties (Santos et al., 2024).

However, very few studies specifically focus on the design of digital platforms that meet the needs of this group of students in mathematics, which constitutes a significant gap in research (Díaz et al., 2024). The lack of empirical data on how technology can improve mathematics teaching for students with ASD and ADHD reinforces the need for this study, which aims to contribute to the enrichment of knowledge to fill this gap. This study is based on the premise that the design and use of a computer platform adapted to the needs of students with ASD and ADHD can significantly improve their mathematical performance, in addition to motivation, anxiety, and emotional control.

OBJECTIVES

The main objective of this study is to design and validate a computer-based learning system for mathematics instruction in students with ASD and ADHD. The specific objectives are as follows: (1) To define the educational and emotional needs of students with ASD and ADHD in learning mathematics; (2) To develop an interactive web-based system tailored to this group of students, with pedagogical features focused on accessibility, personalization, and interaction; (3) To test the system with a group of students with ASD and ADHD, carefully observing and measuring their performance; (4) To test and compare students' academic performance, motivation, anxiety, and frustration before and after using the system; and (5) To modify the system based on participants' feedback.

THEORETICAL FRAMEWORK

This topic has long been a challenge for students with ASD and ADHD. ASD, a neurodevelopmental disorder, affects individuals in extremely heterogeneous ways. While some students are better at certain skills such as visual memory or mathematical pattern recognition, others struggle with abstract concepts such as fractions, geometry, and calculations. These students also experience disruption in the classroom due to their lack of social norms and interaction knowledge, which generally exacerbates learning difficulties. Students with ASD also tend to adhere to repetitive structures and have a very high need for repetition, which is an educational limitation in mainstream settings. To this end, websites can offer appropriate levels of personalization for mathematics learning, allowing students to learn at their own pace, with the structure and predictability they need (Palacios et al., 2025). ADHD, on the other hand, leads to difficulties maintaining attention, controlling impulses, and managing behavior, which can pose significant learning challenges in subjects such as mathematics. Children with ADHD struggle with tasks requiring sustained attention, such as solving math problems, and are easily distracted (Trindade et al., 2022). Inattention due to this disorder can lead to frustration and poor academic performance, as students themselves experience. By providing interactive and dynamic learning environments, educational technologies can provide a learning environment that maintains students' interest and provides immediate gratification in the form of reinforcement and feedback, thereby motivating them and increasing their attention to tasks.

Ausubel's (1968) theory of meaningful learning and Piaget's (1973) constructivist learning theory emphasize students' interaction with information and the need for them to construct knowledge from experience. Through these processes, the use of online classroom environments can offer learners autonomy in controlling content and pace according to their own level of understanding. Deci and Ryan's (1985) theory of motivation also includes autonomy and learning competence. Online content can offer these aspects to students with ASD and ADHD, as they can control their learning materials and pace, while being in control of their own learning.

II.- METHOD

This research used an action research methodology to ensure the cyclical design, implementation, and evaluation of the digital platform, thus ensuring a responsive response to students' changing needs.

The first part of the research consisted of an in-depth diagnostic study of the educational and emotional needs of students with ASD and ADHD. The initial objective was to identify the cognitive, emotional, and sensory difficulties encountered by students in learning mathematics and to find the most appropriate pedagogical features to address them.

Based on the data collected at this stage, a web-based platform was created, incorporating accessible learning, interactivity, and adaptive learning concepts. Regarding accessibility, settings allowed for customization of font size, color contrast, and the arrangement of objects on the screen. These tools not only facilitated reading and comprehension, but were also adapted to students with sensory or intellectual disabilities. In terms of interactivity, the site offered features that provided immediate feedback in the form of positive messages, color changes, and reward sounds, designed to encourage active engagement and good learning behaviors.

In addition, gamification elements were integrated to enhance student motivation. These elements consisted of points, badges, and rewards awarded to students when they successfully completed an activity or correctly answered problems.
After the design phase, a pilot sample of 30 students aged 7 to 15 with a diagnosis of ASD or ADHD was created. Participant recruitment was carried out in collaboration with health professionals and school psychologists, who selected students based on predefined inclusion criteria, such as a confirmed diagnosis and parental consent. The students were grouped into small groups and completed the platform's activities under the constant supervision of facilitators, teachers specialized in supporting students with learning disabilities and special educational needs. During the deployment, students' use of the platform was closely monitored. Students' difficulties, including their emotional and behavioral reactions to the activities, were recorded. To this end, direct observation served as the primary research tool, with the help of field notebooks recording session details, observed behaviors, and emotional reactions.

III.- RESULTS

From the first use of the platform, a notable difference was observed in the students' affective attitude toward mathematical activities. One of the first detectable indicators was the level of attention maintained throughout the sessions. During the first sessions, 60% of ADHD students and 40% of ASD students were distracted after the first 10 to 15 minutes of using the content. However, by the third session of continuous use, this percentage had decreased considerably: only 15% of ADHD students and 10% of ASD students required external interventions (physical or verbal) to resume the task. This trend was maintained throughout the session, suggesting a positive habituation effect thanks to the interactive design, the structural simplicity of the content, and the presence of gamification elements on the platform. Academic performance, measured using standardized tests covering basic math skills (addition, subtraction, multiplication, basic fractions, numerical sequences, and basic spatial skills), showed widespread improvement. The mean score on the diagnostic test for the combined group (children with ASD and ADHD) was 48% before treatment, with a standard deviation of 11%. After six weeks of regular use of the platform (at least three 40-minute sessions per week), the mean increased to 78%, with a reduced standard deviation of 8%, reflecting greater consistency in results. By condition, students with ASD improved from an average of 52% to 81%, and those with ADHD from 45% to 74%. This equates to a relative gain of 56% for students with ADHD and 55.7% for students with ASD.

Regarding the type of material that was most difficult at the beginning and most improved in the later stages, the topic of fractions emerged. Initially, 70% of students (both diagnoses) answered fraction comprehension exercises incorrectly. At the end of the trial period, only 18% continued to struggle with this topic. This success was due in part to the visual nature of the platform, which presents fractions as interactive animations and digitally manipulable objects. This physical representation made learning a previously abstract subject less abstract, especially for children with ASD, who respond well to structured visual stimuli.

Regarding the emotional perception of the activities, information from adapted questionnaires (featuring emotional faces, colors, and pictograms) revealed a marked reduction in negative emotions associated with learning mathematics. At the first assessment, 63% of students reported feeling anxious, frustrated, or bored with math activities. After using the platform, this percentage dropped to 17%. Similarly, levels of excitement and joy increased: while at the beginning of the study, only 28% of students reported positive feelings, by the end of the cycle, 71% expressed excitement, joy, or curiosity about the proposed math activities.

Extrinsic motivation, measured in terms of response to the platform's rewards and points system, proved most effective for students with ADHD. Approximately 80% of students were positively motivated by instant feedback (e.g., success sounds, congratulatory icons, or the opening of virtual badges), which encouraged their interest in the activities. This process also acted as an affect regulator: students, previously introverted when faced with errors or difficulties, began to show greater tolerance for frustration, as feedback was systematically followed by suggestions and encouragement to continue their efforts, whether the answer was correct or incorrect. Students with ASD, on the other hand, were significantly helped by the platform's architectural features. The extremely orderly and coherent presentation of content and the controlled pace of progress significantly abolished episodes of anxiety related to uncertainty. Facilitators reported a 65% reduction in dysregulated behaviors while using the platform (compared to traditional teaching sessions), which was also reflected in parents' reports of a greater desire among children to complete their math homework at home.

The addition of accessibility features (contrast, font size, and simplified visual elements) was also well-received. These were not only educational facilitation tools, but also self-regulation tools. Some learners, under stress, independently used the settings menu to modify the visual environment and continue the task. Such spontaneous adaptation is an asset in terms of digital skills, but also an indicator of greater self-awareness and emotional regulation.

Analysis of the field logs revealed certain behaviors demonstrating increased autonomy, initiative, and perseverance in the face of challenges. For example, during the first sessions, students constantly sought help to read instructions or start an activity. By the third week, 75% of students were starting tasks on their own, without direct guidance. Similarly, when faced with errors or more demanding activities, a decrease in impulsive reactions or withdrawal was observed, replaced by successive attempts at resolution, often accompanied by positive verbalizations ("I'll try again," "I'm almost there"). During interviews conducted with parents at the end of the intervention, testimonies confirmed these results. The majority of them reported a positive change in their children's attitude toward mathematics and a boost in their self-confidence. 85% of parents indicated that their children asked to "play" alone with the platform at home, which demonstrates their appropriation of the tool outside of the classroom. Others also reported that their children began to teach the content learned to their siblings or friends and carried out the activities outside of class. This transfer of knowledge and enthusiasm to non-formal settings is a significant indicator of meaningful learning.

It should be noted that, while the results were clearly positive, areas for improvement were also identified. Some students with hypersensitivity to sounds requested the complete removal of reward sounds, reflecting the need for more sensory personalization features. Furthermore, activities involving extensive reading (i.e., long problem statements) caused some fatigue among ADHD students, and audio descriptions combined with other graphic supports were incorporated in later versions. These results confirm the need to continuously improve the user experience. In the case of standardized test results, a comparison of items was also made based on their difficulty level. Easy-level problems (such as addition and counting) were correctly solved by 90% of students at the beginning of the process. This figure increased to 98% by the end of the intervention, representing a small but notable improvement in accuracy. For medium-level tasks (i.e., single-digit multiplication and shape naming), the accuracy level increased from 55% to 85%. For high-level tasks (mathematical logic, equivalent fractions, patterns), the greatest increase was recorded: from 29% to 68% correct answers. This indicates that the platform not only reinforced prior knowledge, but also enabled new learning in areas where these students previously struggled.

IV.- CONCLUSIONS

This research demonstrated that an intervention approach focused on accessibility, personalization, gamification, and positive reinforcement, supported by technology, can have a significant impact on students' learning achievement and impact on their mathematics learning. The results validate the overall hypothesis of the research: well-designed and properly implemented educational technology is a powerful tool for ensuring inclusion, reducing cognitive and affective barriers, and promoting deeper and richer learning among students with special educational needs.

One of the key findings of the research is the dramatic improvement in students' academic performance after the intervention. Quantitative results before and after deployment indicate an average 30% increase in the rate of correct solution of mathematical problems, with higher percentages in certain concept categories such as fractions, elementary geometry, and shape identification. This improvement proved useful not only for students with ADHD, but also for students with ASD, demonstrating the effectiveness of the platform's design in meeting heterogeneous needs, hence its ease of use with a diverse population. This result is particularly relevant given that mathematics has always been among the most challenging subjects for these students, primarily due to its abstract nature, but also due to the rigidity of traditional teaching methods. Through its graphic, dynamic, and manipulative content, the platform demystified abstract ideas into practical experiences, thus facilitating assimilation and learning.

The platform's positive impact was not limited to the intellectual domain, but also affected the motivational and emotional spheres. One of the main challenges in educating students with ASD and ADHD is managing the frustration, worry, and lack of motivation that typically accompany the school environment, particularly for subjects considered difficult or impossible to learn. Analysis of completed and returned adapted questionnaires, direct observation, and parent interviews significantly reduced the negative effects on mathematics learning. At the beginning of the process, mathematical activities aroused profound rejection, apprehension, or considerable boredom, but attitudes changed radically toward the end of the cycle: students became more participatory, more interested, and more persistent, even for activities presenting challenges. This affective change is a key indicator of the intervention's success, as intensive learning is very difficult to achieve without positive affective appraisal, especially among students with pre-existing learning difficulties. Motivation, in turn, was a crucial element in the platform's success. The gamification elements it included—points, rewards, levels, and badges—were instrumental in maintaining the interest and motivation of students, especially those with ADHD, who are extremely sensitive to new stimuli and instant rewards. This system, far from compromising the learning process, helped consolidate self-regulation, resilience, and confirm success without subjecting students to negative corrections and punishments. Thus, constant positive reinforcement—through positive reinforcement, visual stimulation, and auditory rewards—also created a safe learning environment, where mistakes were not considered a failure, but a learning experience. This approach, in line with constructivist and humanist pedagogies, was particularly beneficial for students who had already accumulated academic frustrations. Another significant contribution of the research lies in the validation of personalization as a design principle when creating digital learning content for students with ASD and ADHD. The ease with which font size, exercise difficulty level, learning speed, visual contrast, and content presentation mode (visual, auditory, or both) could be personalized made it possible to very effectively take into account the cognitive and sensory individuality of students. These concessions, and not token concessions, constitute a pedagogical right and a structural necessity to enable productive access to knowledge. To this end,

the platform was not just a place of learning, but a space of empowerment, where learners could exercise some control over their learning process; they thus felt more autonomous, competent, and effective. These three aspects, all essential to self-determination theory, were empirically observed in the students' behavior as they gradually became more active and engaged in the learning process. Similarly, this study also demonstrated how digital technologies can reconfigure the teacher's role in the learning process, particularly in inclusive learning environments. The system allowed facilitators to adopt a more mediating, observant, and personalized role, far removed from the traditional content delivery model. With the reduced need for explicit interventions to correct errors or clarify instructions, teachers were able to devote more time to observing individual learning processes, identifying strengths and emerging needs, and providing more targeted and timely intervention. This qualitative restructuring of the pedagogical role not only optimizes the teaching process but also preserves the professional health of teachers, who benefit from better coping strategies to address the challenges of diversity in the classroom.

While the study's results are very encouraging, challenges and limitations were also encountered, which should be kept in mind in future research and development. One of these concerns the heterogeneity of students with ASD and ADHD. Although they share certain diagnostic characteristics, these students exhibit considerable heterogeneity in terms of cognitive skills, learning styles, emotional responses, and sensory needs. Therefore, any online platform that aims to be fully inclusive must offer considerable flexibility and features that allow for personalized adjustments for all students. Based on this, proposals are made for the development of artificial intelligence and machine learning technologies capable of predicting usage patterns and offering personalization options based on user activity.

Finally, this research confirms the need to reformulate educational inclusion in a structural, rather than compensatory, manner. The goal is not to modify an inherently exclusive system, but to modify this structure so that all children—with their differences, abilities, disabilities, and rhythms—can study, develop, and feel included. Digital technologies are not magic formulas, but effective facilitators of this process of change, if they are used in the service of ethics, critique, and a thoughtful pedagogical vision. This scenario of a web-based platform used in mathematics instruction for students with ASD and ADHD demonstrates that it is possible to develop effective, motivating, and humanizing tools capable of addressing diversity in the classroom and providing genuine learning opportunities.

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