# Empowering Students with Autism Spectrum Disorder in Mathematics. A Case Study of Successful Interventions

# Empoderando a Estudiantes con Trastorno del Espectro Autista en Matemáticas. Un Estudio de Caso de Intervenciones Exitosas

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Fecha de recepción: 17 de abril de 2024
Fecha de aceptación: 31 de julio de 2024

**Summary.** This paper presents a case study of John, a high school student with Autism Spectrum Disorder (ASD), and his journey towards pursuing computer engineering at Las Tunas University. Despite John's strengths in computer science and programming, he faced challenges in mathematics, specifically geometry and logarithms, due to ASD-related difficulties in abstract thinking, sensory processing, and executive functioning. To support John, a multi-faceted intervention approach was adopted, including a structured learning environment, visual aids and manipulatives, breakdown of complex tasks, multisensory instruction, technology integration, positive reinforcement, peer collaboration, and university preparation. John's significant progress highlights the effectiveness of individualized support and a strengths-based approach in empowering students with ASD to overcome mathematical challenges. This case study serves as a valuable resource for educators and families supporting students with ASD in STEM fields, emphasizing the importance of tailored interventions and collaborative efforts.

**Keywords:** Mathematics, Autism Spectrum Disorder, Interventions.

**Resumen.** Este artículo presenta el caso de estudio de John, estudiante de Educación Preuniversitaria con Trastorno del Espectro Autista (TEA) y su camino hacia la Ingeniería Informática en la Universidad de Las Tunas. A pesar de sus habilidades en Informática y programación, John enfrentó desafíos en matemáticas, específicamente Geometría y logaritmos, debido a dificultades propias del TEA en pensamiento abstracto, procesamiento sensorial y función ejecutiva. Para apoyarlo, se implementó un enfoque de intervención multifacético: entorno de aprendizaje estructurado, ayudas visuales y manipulativas, desglose de tareas complejas, instrucción multisensorial, integración de tecnología, refuerzo positivo, colaboración entre pares y preparación universitaria. El progreso de John evidencia la efectividad del apoyo individualizado y un enfoque basado en fortalezas para que estudiantes con TEA superen desafíos matemáticos. Este caso busca servir como recurso para educadores y familias que apoyan a estudiantes con TEA en campos STEM, destacando la importancia de intervenciones personalizadas y la colaboración.

**Palabras Clave:** Matemática, Trastorno del Espectro Autista, Intervenciones.

## 1 Introduction

Meet John, a 17 years old senior high school student who is passionate about computers and has autism spectrum disorder (ASD). He has always been fascinated by technology and loves tinkering with computers in his free time. He is very good at coding and has already created a few small software programs on his own.

John's ASD means that he faces some challenges in social interactions and has difficulty with certain sensory experiences. However, he has learned to cope with these challenges and has developed some strategies to help himself manage his symptoms.

John is determined to pursue a degree in computer engineering at Las Tunas University. His family and mentors have researched several universities, and their computer engineering programs, and have identified that this profession suits his interests and abilities. They have also connected with a few current students with ASD who are studying computer engineering to get advice and support. So, he could be the first student with ASD ever studying any engineering career in this Cuban university.

John's school has been very supportive of his goals and has provided him with accommodations, such as extra time on tests, to help him succeed academically. However, he is unable to be in a support group for students with ASD where he could connect with peers who face similar challenges and share strategies for coping.

Despite the challenges he faces, John is excited about the opportunities that studying computer engineering can bring him. He hopes to use his skills to develop new technologies that can help people with disabilities and make the world a better place.

As a student with ASD, John faces some difficulties in Mathematics. These difficulties include:

- *Difficulty with abstract thinking:* He has difficulty with abstract concepts, which can make it challenging for him to understand advanced mathematical concepts such as algebra or geometry.

- *Sensory issues:* He has had hypersensitive to certain sensory inputs, such as noise, which can make it difficult for him to concentrate on mathematical problems.
- *Difficulty with social communication:* Mathematics often involves group work and collaboration, which have been challenging for him, because he struggles with social communication.
- *Rigid thinking:* He often has a tendency towards rigid thinking, which can make it difficult for him to see alternative ways of approaching mathematical problems.
- *Difficulty with executive functioning:* Executive functioning refers to a set of cognitive skills that are necessary for planning, organizing, and completing tasks. He struggles with executive functioning, which make it difficult for him to stay focused on mathematical tasks and complete them in a timely manner.

Despite these challenges, with appropriate support and accommodations, John can still succeed in mathematics and pursue his passion for computer engineering.

## 2 Background information

The neurodevelopmental disorder known as ASD is characterized by deficits in social interaction and communication as well as the presence of restricted, repetitive behaviors [1]. It is a spectrum disorder, which means that individuals with ASD can have a wide range of symptoms and abilities.

Mathematics is a subject that can be particularly challenging for individuals with ASD. Some studies have shown that students with ASD tend to have lower math achievement scores compared to their neurotypical peers. Additionally, some individuals with ASD may have difficulty with specific aspects of math, such as understanding abstract concepts, following multi-step instructions, and solving word problems.

One reason for the difficulties in math among individuals with ASD may be related to their cognitive processing. People with ASD tend to have strengths in visual-spatial processing, but they may have difficulties with executive function, which can affect their ability to organize and plan complex tasks like math problems. In addition, they may have difficulties with working memory, which can impact their ability to hold information in their mind long enough to solve math problems.

Sensory issues can also play a role in math difficulties for individuals with ASD. They may be easily distracted by environmental stimuli such as sounds, lights, or textures, which can interfere with their ability to focus on math problems.

In conclusion, individuals with ASD may face unique challenges in learning mathematics due to a combination of factors related to cognitive processing, executive function, working memory, and sensory issues. However, with appropriate support and accommodations, many individuals with ASD can succeed in math and pursue careers in STEM fields.

## 3 Addressing these difficulties

There are several interventions that have been suggested to address the difficulties that individuals with ASD may face in learning mathematics. Here are a few examples, along with relevant references:

- *Multisensory Teaching*: Research has shown that using multisensory teaching methods can help individuals with ASD better understand mathematical concepts. This approach involves incorporating multiple senses, such as visual and auditory, into the teaching of math. For example, teachers can use manipulatives, diagrams, and videos to help illustrate concepts. [2]
- *Assistive Technology*: Assistive technology can provide additional support for individuals with ASD in math. For example, software programs that use visual representations or gamification can help make math more engaging and easier to understand. [3]
- *Explicit Instruction*: Providing explicit instruction and breaking down mathematical concepts into smaller, more manageable steps can be helpful for individuals with ASD. This approach involves being very clear and precise in instructions and breaking down complex tasks into smaller, more manageable steps. [4]
- *Peer Tutoring*: Peer tutoring has been shown to be an effective strategy for improving math skills for individuals with ASD. This approach involves pairing a student with ASD with a neurotypical peer who is skilled in math. The peer tutor can provide additional support, explanation, and guidance as needed. [5]
- *Individualized Accommodations*: Providing individualized accommodations can also be helpful for students with ASD in math. For example, allowing extra time on tests, providing a quiet testing environment, or

breaking assignments into smaller parts can help students manage their symptoms and succeed academically. [6]

Overall, addressing the difficulties that individuals with ASD may face in math involves using a range of interventions and accommodations that are tailored to their specific needs and learning styles.

## 4 Experimentos y ResultadoSharing experiences

Here are some examples of teachers' experiences working with students with ASD in mathematics:

- Teachers reported that students with ASD benefited from the use of computer-based learning environments for math instruction. A study found that the use of multimedia resources and interactive simulations helped engage students with ASD and promote their understanding of mathematical concepts. They draw attention to significant ramifications for educational interventions involving the provision of metacognitive assistance students with ASD in order to address classroom math performance deficiencies. [7]
- Another study examined the use of a virtual reality math learning environment for students with ASD. The study found that the virtual reality environment helped students with ASD overcome their anxiety and improve their performance in math tasks. [8]
- Teachers have also reported success using peer-mediated interventions to support students with ASD in math. Teachers reported that peer-mediated interventions helped students with ASD improve their math skills and social interactions with their peers. [9]
- Teachers have also found success using visual supports and manipulatives to support students with ASD in math. Teachers reported that the use of visual supports such as graphic organizers and manipulatives such as blocks and shapes helped students with ASD better understand mathematical concepts. [10].

Overall, these studies suggest that teachers have found success using a variety of interventions and technologies to support students with ASD in mathematics. However, it's important to note that individualized support and accommodations may be necessary to meet the unique needs of each student with ASD.

## 5 Some successful interventions for helping John overcome his challenges

Here are some interventions that were helpful for John to overcome challenges in mathematics, especially when he was struggling with geometry and logarithms:

- *Provided a Structured Learning Environment*: John benefited from a structured learning environment with clear expectations and routines. For example, when John struggled with understanding geometry, it was useful to use pictures to explain the properties of shapes or use videos to demonstrate geometric constructions. Teacher created a consistent routine for math instruction and used visual supports such as schedules, checklists, and organizers to help John with planning and organizing his work.
- *Used Visual Aids and Manipulatives*: Visual aids and manipulatives helped John understand mathematical concepts. Teacher used visual representations, diagrams, and charts to help illustrate abstract concepts, and manipulatives such as counters and shapes to help John learn math through hands-on activities. For example, when John struggled with understanding abstract concepts in math, such as fractions or algebraic equations, it was helpful to use concrete objects or manipulatives such as blocks or fraction circles to help him visualize the concepts. Visual aids such as diagrams or graphic organizers were also used to help John organize his thoughts and see the relationships between different concepts. Since John also battled with understanding logarithms, it was used color coding to visually differentiate between the different parts of a logarithmic equation. For example, they used one color to represent the base, another color to represent the exponent, and a third color to represent the result. This helped John better understand the concept of logarithms.
- *Broke Down Complex Tasks*: John had difficulty with multi-step tasks, so breaking down complex math problems into smaller steps was helpful. Teacher provided step-by-step instructions, used visual supports, and broke down problems into smaller, more manageable parts. For example, teacher broke down the steps involved in constructing a triangle and taught each step separately. He also broke down complex shapes into smaller, simpler shapes. For example, a hexagon was broken down into six triangles and a rectangle was broken down into two squares. Teacher also broke down logarithms into smaller steps like to introduce the concept of exponents and show how they relate to logarithms, define logarithms as the inverse operation of

exponents and provide examples of logarithmic functions, simplify logarithmic expressions by using the properties of logarithms, practice solving equations by applying the rules of logarithms and use real-world examples to help John understand how logarithms are used in practical applications such as to measure sound levels or earthquake magnitudes.

- *Used Multisensory Instruction*: Multisensory instruction involved engaging multiple senses, such as visual, auditory, and kinesthetic, to help John learn math. Teacher used videos, songs, and games to help reinforce math concepts, and incorporated movement and hands-on activities to make learning more engaging. For example, to help John with his problems in geometry, it was used blocks to teach the concept of volume, and tangrams to teach the concept of congruence. Teacher also used tactile experiences to help John understand geometric concepts. For example, he had him trace shapes with his fingers or use different textures to help him differentiate between different shapes. John got better about his sensory issues, nonetheless, it was understood that it was good to provide him with a quiet space to work, minimize distractions in the classroom, and let him take breaks when he wanted to.
- *Used technology*: Technology was a valuable tool for John. Math software and online resources helped him to learn and practice logarithmic concepts in a way that was engaging and interactive. For example, Graspable Math provided a visual and interactive representation of logarithmic concepts, which helped John to understand the concept better. He manipulated the visual representation of logarithmic expressions and equations, which helped him to see the relationships between the different parts of the expression or equation. This tool provided immediate feedback that was particularly helpful for John because he struggled with identifying and correcting errors on his own. It provided step-by-step guidance and reduced the cognitive load required by providing a visual interface that allowed him to manipulate expressions and equations, he was focused on the mathematical concepts rather than the mechanics of solving the problems. Overall, Graspable Math was a valuable tool to support John in learning logarithmic concepts. By providing a visual and interactive interface, step-by-step guidance, error correction, and feedback, Graspable Math helped him to develop a deeper understanding of logarithmic concepts and build his confidence in mathematics. Excel was also used to create interactive learning activities that engaged John. By inputting the logarithmic function into Excel, he saw how changes in the logarithmic base and coefficient affect the graph. So, it helped him understand logarithmic concepts in a concrete and visual way.
- *Provided Positive Feedback and Reinforcement*: John benefited from frequent positive feedback and reinforcement to help build his confidence and motivation. Teacher provided praise for effort and progress and used rewards such as tokens or points to reinforce positive behavior and academic achievement. They also repeated key concepts frequently to help reinforce learning. For example, when teaching the difference between a square and a rectangle, they kept repeating the key differences until John understood.
- *Provided Proper Peer Collaboration*: Appropriate peers were selected for John to work with. Teacher chose peers who were patient, understanding, and willing to help. These peers also had a good understanding of the subject matter. It was provided structured peer collaboration activities, designed to help John build his confidence in his ability to solve math problems. This allowed him to learn from his peers and receive additional support and feedback. John benefited from peer collaboration to enhance interpersonal relationships. It also helped him develop social skills and build friendships with his classmates.
- *Provided University Spaces*: John expressed his expectations and interest in pursuing a university degree in a university meeting [11]. This helped him with his attitude towards overcoming challenges in learning mathematics. He stated that he wanted a career in computer engineering and assured that he was preparing to achieve his goal. His interventions made the university's administrators and teachers aware of the need to create conditions to attend to his diversity, with complex characteristics in his development, but with real potential to pursue the career he aspires to.

These interventions were helpful for John to overcome challenges in mathematics and improve his understanding and skills in geometry and logarithms. However, it's important to note that every student is unique and may require different interventions and accommodations to support their learning. Teachers and educators should work closely with students and their families to develop individualized plans and interventions to meet their specific needs and help them achieve academic success.

## 6 John's successes and progress in his studies

John is a remarkable senior high school student who has made significant progress in his academic journey despite facing some challenges in learning mathematics. He has demonstrated great perseverance and resilience, which are essential qualities for success in any field of study.

He has taken steps to address his difficulties in mathematics. He has sought out additional support from his teachers and peers and has been attending after-school tutoring sessions regularly. Through his hard work and dedication, he has made steady progress in his math studies and has shown improvement in his grades.

Overall, John is a shining example of a student who has overcome obstacles and achieved success through hard work, perseverance, and dedication. His passion for computer engineering and his determination to succeed are admirable qualities that will serve him well in his future studies and career. It is a pleasure to emphasize John's successes and progress in his studies, especially in the field of computer engineering:

- *Academic excellence*: John has consistently performed well in his academic studies, consistently achieving excellent grades in his computer science courses. He has demonstrated a strong understanding of complex concepts and has applied them effectively in his coursework.
- *Passion for computer engineering*: John's passion for computer engineering is evident in his academic pursuits. He has shown a strong interest in programming languages and has consistently demonstrated a keen interest in learning new software and technologies.
- *Research and Innovation*: John has demonstrated creativity and innovation in his research projects, applying computer science and engineering principles to real-world problems. His projects have been recognized by his teachers, peers, and experts in the field.

Overall, John's successes and progress in his studies are impressive, and he has shown exceptional talent and potential in the field of computer engineering. With his passion, dedication, and leadership skills, there is hope that he will excel in his future studies at the university and make significant contributions to the field of computer engineering. There is no doubt, he will be the first student with ASD ever studying computer engineering in Las Tunas University. Teachers have a year to get ready for applying some new interventions and helping John overcome his challenges. It is worthy.

## 7 Conclusions

John is a student with ASD who is struggling with math in senior high school but is planning to study computer engineering at Las Tunas University next year. To help John overcome his difficulties and succeed in his future studies, the following interventions should be implemented:

- Identify John's strengths and interests in computer engineering and use them to motivate him and increase his engagement in math-related activities.
- Use multisensory instruction techniques that cater to John's learning style, such as visual aids, kinesthetic activities, and verbal cues.
- Implement a structured learning plan that breaks down math concepts into smaller, more manageable steps, and provides regular feedback and support.
- Utilize assistive technology such as calculators, graphing software, and other math-specific software that can help John overcome challenges with complex math concepts.
- Encourage John to seek help from his teachers and peers and provide opportunities for him to collaborate with others in group projects and activities.

Overall, with the right support and interventions in place, John can overcome his challenges in math and excel in his future studies in computer engineering at Las Tunas University.

Supporting students with ASD in their academic pursuits is crucial for their academic success, social-emotional well-being, independence, future success, and promoting inclusivity and diversity. It is important for educators, parents, and the wider community to work together to ensure that students with ASD have access to the support and resources they need to thrive academically and beyond. It´s a pleasure to strongly encourage readers to learn more about ASD and to consider ways they can help students with these challenges succeed.

## References


1. American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders: DSM-5™. 5th ed. American Psychiatric Publishing, Inc. (2013). doi: 10.1176/appi.books.9780890425596.
2. McClenney-Rosenstein, L.: Sensory Integration: Exploring the Benefits for Students with Autism at the Secondary Level. Doctoral dissertation, Northeastern University (2019).
3. Root, J. R., Ingelin, B., Cox, S. K.: Teaching Mathematical Word Problem Solving to Students with Autism Spectrum Disorder: A Best-Evidence Synthesis. Education and Training in Autism and Developmental Disabilities, 56(4), 420-436 (2021).
4. Root, J. R.: Effects of explicit instruction on acquisition and generalization of mathematical concepts for a student with autism spectrum disorder. Research in Autism Spectrum Disorders, 57, 1-6 (2019).
5. Haas, A., Vannest, K., Smith, S. D.: Utilizing peers to support academic learning for children with Autism Spectrum Disorder. Behavior Analysis in Practice, 12, 734-740 (2019).
6. Keith, K.: Academic Outcomes for Students with Autism in Middle and High School. Master thesis. George Mason University (2021). https://hdl.handle.net/1920/11918
7. Maras, K., Gamble, T., Brosnan, M.: Supporting metacognitive monitoring in mathematics learning for young people with autism spectrum disorder: A classroom-based study. Autism, 23, (1), 60-70 (2019).
8. Delisio, L. A., Dieker, L.: Avatars for Inclusion: Innovative mathematical approaches for students with autism. Childhood Education, 95(3), 72-79 (2019).
9. Tan, P., Alant, E.: Using peer-mediated instruction to support communication involving a student with autism during mathematics activities: A case study. Assistive Technology, 30(1), 9-15 (2018).
10. Taylor, J. C., Hwang, J.: Science, Technology, Engineering, Arts, and Mathematics Remote Instruction for Students with Disabilities. Intervention in School and Clinic, 57(2), 111-118 (2021).
11. Hernández López, R. M., Gamboa Graus, M. E., Rivas Almaguer, B. N.: Meeting of students with disabilities for a more accessible and inclusive university. In 2022 International Conference on Inclusive Technologies and Education (CONTIE), pp. 71-76. IEEE (2022).