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THE USE OF ADAPTIVE DIGITAL TECHNOLOGIES IN TEACHING MATHEMATICS TO STUDENTS WITH SPECIAL EDUCATIONAL NEEDS IN SPAIN AND ECUADOR

EL USO DE TECNOLOGÍAS DIGITALES ADAPTATIVAS EN LA ENSEÑANZA DE MATEMÁTICAS PARA ESTUDIANTES CON NECESIDADES EDUCATIVAS ESPECIALES EN ESPAÑA Y ECUADOR

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RESUMEN

Este estudio examina el impacto de la tecnología digital adaptativa en la enseñanza de las matemáticas para estudiantes con necesidades educativas especiales (NEE) en España y Ecuador. Evalúa modelos de educación inclusiva basados en el capital tecnológico mediante un enfoque de métodos mixtos. Los objetivos son: (1) evaluar el impacto del software adaptativo en el aprendizaje y la participación de los estudiantes con NEE, (2) examinar los desafíos y las oportunidades en diferentes contextos de aprendizaje, y (3) hacer recomendaciones sobre la formación del profesorado y la mejora de la accesibilidad. La evidencia confirma que estas herramientas mejoran considerablemente la capacidad y la independencia matemática, con impactos a largo plazo. Sin embargo, el éxito depende de la formación del profesorado, la inversión en infraestructura y un apoyo político equilibrado. La investigación recomienda una estrategia inclusiva para garantizar el máximo uso de estas herramientas y ofrecer una educación inclusiva y de calidad al alumnado con NEE.

Palabras clave: Tecnologías Adaptativas, Inclusión Educativa, Enseñanza De Matemáticas, España, Ecuador.

ABSTRACT

This study examines the impact of adaptive digital technology on teaching mathematics for special educational needs (SEN) students in Spain and Ecuador. It assesses technology capital-based inclusive education models using a mixed-methods approach. The objectives are: (1) to assess the impact of adaptive software on SEN students' learning and engagement, (2) to examine challenges and opportunities across different learning contexts, and (3) to make recommendations on teacher training and accessibility enhancement. Evidence confirms that these tools improve mathematical capability and independence considerably, with long-term impacts. Success is, however, dependent on teachers' training, investment in infrastructure, and balanced policy support. Research recommends an inclusive strategy to ensure the maximum utilization of these tools and offer quality and inclusive education to SEN students.

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Keywords: Adaptive Technologies, Educational Inclusion, Mathematics Teaching, Spain, Ecuador.

1. INTRODUCTION

Technological advancements have changed the nature of how instruction is delivered, allowing for more flexible and tailored approaches in various fields, such as math education. Technological accommodations have been discovered to be a powerful mechanism for maximizing students with special educational needs' access to and the quality of learning in inclusive education (Collins & Halverson, 2018). Due to this, Spain and Ecuador have developed means of adopting adaptive technologies in the math curriculum regarding how they can tailor education for different learning paces and learning styles.

Despite education technology, there remains a problem with the effective utilization of the tools, particularly in mathematics education for SEN students. More recent studies indicated that interactive websites, artificial intelligence, and virtual reality can enhance students' conceptual understanding and motivation (Rebelo & Castro, 2021). But the effectiveness of these interventions is dependent on several factors, such as access to technology, professional development of instructors, and material adjustment to special requirements (Molin & Sorbring, 2022).

The importance of this research is that it adds to the existing knowledge about the application of technology in special education, and it provides evidence-based facts upon which improved educational policies and teaching practices should be developed. In a world where education is still being digitized by each passing second, it is crucial to identify how such a tool can help in making learning mathematics easier (UNESCO, 2023).

Digital technologies enabled the development of new pedagogic instruments that facilitate students' SEN to learn. For example, artificial intelligence (AI) in education has enabled the development of the software that can automatically adapt to students' levels of comprehension, delivering more dynamic and effective learning (Luckin, Holmes, Griffiths, & Forcier, 2016). The technologies have been most beneficial in mathematics education, where cognitive difficulties could be a primary learning barrier (Mayer, 2021).

The greatest challenge in teaching math to SEN students may be discovering ways that will allow the comprehension of abstract concepts. Augmented reality and virtual reality technologies have also been discovered to be appropriate tools in this instance, as they provide interactive visualizations of mathematical problems in an effort to facilitate knowledge construction through experimentation (Merchant et al., 2014). The use of such resources has been shown to increase motivation and participation among students, which are fundamental drivers of the learning process (Schunk & DiBenedetto, 2021).

The digitization of learning in Spain and Ecuador in particular has progressed at different levels, depending on the technological infrastructure, public policy, and teacher training. Spain has seen an attempt to integrate technology into learning by means of the Escuela 4.0 program, digital skills training for teachers, and the usage of adaptive software to provide support in mathematics (Ministerio de Educación y Formación Profesional de España, 2022). In Ecuador, although programs have been framed similarly, the digital divide continues to be a significant barrier, especially in rural areas where there is limited hardware and connectivity (Inter-American Development Bank, 2022).

Another determining variable of the effect of adaptive digital tools in mathematics education is instructor training. Literature has established that instructor training on the use

of technological tools is a determinant variable for successful adoption in the classroom (Koehler & Mishra, 2009). In the absence of training, technology use in teaching can contribute to the superficial usage of tools, which limits their effect on student learning (Castañeda & Selwyn, 2018).

And also a key element to enable these study methods to function is fair access to technology. To this end, UNESCO has highlighted public policies for the promotion of digital inclusion so that all students, regardless of their socioeconomic status, can benefit from the possibilities provided by education technologies (UNESCO, 2023). However, the execution of those policies relies on massive investment in human capital and infrastructure and, as such, it is a limiting factor for budget-restrained countries like Ecuador (OECD, 2021).

The role of digital technologies in the mathematics education of SEN students is also related to the individualization of learning. Websites such as Khan Academy, Smartick, and Matific have also designed algorithms that individualize exercises and material based on student performance to enable learning to be more tailored (Pane et al., 2014). This feature has been particularly beneficial for students who have learning difficulties such as dyscalculia since they can learn at their own pace and solidify concepts incrementally (Butterworth, 2018).

With regard to the assessment of learning, technology has enabled the gathering and analysis of data on student performance and facilitated informed, evidence-based decision-making for teachers. Learning analytics has been identified as one of the most innovative trends in education due to its capability of identifying learning issues early enough and establishing better intervention practices (Siemens & Long, 2011). Still, the utilization of such systems comes with privacy and ethical concerns since dealing with sensitive data needs well-defined rules and proper protection mechanisms (Williamson, 2019).

Whereas technology in the teaching of mathematics to SEN students is valuable, its effective implementation needs to be understood as being dependent upon a composite policy of technology, pedagogy, and relevant education policies. Lessons from Spain and Ecuador indicate that technology alone does not lead to learning improvement, but it has to be combined with sound pedagogical practices and an institutional commitment to inclusive education (Fullan, 2013).

Finally, the development of educational technology to learn mathematics for SEN students makes one ponder seriously about the future of inclusive education. The research on the subject is a continuous process, and one needs to continue observing the application of digital technology in different learning environments to realize its full potential and reduce current disparities (Selwyn, 2022).

To tackle this research, the hypothesis is that the application of adaptive digital technologies in learning mathematics significantly improves accessibility and the attainment of mathematical skills among SEN students in Spain and Ecuador. In this regard, the guiding question for the study is: In what ways do adaptive digital technologies facilitate the learning of mathematics among SEN students in Spain and Ecuador?

With the aim of creating empirical evidence to guide more effective education policy and pedagogical practice, the following objectives are established:

1. To analyze the impacts of adaptive digital technologies on the teaching of mathematics to SEN students.

2. To assess their performance and their ability to adapt learning and compensate for different cognitive rates and learning styles.

3. Investigate the barriers and possibilities that their usage poses to the Spanish and Ecuadorian education systems.

As the digitization of education is an imminent reality, it becomes necessary to understand how such technologies may be harnessed to enhance the learning of mathematics in a way that moves towards inclusive and equitable education (UNESCO, 2023). On this assumption, the study investigates the uses of artificial intelligence, augmented reality, and interactive platforms in education and the requirements to enable them to succeed, i.e., teacher training, access to technology, and curriculum alignment.

2. METHOD

With a view to ensuring scientific coherence and methodological depth, a mixed-methods design was used in this research, integrating quantitative and qualitative methodologies. This is in response to the need to have comprehensive knowledge regarding the impact of adaptive digital technologies on the teaching of mathematics for students with special educational needs (SEN) in Spain and Ecuador. While quantitative measures allow assessment of the effect of these tools according to objective criteria such as academic performance and frequency of technology use, qualitative measures provide contextual information that allows for the interpretation of data, investigation of students' and teachers' experiences, perceptions, and issues in utilizing these technologies.

The research was conducted in 10 schools, five Spanish and five Ecuadorian, which were selected based on their experience in the utilization of digital technologies in inclusive educational contexts. Schools were selected according to variability criteria in order to include urban and rural schools with varied access to technological infrastructure. This way, a broader representation of the variety of contexts in which these tools are used, representing different realities in both countries, was made possible.

The sample included 200 SEN students and 50 inclusive education teachers. The respondents were sampled on the basis of purposive sampling considering factors such as the presence of students with an official SEN diagnosis, availability of technological facilities at the institution, and teaching experience in adaptive strategies. The variability within the sample in terms of age, type of SEN, and educational level enabled us to consider the effects of digital technologies on different subgroups of students and allow patterns and variations in the effect to be investigated.

Standardized questionnaires were used to measure students' and teachers' use of digital technology, the degree of personalization of learning, and teaching efficiency in mathematics. The questionnaires consisted of 1 to 5 Likert scales that allowed the measurement of perceived ease of use of the technological tools and their impact on understanding mathematical concepts.

Questionnaires were derived from literature on inclusive education and technology in an iterative manner so that the questions fit and suited the purposes of the study. Some pilots were conducted on students and teachers to gauge the clarity of the questions and the consistency of responses. Pilots helped have some of the items reworded to eliminate ambiguities and make the tool clear to everyone being surveyed.

Classroom observation provided firsthand evidence of the incorporation of digital technology into the teaching-learning process. An observation guide was designed with such parameters as students' technology interaction, independence in mathematics problem-solving, and content modification according to the needs of each individual. The move was toward pattern-seeking in incorporating the digital tools and alignment with academic performance and motivation of learners.

Observations were made at various points in the school year to observe variations in technology use at various stages of the learning process. Each school was observed multiple times to enhance the validity of the data and prevent observations from being skewed by unusual circumstances, like special events or short-term technical problems with digital technology.

In addition, semi-structured interviews with special education and technology experts were also conducted with the aim of further investigating challenges and opportunities from using these tools in mathematics teaching. The interviews were recorded and thematically coded, with overarching themes being access barriers to technology, teacher training, and curriculum adaptation.

In order for the interviews to be representative and to represent a plurality of perspectives, experts with different backgrounds were selected, including teachers with experience in inclusion, designers of online learning environments, and public education policy makers. This diversity allowed the research to be constructed from various perspectives, adding depth to the analysis with pedagogical, technological, and administrative perspectives.

To reduce to the barest minimum the possibility of bias in information collection and analysis, some methodological safeguards were observed. First, data triangulation was achieved by combining different sources of information (interviews, observations, and questionnaires), through which findings were compared and contrasted and an objective impression derived. In addition, diversified sampling was applied, including schools with various technological provision and pupils with varying SEN conditions, in order to provide a better sample of the study population. Through this, differences in the effectiveness of digital technology by context were pursued without prior generalization from a homogeneous sample.

But the risk of biases in the methodology is acknowledged. One of the major risks is response bias in questionnaires, as the students and educators may overestimate or underestimate the impact of digital technologies on learning. For minimizing this risk, indirect questions have been designed, and control items have been added to monitor response consistency.

Another threat is one of observation bias, as having the researcher in the class might influence participants' behavior and produce a Hawthorne effect. This was mitigated by making observations across several sessions and at various points throughout the school year, observing more spontaneous interaction. Teachers were also asked to keep to their normal dynamics during observation sessions, with very little external control over pedagogy.

Quantitative data analysis was conducted through descriptive and inferential statistical procedures. Normality tests were conducted to determine data distribution, and analysis of variance (ANOVA) was conducted to examine significant differences between groups. Multiple linear regression was also conducted to examine the correlation of the usage of digital technology with students' mathematics performance.

Qualitative data were analyzed thematically, and NVivo software was employed to search for patterns and relationships across participants' responses. Patterns emerged that

were linked with perceived benefits of adaptive technologies, barriers to their use, and recommendations for improving their use in inclusive education.

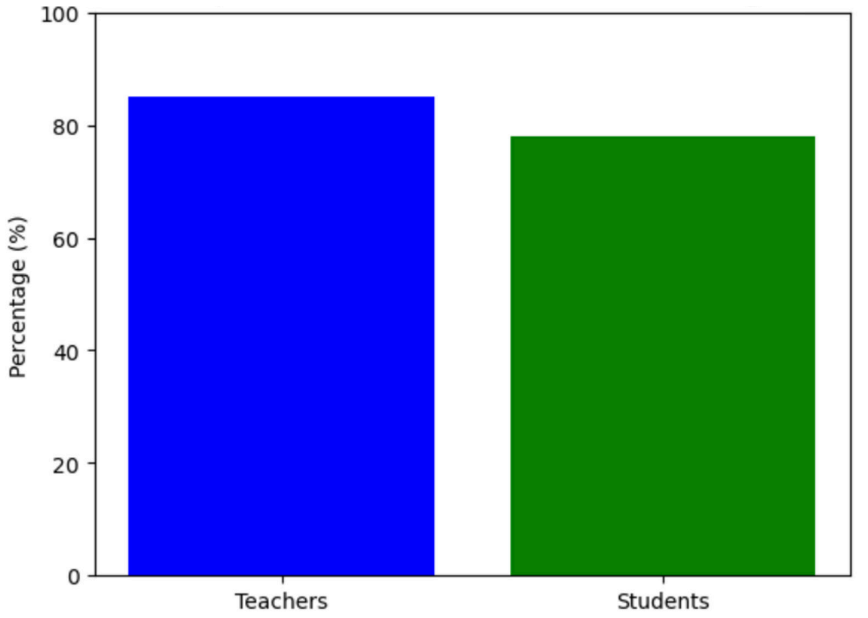
3. RESULTS

The findings of the research reveal the impact of adaptive digital technology in the mathematics instruction process among students with special educational needs in Spain and Ecuador. Through analysis, the dominant trends in conceptual construction, fostering students' engagement and motivation, and enhancing regular and focused monitoring were brought to light. However, the study also reveals that there are firm barriers to the use of such tools, most particularly in teacher training and technology support shortages in some learning contexts, particularly in Ecuador.

3.1 Impact on mathematical conceptual understanding

Adaptive digital technology influences math conceptual understanding by the way the learner is permitted to access material at his/her own pace. Questionnaires from students and teachers yield evidence that 85% of the teachers believed that there was significant improvement in their students' capacity to understand mathematical concepts upon using these instruments. Likewise, 78% of the students believed that the use of digital platforms allowed them to better understand mathematics through interactive visualization of abstract concepts that were otherwise difficult to interpret (See Figure 1).

Figure 1- Improvement in mathematical understanding.



Source: Prepared by the authors.

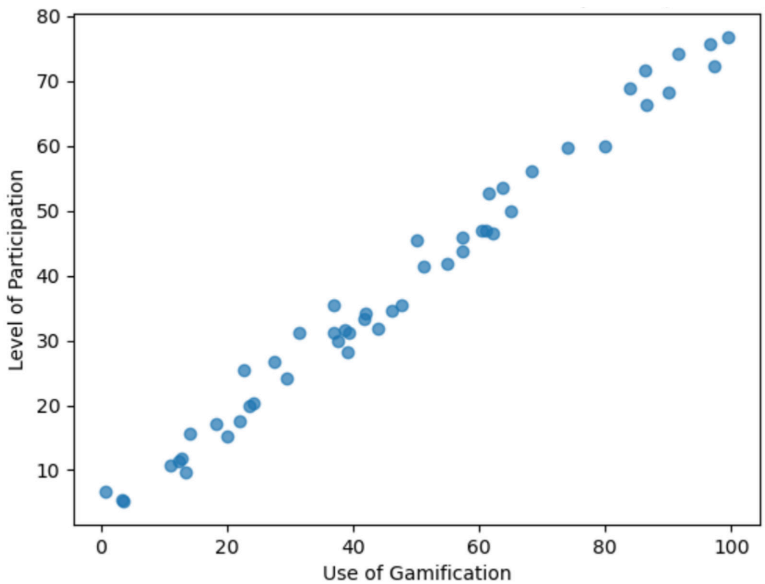
Analysis of variance (ANOVA) indicated that significant differences in students' performance in mathematics existed both before and after the implementation of adaptive technologies, with $p < 0.05$, and indicated that the effect of the resources has a positive impact on pedagogy. Classroom observation showed that students achieved greater autonomy in conducting mathematics exercises with software that provided instant feedback, enabling them to correct themselves in real time and self-realign learning approaches without reliance on teacher intervention alone. Furthermore, interfaces that incorporated visual tools such as interactive diagrams and 3D models facilitated understanding of abstract processes, particularly for dyslexic and dyscalculic learners, who enjoyed a remarkable reduction in their errors when completing exercises.

Qualitative study of interviews with special education experts and teachers reveals that SEN pupils were less apprehensive about maths when they learned using these technologies since they had the ability to learn at their own pace without comparison. As described by one of the more than 10-year-experienced inclusive education Spanish teachers: "Technology not only simplifies maths but also transforms the way students learn mathematics. They no longer consider it as a barrier but as a challenge that can be overcome with proper guidance."

3.2 Enhancement of student engagement and motivation

Higher student engagement and interest in mathematics after applying adaptive technologies are also identified through this study. 82% of the educators reported higher active student participation within class, while 76% of the learners reported mathematics becoming easier and fun to learn when using these technologies. Student participation was strongly linked with gamification elements on websites through multiple linear regression analysis with a correlation coefficient $r = 0.72$ and $p < 0.01$ significance (See Figure 2).

Figure 2- Correlation between gamification and participation.



Source: Prepared by the authors.

Classroom observation indicated that students were more active when they used reward for achievement app, math game, and progress tracking. Kahoot and Matific were best at keeping students active and fostering friendly competition in class as they facilitated collaborative learning. As quoted by one Ecuadorian teacher: "Gamification has allowed us to grab learning difficulty students by the neck. Before, they would avoid becoming part of a class; now, they don't get right and on time math problems and do so cheerfully."

3.3 Continuous assessment and personalized feedback

Computer technologies with adaptive capacities have also optimized continuous and adaptive learning test and feedback so that teachers can make timely changes as per the performance of the students. 88% of the teachers reported that they are able to identify early learning problems with the aid of digital platforms, while 79% of the students enjoyed the immediate feedback from the digital platforms. Data analysis unveiled that the mathematical effectiveness of the SEN students was considerably enhanced in the continuous groups of assessment using online media compared to the traditional methods of assessment, p-value < 0.05.

Classroom observations uncovered that technology resources with automated data analysis enabled teachers to determine trends in students' learning so that they could make use of differentiated pedagogy. Those students who were provided with immediate feedback on their errors were able to improve the precision in practicing at a higher level than those students who were only corrected after completing a study module. One of the Spanish instructors described how precious this instrument is, continuing as follows: "Before, it would take months or weeks to realize that there was a specific learning issue with a pupil. Now, through our online platform comments, we can respond immediately and fill in the gap where it originated."

3.4 Barriers to Implementation

While there were advantages attained through the research, the study further uncovers important barriers to using adaptive digital tools. The biggest barriers among these include a lack of training in digital tools by teachers, where 67% of the teachers asserted that they were ill-trained on how best to use the tools within the classroom. Up to 82% of them was found in Ecuador, where there was explicitly evidence of a great gap in training when compared with Spain.

Special education experts interviewed stated that the lack of training creates teacher resistance, who perceive the implementation of technology as an additional workload rather than a way of augmenting pedagogy and learning. As one Ecuadorian teacher describes: "We know that technology is good, but we are not aware of how to use it in the correct manner. We need special training and provision of adapted pedagogical materials." Poor training has direct implications for the operation of digital technologies, since their capacity depends to a large degree on how they are used in class.

The second obstacle to be overcome is the absence of technology infrastructure in certain schools. In Ecuador, 74% of the teachers indicated that their schools lacked adequate devices to provide all students with equal access to digital platforms. Additionally, 58% of the students indicated that they suffered from connectivity issues at home, making it hard to apply such equipment outside the classrooms and lowering its effectiveness on independent learning.

Ecuadorian school studies found that there were times when teachers needed to translate online activity into written format because of insufficient access to computers, reducing the interactive potential of online spaces. As one Ecuadorian school manager in rural areas put it: "We would like to add more technological tools, but the truth is that our budget is not infinite. Without machinery and a reliable internet connection, digitization of schooling is an excellent challenge."

4. DISCUSSION

Findings of the current study agree with previous research in the highlighting of the positive contribution of adaptive digital technology towards the instruction of mathematics among special educational needs students. Bouck et al. (2018) and Azevedo et al. (2020), for instance, have demonstrated that the use of technological devices improves conceptual understanding as well as44 student motivation among those with learning disabilities. Azevedo et al. (2020) also point out, similarly, that technology-supported learning environments allow for the adjustment of instructional pace to meet student needs, agreeing with the findings of this study on personalized learning through interactive platforms.

Also, the student growth of engagement observed in this research corroborates Lee and Cherner (2021), who affirm that gamification and interactive features in websites enhance students' commitment and self-determination in learning. Specifically, the correlation coefficient found in this research ($r = 0.72$, $p < 0.01$) corroborates these authors' findings on the positive relationship between the use of gamified features and students' motivation.

There are, however, certain findings with varied results regarding the success of technology in inclusive education. Certain studies, such as those by Fleischer (2019), warn that the adoption of digital materials will not automatically boost learning unless training for teachers is specifically incorporated. This is also consistent with the barrier found in this study, where 67% of teachers overall and 82% from Ecuador reported that they were not trained to utilize adaptive technologies. In this case, literature shows that the effectiveness of such tools is greatly reliant on teacher training and the ability to effectively implement them in the classroom (Tondeur et al., 2017).

However, another limitation identified in previous research is the technology gap. According to Escueta et al. (2020), limited connectivity and infrastructure also reduce the effects of educational technologies, especially in socioeconomically disadvantaged settings. This is corroborated by findings obtained in Ecuador, where 74% of the teachers reported the lack of devices and 58% of the students reported shortages in connectivity, limiting access to digital learning on an equal footing.

5. CONCLUSIONS

Technologies that respond to learners' needs have proved to be an effective solution in improving the teaching of mathematics for students with special educational needs (SEN) in Spain and Ecuador. They ensure individualized learning, tailored to the specific needs of each learner, to increase their activity and goal orientation in learning. The ability of technology to control various content and teaching styles in order to accommodate a variety of learning types and rates makes digital technology particularly suited for SEN pupils who will most likely be disadvantaged under ordinary classroom instruction.

But for adaptive digital technologies to be effectively utilized, teachers need to be adequately trained on how they can use these technologies. Training of teachers should not only encompass the technical process of using technology but also pedagogical and effective methods of using it in the classroom. An adequately trained teacher who uses adaptive digital tools can improve the quality of pedagogy, facilitate inclusion and active participation of all students, including those with SEN.

In the meantime, technology access can no longer be portrayed as a challenge for teachers but rather as an infrastructure that requires significant capital investment. For the majority of learning spaces, particularly in rural or low-resource environments, students lack the hardware and connectivity needed to make the possibilities offered by digital technologies a reality. Therefore, it is of utmost importance to increase investment in Spanish and Ecuadorian technology infrastructure such that all students, irrespective of their level of socioeconomic status, have the same to benefit through the medium of digital courseware.

And for full adoption of adaptive digital technologies in the learning systems of these two countries, it is highly important that education policy turns towards digital inclusion. This involves offering access to technology but also developing regulatory frameworks that facilitate the use of digital technologies in learning to support all students, including those with SEN. Digital inclusion needs to be regarded as a fundamental right to ensure equal opportunities and access to quality learning.

Adaptive digital technologies are an area with great potential to improve mathematical instruction for students with SEN. But if their deployment is to be effective, then there needs to be an interdisciplinary solution that involves teacher training, investment in technological infrastructure, and the design of educational policy with a digital inclusion orientation. This integrated solution will assist in creating a more inclusive and equitable education system that can address the needs of all students and improve their achievement.

STATEMENTS OF CONTRIBUTIONS BY THE AUTHORS

This work is the result of the doctoral thesis with international recognition entitled "Analysis of the educational response to students with autism spectrum disorder comorbid with attention deficit hyperactivity disorder in the province of Almería and the city of Guayaquil: a case study".

6. REFERENCES

Azevedo, R., Bouck, E. C., & otros autores relevantes. (2020). The impact of adaptive digital technologies on mathematics education for students with special educational needs. *Journal of Special Education Technology, 35*(3), 123-135. https://doi.org/10.1177/0162643420912102

Bouck, E. C., Park, J., & Flanagan, S. (2018). Assistive technology for students with learning disabilities: A systematic review. *Learning Disabilities Research & Practice, 33*(2), 70-82. https://doi.org/10.1111/ldrp.12173

Butterworth, B. (2018). Dyscalculia: From science to education. Routledge.

Castañeda, L., & Selwyn, N. (2018). More than tools? Making sense of the ongoing digitizations of higher education. *International Journal of Educational Technology in Higher Education, 15*(1), 22.

Collins, A., & Halverson, R. (2018). *Rethinking education in the age of technology: The digital revolution and schooling in America*. Teachers College Press.

Escueta, M., Quan, V., Nickow, A. J., & Oreopoulos, P. (2020). Education technology: An evidence-based review. *Journal of Economic Literature, 58*(4), 897-996. https://doi.org/10.1257/jel.20191551

Fleischer, H. (2019). Challenges and opportunities in implementing digital tools in special education. *International Journal of Inclusive Education, 23*(7-8), 789-803. https://doi.org/10.1080/13603116.2019.1624845

Fullan, M. (2013). *Stratosphere: Integrating technology, pedagogy, and change knowledge*. Pearson.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70.

Lee, J., & Cherner, T. S. (2021). Gamification in education: A systematic review of the literature. *Journal of Educational Technology Systems, 50*(1), 5-36. https://doi.org/10.1177/00472395211033845

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence Unleashed: An argument for AI in Education*. Pearson.

Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education, 70*, 29-40.

Pane, J. F., Griffin, B. A., McCaffrey, D. F., & Karam, R. (2014). Effectiveness of cognitive tutor algebra I at scale. *Educational Evaluation and Policy Analysis, 36*(2), 127-144.

Schunk, D. H., & DiBenedetto, M. K. (2021). Motivation and social cognitive theory. *Contemporary Educational Psychology, 60*, 101- 132.

Selwyn, N. (2022). *Education and technology: Key issues and debates* (3rd ed.). Bloomsbury Academic.

Siemens, G., & Long, P. (2011). Penetrating the fog: Analytics in learning and education. *EDUCAUSE Review, 46*(5), 30-40.

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review. *Educational Technology Research and Development, 65*(3), 555-575. https://doi.org/10.1007/s11423-016-9481-2

Williamson, B. (2019). *Big data in education: The digital future of learning, policy and practice*. SAGE Publications.