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ICT as a Didactic Strategy to Strengthen Numerical Thinking - Fractions in Students with ADHD

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Abstract

The learning of mathematics in educational scenarios, due to the language it uses, as well as the cognitive development it requires, sometimes generates difficulties in students, as they must appropriate algorithms and basic theorems for problem solving. In this sense, the purpose of this research was to implement a didactic strategy oriented from the use of ICT, in order to examine how these technologies affect the learning of mathematics in a group of primary school students diagnosed with Attention Deficit and Hyperactivity Disorder (ADHD). The aim was to integrate these technologies adapted to the characteristics of this population, as educators, in their role as innovative agents, must provide means and aids that contribute to mitigating the situations that arise from the aetiology and characteristics of ADHD. In relation to the methodology used in the research process, the research is oriented from the qualitative approach, descriptive scope and educational action research design. The results of the pedagogical experience are conclusive, as it was possible to establish the need to implement innovative learning environments that allow students with ADHD to develop their numerical thinking, in this sense, the use of ICT, allowed to focus the student's attention on the appropriation of mathematical knowledge, also aroused their liking and motivation to develop interactive playful activities.

Keywords: *Numerical Thinking, ADHD, ICT.*

Introduction

In today's education, it is necessary for education systems to guarantee equity, which means ensuring equal opportunities for all students. This is achieved by promoting the full development of their identities through educational inclusion, providing equal rights and opportunities to overcome any form of discrimination and facilitating access to education, especially for those who may face challenges due to any disabilities they may have.

In school classrooms there is heterogeneity in the students who must be attended to by educators, given that they have individual characteristics, which is why the role of the teacher must focus on achieving maximum development in their integral formation. This variability includes students who experience Attention Deficit Hyperactivity Disorder, commonly known as ADHD. They are students who need, above all, recognition of their condition by the educational institution and the educators involved in their school education process, as, due to the characteristics of this disorder, they sometimes have

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difficulties in learning and relating to their environment, in addition to the notable differences with other students (González Lajas, 2013). It is a group of students who must be made visible, as their manifestations are confused with disinterest, poor education or not wanting to learn (Hernández, 2012).

From this approach, it is evident that the widespread lack of knowledge about Attention Deficit Hyperactivity Disorder and the most appropriate strategies for teachers' actions in the school environment requires the appropriation of general information about this disability. This implies understanding its influence on students' learning and behaviour, as well as providing guidelines on how to interact with them and improve their cognitive processes. Therefore, the purpose of this study is to promote the development of numerical thinking in students with ADHD. This is achieved through the design and implementation of a didactic strategy based on the use of Information and Communication Technologies, which facilitates the assimilation of mathematical problem solving. At the same time, this strategy benefits the work of educators in the classroom, since learning mathematics involves the acquisition of theorems and algorithms for problem solving.

Based on these considerations, the use of ICT is intended to mitigate the situations that limit learning in the area of mathematics in students with cognitive disabilities ADHD, particularly through the use of interactive digital resources, to enable an innovative learning environment in which these students can improve their level of attention in such a way as to achieve better school performance in the area of mathematics, specifically the appropriation of operations and problem solving with fractional numbers.

This is a qualitative research oriented through a descriptive approach, descriptive scope and educational action research design, in which an opinion survey is applied to teachers who guide teaching in the area of mathematics and who have been linked to the purposive sample, in order to determine what are the possible factors of the pedagogical process that affect the poor school performance of students diagnosed with ADHD belonging to the fifth grade of primary basic education.

Literature Review

The literature review focuses on several aspects related to the object of study. These include the conceptualisation of Attention Deficit Hyperactivity Disorder (ADHD) and the learning difficulties that derive from this disorder. Among these difficulties, the challenges encountered in the process of learning mathematics, operational difficulties and dyscalculia will be specifically analysed. The importance of the use of digital resources in the empowerment of students with ADHD is also recognised.

Conceptualisation of Attention Deficit Hyperactivity Disorder (ADHD)

One of the most representative authors in the research literature on ADHD is Barkley who, in 2002, conceptualised it as a neurodevelopmental deficiency that generates alterations in executive functions and the ability to maintain attention on an activity in infants. He also indicates that this disorder is mostly inherited and the symptoms begin to manifest themselves in the first years of life, including alterations in the cognitive and socioemotional dimension of infants, there may be alterations of a sensory, motor, speech, marked emotional disorders and in the most extreme cases mental retardation, which limits the development of executive functions and activities that require a certain level of concentration.

On the other hand, authors such as (Gratch, 2009; Lavigne and Romero, 2010; Gemma et al., 2015) indicate that the particular characteristics of ADHD in infants can be evidenced by their impatient actions, including: not remaining stable, but moving from one side to another, excessive movement in limbs, states of anxiety, lack of concentration at the

slightest interruption, restlessness, in general, the researcher indicates that the predominance of the symptoms of this disorder are framed within a facet of anxiety and instability. It should be stressed that there are other symptoms that are typical of ADHD, including irritability, rejection of failure, poor control of feelings, emotional impulsivity that sometimes leads to abrupt changes in behaviour.

In relation to ADHD in the school environment (Siegenthaler and Presentation, 2011; Zavadenko et al, 2011; Vélez and Vidarte, 2012; Rodríguez, 2015) point out that the characteristic features of students with this condition are marked by instability during the development of classes, scattered attention, and little adaptability to the resources used by the teacher as mediation of the educational process, therefore, it is necessary for educators to implement strategies that allow the student to maintain their cognitive skills without allowing them to deteriorate, therefore educational materials for students diagnosed with ADHD should be designed according to their needs.

Learning Difficulties that Derive from ADHD

School performance in students with ADHD is affected due to the characteristics of the disorder; usually students are unable to connect with the teacher's explanations due to scattered attention, and they are also scattered in the school work they do. Soriano et al. (2011) state that it is typical for students with ADHD to have poor school performance in the different areas of the school curriculum, as they find it difficult to follow instructions, i.e. their executive functions are affected by the disorder. In particular, studies show that the school skills most affected are text production, reading comprehension and numerical thinking.

From the studies of (Muñoz et al., 2006; Miranda and Melia, 2006; Martínez, 2010; Schuck and Cirinella, 2005; Parellada, 2009), the cognitive dimension in students diagnosed with attention deficit hyperactivity disorder is the one that is most affected, since the incidence of the disorder in executive functions could be the cause that sustains poor school performance and cognitive development. It should be emphasised that, when performing complex tasks, students with the disorder are unable to follow organised sequences for the execution of school activity, not because of a lack of skills or aptitudes, but because of the incorrect use of these. Furthermore, according to the authors' perspectives, it is observed that approximately 10% of students who do not have special educational needs face challenges in their school performance and difficulties in the learning process. In contrast, about 50% of students diagnosed with the disorder are identified as experiencing these obstacles.

Another relevant aspect regarding the low performance of ADHD students is that their command of written language is very dysfunctional, as they require a great deal of effort to produce texts; in terms of reading and writing, as Gutiérrez (2010) indicates, the main deficiency is dyslexia, i.e. difficulty in reading; in the area of mathematics, students with the disorder have deficiencies in mental calculation, recognition of operations, application of formulas and algorithms, with the main problem being dyscalculia.

- Difficulties in the Learning of Mathematics

On the other hand, one of the areas of knowledge that is most affected in students with ADHD is mathematics, based on the studies of (Saudino and Plomin, 2007; Miranda et al, 2009; Jacubovich, 2013; Correa and Restrepo, 2018; Gutiérrez Álvarez, 2021), students with attention deficit hyperactivity disorder usually have numerical problems related to the development of operations, recognition in the symbolic and numerical representation of quantities, as well as subitization and confusion between mathematical signs, these problems have their origin in a condition known as dyscalculia.

Studies on the incidence of ADHD in the learning of mathematics are few, so the research literature has not been able to elucidate what specifically are the conditions of this disorder that affect logical, mathematical and numerical thinking, from the perspective of

Miranda et al. (2002) it seems that the factors of ADHD that limit the learning of mathematics are reacted with the constant scattered attention of students and impulsivity which leads to difficulties in learning mathematics, but the researchers indicate that there is sufficient evidence to affirm that the cognitive ability of students is affected by the disorder, which opens the way for studies that allow to specify the cognitive processes that would be involved in the problems of learning mathematics.

Based on the researcher's proposals, the main impairments that students show in the area of mathematics due to ADHD are Operational difficulty and dyscalculia.

- Operational Difficulty

There is no doubt that students diagnosed with ADHD present difficulties in the development of their numerical thinking. Geary (2005), indicates that the possible cause that affects their operational capacity is due to brain alterations, which control different neuropsychological processes and in turn regulate logical and mathematical thinking. Specifically, these students have problems in arithmetic calculation, symbolic-numerical recognition of quantities and, of course, the execution of operations.

For Carmona et al. (2014), the operational problems of students with ADHD appear at an early school age, and in most cases affect the development of logical, mathematical and numerical thinking, which puts disciplinary learning at risk. In the operational difficulty, it is difficult for students to adequately use their memory to associate a quantity with the symbolic representation through objects, as they do not correctly interpret that a number is not just a word, but that it denotes quantifiable elements that have a relationship of order with other quantities. According to González (2013), children with ADHD can develop addition operations and even count; however, they do not recognise the meaning of numbers, and these difficulties increase when the numbers increase or when operations are performed with other number systems such as decimal. Likewise, in the case of students affected by attention deficit hyperactivity disorder, there is a limitation in their mental capacity to carry out reflective analysis in problematic situations that require the use of mathematical, logical and numerical thinking skills. Specifically, they face difficulties in planning, execution of operations, revision of procedures and responses during problem solving.

- Dyscalculia

While it is true that mathematics learning occurs from the moment a child is born, most children succeed in the development of numerical thinking. However, as indicated by (Quenneville, 2001; Poeta and Rosa, 2007; Orza, 2012; Peral, 2016; Sans et al., 2017) there is a small group of infants who, due to problems of a neuropsychological nature, originating in neurobiological alterations, have limitations in the proper development of numerical and mathematical thinking, and throughout their lives have difficulties in learning mathematics, which the authors have identified as dyscalculia.

Rapin (2016) defines this disorder as a set of difficulties inherent to learning mathematics, which interfere in the calculation of basic operations such as addition and subtraction, in other words, cognitive alterations that prevent the person from having an adequate mastery of mathematical knowledge. It should be emphasised that dyscalculia is isolated from the mental level, teaching and learning methods and the emotional conditions of some students, and also manifests itself early, with its own characteristics such as difficulty in recognising quantities, as students do not relate iconic, symbolic and numerical correspondence.

From the point of view of Sans et al. (2017), dyscalculia is related to some neurodevelopmental disorders, including ADHD, ASD, Down's, among others, which in turn leads to a cognitive alteration that affects processes such as language, attention, memory, intelligence, development of executive functions that in one way or another are implicit in numerical thinking. According to Geary (2006), dyscalculia tends to present

itself in the first years of schooling, as there have been cases of students who at pre-school level present limitations in subitization, ordinality, numerical representation of quantities, usually students who, when faced with these difficulties, can develop an aversion to learning mathematics and in the worst cases opt for dropping out of school.

It should be stressed that the incidence of dyscalculia in number sense is wide, in the opinion of (Hanich et al., 2001; Fias et al., 2013; Mokotjo, 2017; Benedicto and Rodríguez, 2019; Delgado et al., 2019; Tamayo et al, 2019) in each case of dyscalculia the manifestations are different, even being students of the same age, physical characteristics and similar socioeconomic conditions there have been cases in which some students are more skilled than others in the development of arithmetic operations, however they can present serious difficulties in the development of mathematical problems, there are also students who although they handle the operational part of mathematics and problem solving, they find it difficult to interpret the conceptual part.

Rosselli et al. (2010) indicate that there are also students who have limitations in the recognition of the positional value of quantities, the correct application of mathematical procedures or algorithms, the use of modelling to solve problems and deficiencies in memory to adequately use numerical quantities. When performing arithmetic operations, students with dyscalculia usually do not find the correct answer, their numerical thinking does not progress in the same way as other children who do not have this condition, so that the use of techniques used by children at lower school levels prevails, for example, counting on the fingers.

The American Psychiatric Association, by its acronym APA (2013), refers that dyscalculia not only affects numerical thinking, but also the linguistic dimension, perception and attention of students, in addition this association indicates that dyscalculia is associated with other disorders such as ASD, ADHD, Down, Gerstmann, among others, which makes the learning of students who present any of these comorbidities too complex. (Shalev et al., 2000; Kaufmann and Von, 2012; Devine et al, 2013; Canto, 2015; Lin and Jiar, 2017), point out that children with dyscalculia also have limitations in reading quantities, as cases have been found in which they tend to read from right to left, also, the greater the distance that exists between the quantities the more complex the difficulties are, for example when counting small numbers from 1 to 10, the problems are not so marked, but when it comes to larger quantities the numerical thinking of students with dyscalculia is considerably affected.

Digital Resources for the Empowerment of Students with ADHD

The incorporation of digital technologies in the inclusive education classroom has proven to be a valuable tool in supporting students with Attention Deficit Hyperactivity Disorder (ADHD). Several authors have highlighted the importance of adapting these technologies to the needs of these students in order to improve their learning and socioemotional well-being.

According to Cabero and Córdoba (2009), technology in the classroom should not be a factor of exclusion, but rather a tool that fosters the integration and participation of all students, including those with ADHD. The adaptation of technological supports to the needs of students can contribute to constructivist learning and improved attention.

Regarding the development of numerical thinking in students with ADHD, the implementation of ICT-based strategies has shown significant results. Shaw and Lewis (2005) point out that the use of multimedia elements, such as images and sounds, through resources such as the ITS (Tutorial Intelligence System) programme and the PICCA application, can capture students' attention and improve their concentration in solving mathematical problems.

Students with ADHD can also benefit from the use of devices such as the iPad, which offers interactive applications to keep them motivated in school activities. Interacting

with these technologies helps to keep students' attention stable and awakens their interest in learning (Tobar Muñoz et al., 2015).

In terms of strengthening literacy and mathematical skills, digital resources have been developed that address the specific difficulties of students with ADHD. Resources such as Ditres, MeMotiva, Clic 3.0 and Cerebriti Edu focus on improving reading and mathematical skills. Designers recommend using these resources consistently to achieve significant results in the literacy process.

The benefits of ICT in strengthening literacy and numerical thinking processes are evident. The audiovisual and interactive nature of these resources allows students with ADHD to enjoy learning and improve their cognitive and emotional skills (Molina and Martínez, 2015).

For the socio-emotional empowerment of students with ADHD, digital resources have been developed that foster communication, cooperation, self-control and empathy. Programmes such as "We are all different and valuable" and "Ombudsman Blog" have proven to be effective in promoting social ethical values and helping students understand diversity.

In general terms, digital resources have demonstrated their relevance and effectiveness as fundamental tools in the empowerment of students with ADHD, especially in the area of numerical thinking and mathematical skills. These resources have contributed to improving the understanding of complex mathematical concepts, motivating students and promoting active participation in the learning process. The adaptability and diversity of these resources allow for personalised teaching, where each student can approach the content at his or her own pace. The interactivity and multimedia approach stimulates diverse learning channels, optimising the retention and assimilation of knowledge. Consequently, digital resources have become essential allies in fostering the development of numeracy and social-emotional skills in students with ADHD, creating an enriched and meaningful learning environment that is conducive to both their academic success and emotional well-being.

Materials and Methods

This study is framed within a qualitative research approach whose purpose is to understand ADHD from the unique perspectives of the people involved. In this approach, we focused on maintaining a dialogue with people's beliefs, attitudes and emotions, considering them essential elements for constructing knowledge about life in society, as González (2013) points out. Therefore, the purpose of using this qualitative approach was to understand and analyse social and human reality in a practical way. This involved gaining an understanding of what makes each individual and group unique through their opinions, reflections and arguments. All of this was done with the purpose of examining the factors that influence the low mathematics performance of students diagnosed with ADHD at the St. Thomas Aquinas Educational Institution, from the perspective of the study participants.

On the other hand, the descriptive approach was incorporated as a supplementary research tool to enrich the research process. Following Danhke's (1989) perspective, this approach allows the researcher to narrate and detail phenomena, situations, contexts and events, i.e. to provide a detailed explanation of how they present and manifest themselves. Descriptive studies focus on defining the properties, characteristics and profiles of individuals, groups, communities or any other phenomenon under analysis. In this particular study, description was used to delve into aspects related to the academic performance in mathematics of students with ADHD, who have been purposively selected to be part of the sample.

As for the design of this research, it is situated in the field of educational action research methodology. This approach has been used in school contexts with the purpose of creating academic programmes, improving teaching and designing educational policies aimed at improving the quality of education, in line with Elliot (1989).

Unit of study

In the context of this research, the unit of study has been defined as the students in the fifth grade of primary education, enrolled in the three schools of the Santo Tomás de Aquino Educational Institution, located in Duitama, Boyacá, Colombia. In total, this group comprises 120 students. The sample for the study was selected purposively through convenience sampling, and it was decided to include 15 students, following the criteria detailed in Table 1.

Table 1. Aspects taken into account for the selection of the sample subjects

Sample subjects	Selection criteria
Fifteen fifth grade primary school students were selected for the study.	The aspects taken into account for the selection of the sample are the following: - Being active in the school enrolment system. - Having been diagnosed with ADHD or presenting characteristics of this disorder. - Having difficulties in learning mathematics (dyscalculia). - To have the approval of the guardian or tutor to take part in the research, I.E. to present an informed consent form.

Note: The table details the criteria established for the selection of sample subjects.

This study included 9 girls and 6 boys, all aged between 10 and 12 years, in the fifth grade of primary education. The students' ability to interact with the techno pedagogical resources incorporated in the teaching strategy was assessed and it was ensured that they had digital skills to use multimedia tools.

Categories of Study

Since this research has a qualitative approach, categories of study have been formulated to explore the factors that influence the school performance of students with ADHD in the area of mathematics. Table 2 presents the study categories that have been defined.

Table 2. Categories and subcategories emerging from the opinion survey applied to mathematics teachers.

Object of study: ICT in the reinforcement of numerical thinking: fractional numbers, in students with ADHD.
Central Category: Low school performance in the area of mathematics in students with ADHD.

Category	Subcategory
Lack of curricular adaptation	- Non-flexible curriculum - Little professional support in pedagogical processes - Lack of teacher training for inclusive care
Inadequate teaching materials	- Conventional resources for teaching mathematics - Low interest, enjoyment, motivation of students with ADHD
Cognitive problems	- Subitization / dyscalculia - Little time for personalised attention to students
Low level of digital skills	- Limited use of ICT - Lack of innovative teaching strategies in the classroom.

Note: The table lists the categories and subcategories that emerge from the data analysis process. Source: AtlasTi 7.0.

Stages of the research

In congruence with the stated objectives, the study follows a scheme of four phases that seek to fulfil these objectives, and which have been established on the basis of the relevant research methods.

- Stage One

In this phase of the research process, an opinion survey was administered to the teacher in charge of teaching the area of mathematics, the purpose of which was to characterise the factors and causes that influence the low school performance in this subject by the students in the sample.

- Stage Two

The primary objective of this phase of the study was to create an innovative learning environment using digital resources to foster numerical thinking in the sample students. To this end, a techno-pedagogical strategy is designed that uses educational technology to motivate learners diagnosed with ADHD and thereby improve their performance in the subject area. It is recognised that ICT is capable of maintaining the attention of these students and it is hoped that this will contribute to the achievement of the proposed objectives. The findings of this stage are detailed in the results section.

- Third Stage

The third stage of the research process focuses on the application and execution of the techno-pedagogical intervention strategy, with the aim of addressing the third objective of the study: to describe the improvements or difficulties that arise for students from the implementation of a didactic innovation framed in educational technology. To achieve this objective, the thematic blocks of the didactic strategy are implemented and the participatory observation technique is used to identify the improvements or difficulties experienced by students in the understanding of mathematical concepts.

- Stage Four

The purpose of the final stage of the research process was to determine the impact of the didactic intervention strategy on disciplinary learning, specifically in relation to the subject of fractional numbers in students with ADHD cognitive disabilities. To this end, the students' previous learning outcomes are compared with those achieved after the implementation of the didactic intervention. In addition, an analysis of the perceptions of the teacher of the disciplinary area is carried out in order to confirm the effectiveness of the use of educational technology in improving the numerical thinking of the students who were part of the sample.

Results

- Results of the first diagnostic stage

The results of the diagnostic stage are oriented towards the fulfilment of the first objective: To diagnose the level of knowledge of the topic of fractional numbers in students with ADHD cognitive disabilities.

In order to fulfil this objective, a pre-test of knowledge was initially applied in order to evaluate the numerical thinking of the sample students on the subject of fractional numbers. It should be noted that the items assessed in the questionnaire were taken from the bank of questions in the repository of the SABER tests, designed by the Colombian Institute for the Promotion of Higher Education (ICFES). In this sense, the instrument applied is understood to be validated, as it has already been evaluated by the aforementioned body.

On the other hand, in order to recognise the factors that affect the learning of fractional numbers, the research required the application of an opinion survey to the teacher who guides the disciplinary area and the parents of the students with ADHD.

The results of the diagnostic stage, in terms of the response or dependent variable: Numerical thinking - fractional numbers, were assessed through the evaluation scale adopted at St. Thomas Aquinas Educational Institution, which is referred to in Table 3.

Table 3. Pre-test knowledge rating scale

Performance	Quantitative Value
Top	9.1 a 10.0
High	7.6 a 9.0
Basic	6.0 a 7.5
Low	1.0 a 5.9

Note: The table shows the academic rating scale adopted by the Instituto Técnico Santo Tomas de Aquino. Source: Adapted from SIEE.

The pre-test aimed at assessing the numerical thinking of the students involved in the research was applied during the fourth school term of the year 2022. Figure 1 shows the sample students taking the diagnostic test.

Figure 1. Grade 5 students taking the diagnostic test

Note: The image shows the detail of the application of the pre-test inherent to the fractional numbers topic.

The results of the test are presented in figure 2.

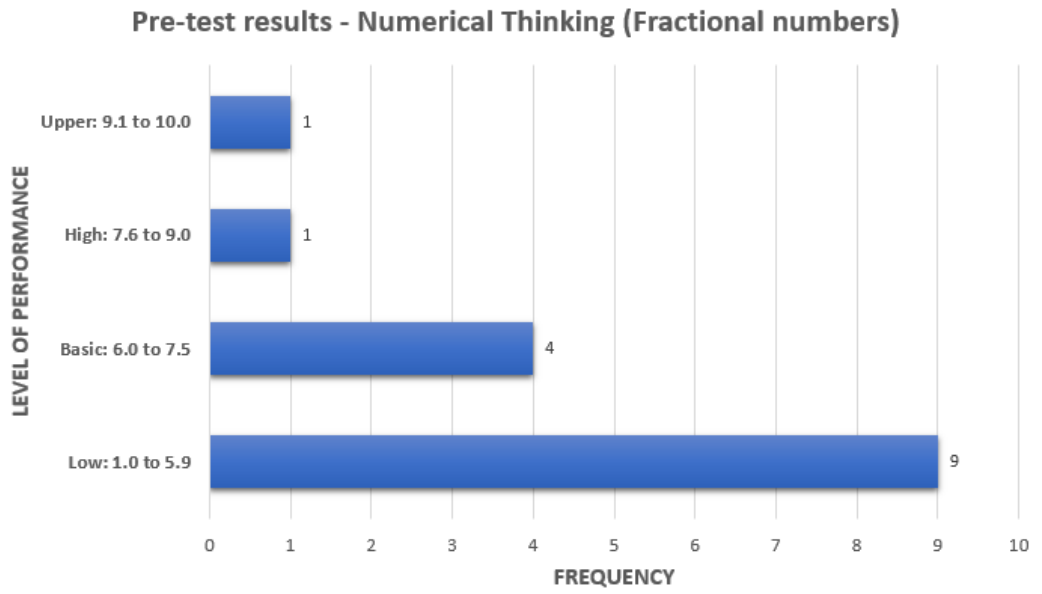

Figure 2 Results of the diagnostic stage - Pre-test

Note: The graph presents the quantitative results emerging from the application of the Pre-Test of knowledge on the subject of fractional numbers.

The data from the diagnostic stage show that 9 of the 15 students, equivalent to 60%, obtained a score in the range of 1.0 to 5.9 points, i.e. their performance was at the low level. 4 of the 15 students, corresponding to 26.6%, achieved a basic performance, as they obtained a score between 6.0 and 7.5 points, only one student was at the high level of performance in the diagnostic test, and one student out of the total number of students reached the higher level.

However, the quantification of the students' school performance is not enough to interpret the factors or causes that influence this situation, therefore, taking as a reference the qualitative approach assumed in the research, to analyse the opinions and arguments of the teacher who guides the disciplinary area. Specifically, an opinion survey was administered to determine pedagogical and didactic aspects that affect the students' school performance. Figure 3 shows the semantic network derived from the AtlasTi analysis of the data collected in the instrument.

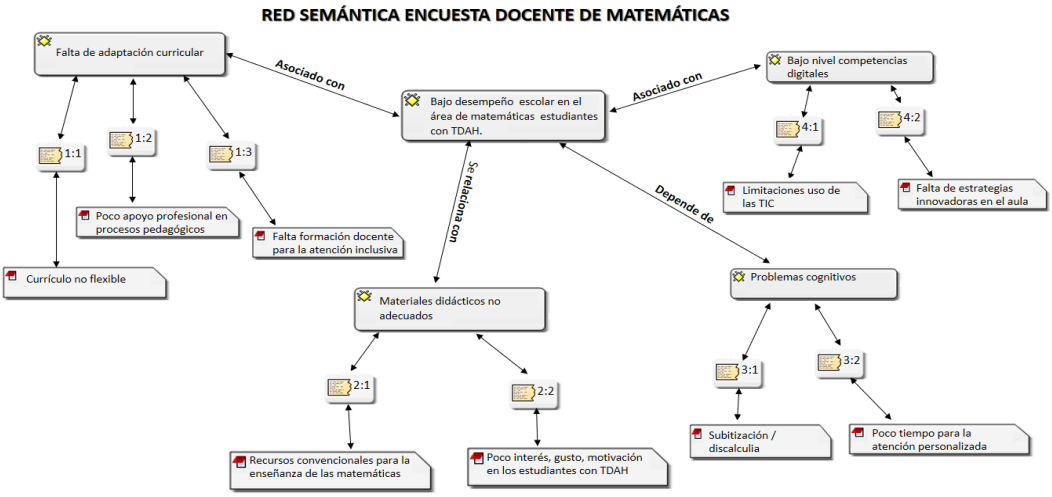

Figure 3 Semantic network opinion survey applied to teachers in the discipline area

Note: The semantic network shows the categories that emerge from the analysis of the data collected in the opinion survey administered to the teacher who guides teaching in the area of mathematics.

Based on the open, axial and selective coding process through the qualitative research software AtlasTi 7.0, categories and subcategories were configured (see table 4) that allow us to analyse the opinions and arguments of the teacher who guides the teaching of mathematics.

Table 4. Categories and subcategories emerging from the opinion survey applied to the mathematics teacher.

Object of study: ICT in the reinforcement of numerical thinking: fractional numbers, in students with ADHD.
Central Category: Low school performance in the area of mathematics in students with ADHD.

Category	**Subcategory**
Lack of curricular adaptation	- Non-flexible curriculum - Little professional support in pedagogical processes - Lack of teacher training for inclusive care
Inadequate teaching materials	- Conventional resources for teaching mathematics - Low interest, enjoyment, motivation of students with ADHD
Cognitive problems	- Subitization / dyscalculia - Little time for personalised attention to students
Low level of digital skills	- Limited use of ICT - Lack of innovative teaching strategies in the classroom.

Note: The table lists the categories and subcategories that emerge from the data analysis process. Source: AtlasTi 7.0.

 Discussion of the categories of the study survey of the mathematics teacher opinion survey

Once the categories of study have been established, we proceed to analyse the arguments and discourse of the teacher who guides the teaching of mathematics at the Santo Tomás de Aquino Educational Institution, taken as a research scenario.

- Category: Lack of curricular adaptation

Based on the analysis of the answers given by the teacher surveyed, who guides the teaching of mathematics in fifth grade of primary basic education, it was possible to identify that among the factors that affect the development of numerical thinking, and particularly the learning of fractional numbers by students with ADHD, is the lack of adaptation of the disciplinary curriculum, since it does not contribute to inclusive education, i.e. it has been designed without taking into account the educational needs of students with ADHD.

Usually, according to the teacher, the group of mathematics teachers are the ones who plan and structure the topics at each school level, but based on their knowledge and what is established by the Colombian Ministry of National Education (MEN). However, the teacher warns that these curricular structures respond to the standards of mathematical knowledge that students should appropriate according to their age and school grade, however, the planned activities do not integrate actions that contribute to strengthening the learning of students with special educational needs, such as autism, cognitive impairment, Asperger's, Down's and, of course, attention deficit hyperactivity disorder, among others.

The teacher's arguments allow us to recognise that there is a need to make the school curriculum more flexible in the area of mathematics, so that the classroom can accommodate the diverse singularities that students present in the appropriation of knowledge. In addition, other professionals such as social workers, psychologists and support teachers need to be involved, since the groups of students that educators manage in most Colombian educational institutions usually exceed 35 students, a condition that does not allow for dedication and personalised attention to be given to students who have some physical or cognitive limitation that affects their learning, and therefore require accompaniment and support in their school education process.

Another aspect pointed out by the teacher surveyed is that Colombian government policies related to the access of students to the school system do not focus on meeting their educational needs, as they are sent to classrooms without analysing whether the teachers who are going to teach them have knowledge inherent to inclusive education, in most cases, educators from their professional university training have received knowledge of a disciplinary area such as chemistry, mathematics, Spanish language, among others, but not directed to education oriented to diverse attention.

- Category: Inadequate teaching materials

One of the factors which, in the opinion of the teacher surveyed, has a major impact on poor school performance in the area of mathematics is the lack of teaching resources to support the pedagogical work of educators, since school management usually provides teachers with conventional teaching resources such as guide books, photocopies, school blackboards, among others, which may have positive results in the learning of the subject area, but to a certain extent do not activate the taste, interest and motivation of students with ADHD.

In this line, the teacher indicates that the behavioural attitudes that derive from the aetiology of ADHD, such as the lack of attention and instability of the students is exacerbated by not having a wide variety of didactic resources that motivate the development of activities in the area of mathematics, as the students find it difficult to concentrate, given that their executive functions are affected and they are unable to follow instructions. He also adds that the use of traditional materials used in the mathematics pedagogical process does not allow for a connection between the student and the educator, especially when the key factor for school attention to differences should focus on providing materials adapted to the curricular content, but above all on guaranteeing personalised attention to the student.

From the point of view of the teacher surveyed, the use of didactic materials not adapted to the needs of students who require attention for differentiated learning, leads to the processes of knowledge transmission and school training in the area of mathematics being routine, mechanistic and monotonous, which results in the student feeling aversion or little pleasure in learning, and that they are restless in the development of school activity and their attention is dispersed. Likewise, the lack of didactic elements for the attention to diversity, forces the classroom methodology to focus on traditional processes, where educators orientate learning from the discourse and transmission of information, rather than acting as guides and orientators of students; it should also be mentioned that the repetitive use of conventional teaching materials makes students feel overloaded with information, and the absence of dynamic and motivating activities predominates, a situation that converges in low academic performance.

- Category: Cognitive problems

Based on the answers provided by the teacher, it was possible to establish that some students diagnosed with ADHD also have comorbidities associated with this disorder, the most common of which is dyscalculia.

According to the interviewee, these students find it difficult to carry out operations involving mathematical processes of analysis and reasoning; even in simple processes such as subitization, students have problems determining the cardinality of a set of elements.

In addition, the educator interviewed points out that the students in the sample exhibit difficulties in performing basic calculations, such as addition, which limits their mastery of mathematical knowledge. They also have difficulties in recognising quantities, as they do not establish the correspondence between the iconic, symbolic and numerical aspects, and tend to confuse addition and subtraction signs when solving operations. They also have limitations in solving mathematical problems, as it is difficult for them to design a plan to deal with numerical situations.

In general terms, based on the analysis of the educator's arguments, it was possible to establish that the cognitive deficiencies derived from ADHD affect the development of numerical thinking in students. Therefore, she considers it pertinent to adapt the educational materials according to the individual characteristics of each case, and also to provide constant accompaniment and support to each student, with the aim of favouring their development process throughout their school career. Although this process can be prolonged, the teacher emphasises that it should not be interrupted, as the success and academic improvement of students with the disorder depends on continuing with the intervention initiated.

- Category: Low level of digital skills

According to the teacher surveyed, one of the main obstacles to a revaluation of didactics in mathematics teaching is the low level of digital competences of teachers. Some of them have only basic knowledge in the use of Microsoft Office programmes such as Word, PowerPoint and Excel, and lack skills in the use of multimedia materials and digital educational resources available on the Internet.

In this sense, the educator argues that it is essential to carry out teacher training processes to bridge the existing cognitive digital divide, so that the use of educational technology is routinely integrated into the pedagogical work of educators. In addition, the adoption of ICT provides the opportunity to address the individual needs of each student diagnosed with attention deficit hyperactivity disorder.

- Results Second stage - Didactic intervention design

From the results derived from the diagnostic phase of the study, it was possible to determine that the academic performance of the sample students in relation to numerical thinking, specifically in the subject of fractional numbers, is at a low level due to the difficulties associated with Attention Deficit Hyperactivity Disorder, mainly highlighting the alterations in attention. In this sense, in order to address these problems, at this stage of the research process a techno-pedagogical strategy was designed, focused on improving students' attention during the process of acquiring mathematical knowledge related to fractional numbers.

The intervention is based on the use of Information and Communication Technologies (Figure 4), in particular, on digital educational resources that allow the cognitive dimension of the students in the sample to be enhanced, so that they feel motivated and avoid distractions or lack of focus in the school activities proposed in each subject.

Figure 4. Didactic intervention strategy interface framed in the use of digital educational resources.

One of the key aspects in the design of the didactic intervention strategy was the integration of digital educational resources (RED), which were adapted following the Universal Design for Learning (UDL) Model. The choice of educational technology as an integral part of the intervention was based on its ability to allow for reasonable and personalised adjustments, which was essential to meet the unique needs of students diagnosed with ADHD. These digital resources provided the flexibility needed to address challenges such as concentration and attention, which are common in these students, in an effective manner.

The intervention strategy therefore involved the implementation of specific activities focused on the use of these adapted digital resources, including apps, interactive games and hands-on activities related to fractional numbers. This approach provided a more engaging and effective learning experience for students.

In general terms, the design of the didactic intervention strategy was based on the integration of educational technology and adapted digital resources, with the purpose of providing students with ADHD with the necessary tools and activities to improve their understanding and performance in the topic of fractional numbers.

- Results Third stage - Implementation of the Didactic Intervention Strategy

The implementation of the didactic strategy took place in the computer classroom of the Santo Tomás de Aquino Educational Institution, specifically in the El Carmen branch. During a period of 40 hours of class, developing four thematic blocks with the purpose of analysing the changes, improvements and difficulties experienced by the students in relation to the comprehension of the subject of fractional numbers.

- Thematic Block 1: Concept and parts of a fraction

This thematic block marks the beginning of the implementation of the didactic intervention strategy, focusing on the understanding of the definition of a fraction and its components. Interactive activities were designed using the Padlet platform, and the topic was developed over 4 hours of class time, with students playing an active role in the acquisition of knowledge. Figure 5 illustrates the interaction of the students with the activities provided on the platform.

Figure 5. Development of the First Thematic Block

As can be observed, the use of information and communication technologies, in particular the interaction with digital activities and games, resulted in a higher motivation of students in understanding the topic of conceptualisation and parts of the fraction. It was observed that the desire to overcome levels in the activities and advance to the next level kept their attention focused on the correct development of the proposed tasks. In addition, it was noted that they were interested in learning mathematics, as they resorted to searching for information on the Internet when they encountered difficulties in aspects related to fractional numbers.

It is important to highlight that friendly relationships were also generated among the students, as working in pairs or in teams allowed them to build learning together. The role of the students was transformed by the use of ICT, going from being mere receivers of information to becoming active agents in their academic training process. Likewise, the teacher who guides the teaching of the subject area adopted a guiding and orienting role in the learning process, a situation that contributed to improving the students' perception of her as someone special in their acquisition of knowledge.

- Thematic Block 2: Graphical representation and reading of the fraction

During the development of this thematic unit, students consolidated their understanding of concepts related to the representation and reading of fractional numbers. To foster their learning, interactive activities were used on the Padlet platform, which effectively captured the students' attention, as illustrated in figure 6.

Figure 6 Development of the thematic block Representation and reading of fractions

Note: The image shows the development of activities focused on the appropriation of the theme representation and reading of fractional numbers.

During the implementation of the activities on the platform, a high level of motivation on the part of the students could be observed. However, due to the characteristics of Attention Deficit Hyperactivity Disorder, some of them required additional assistance from the teacher due to the difficulties associated with dyscalculia, which sometimes affect their learning process. Despite these difficulties, the students managed to do a significant amount of work. It is remarkable to note that, when interacting through the computer, a greater ability to concentrate was observed on the part of the students, and a considerable decrease in their levels of hyperactivity was observed. This was reflected in their calmer and less anxious behaviour compared to their usual attitude in a conventional classroom environment.

- Topic Block 3: Operations with fractional numbers

The implementation of activities aimed at strengthening numerical thinking, focusing on the application of the four fundamental operations with fractional numbers, and their integration with educational technology, has provided the opportunity for students diagnosed with ADHD to understand mathematical concepts more effectively. This has been achieved through the visual and interactive approach provided by the multimedia tools used, as illustrated in Figure 7.

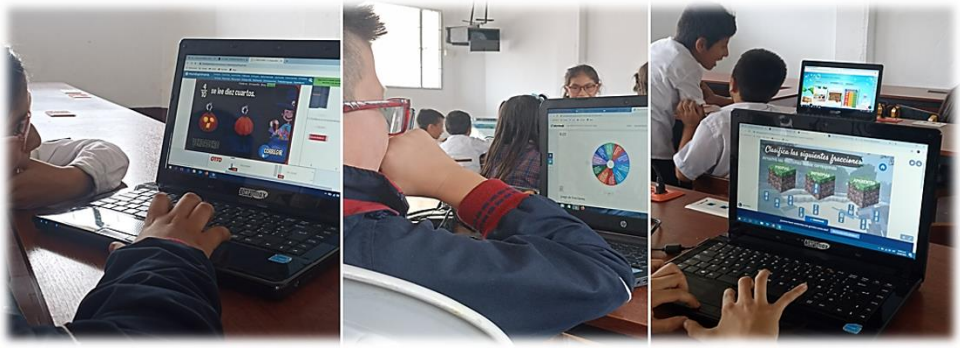

Figure 7 Development of thematic block operations with numbers fractions

Note: The image shows the development of interactive digital activities aimed at the development of the four operations with fractional numbers.

Through the application of the observation technique, specifically the detailed record in field diaries, it was possible to confirm that the use of interactive digital resources for the purpose of facilitating the acquisition of mathematical knowledge, yielded positive results in the learning of students with ADHD. During each class session, a significant level of motivation could be seen in these students, which was manifested in a collaborative and participatory approach to their work. This approach not only allowed them to consolidate their understanding of numerical thinking, but also promoted the development of their socio-emotional dimension by fostering the construction of bonds of friendship and cooperation among them. As a result, an environment conducive to mutual support in tackling exercises related to operations involving fractional numbers was established.

On the other hand, with the integration of ICT, students were able to actively and interactively engage with mathematical concepts, which promoted a deeper and more substantial understanding. These digital tools provided an enriching and stimulating educational environment, where students had the opportunity to explore, experiment and apply mathematical concepts in a practical and concrete way.

In addition to enhancing numeracy skills, the integration of these technologies provided significant additional benefits for students with ADHD. By providing an attractive visual interface and interactive activities, their attention was effectively captured and their level of distraction decreased. This allowed them to maintain a higher level of concentration and active participation during lessons, which in turn contributed to better academic performance and a more satisfying learning experience.

Similarly, the collaborative nature of the interactive digital activities stimulated the establishment of positive social relationships among the students. Through working together on problems and exercises, an atmosphere of mutual support was created, where students helped and motivated each other. This sense of community and cooperation not only contributed to strengthening their learning, but also to improving their self-esteem and self-confidence.

- Thematic Block 4: Solving problems involving fractional numbers

In this thematic unit, students, after acquiring the fundamental concepts about fractions, were involved in solving exercises based on problem situations related to their environment, with the aim of applying this knowledge in a relevant context. In addition, the aim was that learning should not be limited solely to the mechanical application of formulas and algorithms specific to fractional numbers, but that students should develop analytical and reflective skills when interpreting each problem situation. It should be noted that the mathematical problems were adapted considering the particular needs of students with ADHD. The development of the exercises performed by the students is presented in detail in Figure 8.

Figure 8 Development of thematic block problem situations related to fractional numbers.

Note: The figure provides a visual representation of the performance of activities focused on solving problem situations involving fractional numbers.

Despite the benefits inherent in the use of educational technology, it was found that some students with attention deficit hyperactivity disorder, in relation to the resolution of problem situations, had difficulties in analysing and decomposing these situations in order to find the most appropriate solution. Although some students worked in groups of up to three people, they experienced difficulties in tackling the problems posed, which required the intervention of the teacher to find the required answer.

Under this perspective, it became evident that this thematic block is where students with ADHD mainly present limitations, especially with regard to the use of their cognitive abilities to carry out analysis processes. Therefore, it can be affirmed that although the use of ICT contributes to some extent to improving the conditions associated with dyscalculia, it is important to emphasise that it is only a didactic option. In this sense, the support provided by the teacher is fundamental in the resolution of problems by students with this disorder.

- Results Fourth stage - Validation of Didactic intervention strategy

As a result of the implementation of the techno-pedagogical strategy of intervention and didactic innovation, based on the use of ICT, with the aim of strengthening numerical thinking in students who present characteristics associated with Attention Deficit Hyperactivity Disorder, it was found that the use of these tools contributed to students showing a greater state of calm and level of attention. This resulted in a significant improvement in the acquisition of knowledge about fractional numbers, obtaining benefits in the following dimensions:

- Personal Dimension

In relation to the students with Attention Deficit and Hyperactivity Disorder involved in the study, it was possible to identify that the use of Information and Communication Technologies generated a notable change in their attitude towards learning mathematics. Unlike the situation previously diagnosed, where students showed irritation, anxiety and restlessness when being taught in a traditional classroom environment, the use of ICT kept them happy, motivated and interested in the subject area.

It is relevant to highlight that, by dynamising the educational process through educational technology, students experienced satisfaction when participating in the activities proposed in each thematic block. In addition, it was possible to observe a strengthening of the relationship between the teacher and the students, characterised by a friendly and respectful treatment. The students perceived their teacher as someone who understood them and supported them in their learning process. Likewise, the development of activities using the computer contributed to strengthening the bonds of friendship between them.

- Cognitive Dimension

In terms of the cognitive dimension and the integration of Information and Communication Technologies, the students managed to strengthen cognitive processes such as analysis. Through a detailed review of each proposed exercise, they applied the mathematical principles related to fractional numbers. It is important to highlight that learning was not mechanical, but rather that previous knowledge was combined with new knowledge, integrating it into the students' cognitive structure and giving meaning to the school activities.

On the other hand, by presenting activities based on the use of interactive digital resources, students acquired knowledge in a contextualised way. They were able to recognise how mathematics, in particular fractional numbers, are present in different situations in their daily lives.

In terms of the implications derived from the development of the didactic intervention strategy, significant differences were observed in the students' school performance between the pre- and post-assessment stages. The integration of ICT in the pedagogical process allowed students to achieve the learning objectives and goals established for each subtopic related to fractional numbers.

- Social Dimension

In the social sphere, this study had a significant impact on the re-evaluation of the pedagogical process carried out in the educational institution Santo Tomás de Aquino, with the aim of orienting the area of mathematics in primary education and attending to students participating in educational inclusion programmes. There was a transition from the traditional teaching method to the integration of educational technology, in order to motivate students in their learning process and allow teachers to transform their educational practices.

It is important to highlight that this didactic intervention experience had a significant social impact on the educational community of the municipality of Duitama - Boyacá. There are few initiatives in which ICT have been integrated as a teaching-learning strategy for students with symptoms associated with Attention Deficit Hyperactivity Disorder. The results derived from the research process were remarkable, which allows us to affirm that the use of technological tools for educational purposes in students with this disorder contributes to their academic performance. In this sense, the educational experience developed is feasible to be replicated in other schools where there are students with ADHD and low performance in the area of mathematics. Furthermore, the integration of ICT for this population in other disciplines of the school curriculum could

be considered, with the aim of guaranteeing educational inclusion and, above all, access to knowledge for these students.

It should also be noted that after applying the didactic intervention strategy that incorporated the use of Information and Communication Technologies (ICT) and digital educational resources in the learning of fractional numbers by students with ADHD, a notable change in their academic performance was observed.

Prior to the intervention, students had an average score of 5.778 on an assessment scale ranging from 1.0 to 10.0 points. This indicated a relatively low level of performance in the subject of fractional numbers.

However, after the intervention, on the final test, the average score increased significantly to 8.533. This improvement represented a substantial change in performance level, raising students from a low to a high level.

The difference between the average pretest and post-intervention scores was 2.775 points, which translates into an increase in school performance of approximately 47.6%.

These results strongly support the effectiveness of ICT and digital educational resources as didactic tools. Furthermore, they demonstrate their ability to significantly improve the learning of fractional numbers in students with ADHD. These findings not only meet the learning objectives and goals defined in the curriculum, but also underline the great potential of ICT in the education of students with attention deficit hyperactivity disorder.

At the conclusion of the research process, a final opinion survey was conducted with the teacher responsible for teaching mathematics. The purpose of this survey was to gather the perceptions and experiences of the educator in relation to the implementation of educational technology in the teaching of students diagnosed with ADHD. From the analysis of the survey responses, significant categories emerged that provide an in-depth understanding of the impact and role of educational technology in enhancing the learning of these students. These categories provided valuable insight into key aspects such as innovative methodology and didactics, support for the development of cognitive processes and the need for teacher training in the effective use of ICT. These findings not only enrich the understanding of the effectiveness of educational technology, but also highlight its potential to boost educational quality and promote meaningful learning for students with ADHD in mathematics.

- Category: Methodology and innovative didactics

The teacher highlighted the importance of ICT in the learning of students with ADHD in the topic of fractional numbers. ICT provided an engaging learning experience, motivating and maintaining students' attention. The Padlet platform, in particular, helped to manage anxiety and hyperactivity, providing an organised and welcoming learning environment. The adaptability of ICT made it possible to adjust the pace of learning according to the individual needs of the students. In addition, the integration of ICT promoted general skills, such as autonomy and decision-making, along with technological skills.

- Category: Supporting the development of cognitive processes.

ICT improved understanding of fractional numbers and allowed students to explore mathematical concepts visually. Students developed a deeper understanding and learned to apply concepts in a variety of contexts. However, some students faced challenges in applying the concepts. The teacher emphasised the importance of ongoing support from educators in solving specific student problems.

- Category: Lack of teacher training for ICT use

The teacher highlighted the need for continuous training for educators in the effective use of ICT. This training should range from technical knowledge of digital tools to adapting

resources to meet the individual needs of students. Training will not only improve the technological competence of educators, but also enrich their pedagogical skills, promoting equal opportunities and the creation of inclusive educational environments.

Overall, the teacher recognised the value of ICT as an innovative methodology for learning fractional numbers for students with ADHD. However, she also pointed out the importance of continuous training for educators to fully exploit the potential of ICT in inclusive education.

Final Discussion

The research provides a clear picture of a number of challenges in the educational environment that restrict the attention span of students with Attention Deficit Hyperactivity Disorder (ADHD). These challenges are related, in the first place, to the lack of curricular adaptation. Conventional teaching methods and the lack of specific accommodations for the needs of these students have been identified as key obstacles to their learning. This results in poor academic performance and can lead to feelings of frustration and demotivation.

Furthermore, the research reveals that the lack of innovation in teaching methods and didactics represents a significant challenge in the context of ADHD. Traditional methods and conventional materials fail to meet the demands of these students and to facilitate effective learning. This is partly due to a lack of adaptation to individual needs and a lack of differentiated pedagogical approaches that take into account their particularities.

A relevant aspect of this issue is the need to use educational technology effectively. While technology offers significant opportunities for learning for students with ADHD, the lack of digital competencies, both on the part of teachers and students, limits its successful implementation. This is a major challenge that needs to be addressed through teacher training and the promotion of digital skills among students.

In this context, it is demonstrated that the appropriate use of educational technology, in particular through digital activities and games, can have a positive impact on reducing the anxiety and hyperactivity experienced by students with ADHD. These digital resources stimulate students' motivation and engagement in understanding concepts related to fractions. In addition, the possibility of advancing levels and overcoming challenges in digital activities promotes concentration and the development of appropriate academic tasks.

The implementation of a techno-pedagogical strategy resulted in a significant improvement in students' academic performance, with an increase of 47.6%. This supports the idea that educational technology can play a key role in the development of numerical thinking and performance of students with ADHD.

In general terms, curriculum adaptation, innovation in teaching methods and educational technology are crucial elements to improve the learning of students with ADHD in mathematics, especially in the area of fractions. Overcoming these challenges requires differentiated pedagogy, teacher training and the promotion of digital competences. The appropriate application of educational technology can be especially effective in improving the educational experience and academic performance of these students.

Conclusions

The conclusions emerging from the research offer valuable insights into the improvement of mathematics learning in students with Attention Deficit Hyperactivity Disorder through the use of educational technology.

Firstly, it is clear that curriculum adaptation plays an essential role in the education of students with ADHD. This adaptation is not an unfair advantage, but a necessity to ensure that each student receives an education tailored to his or her specific needs. By removing barriers and providing appropriate supports, inclusive and equitable education is promoted.

The re-signification of teaching methods and pedagogy used by mathematics teachers is another important point. Traditional methods are insufficient to meet the needs of students with ADHD in learning mathematical concepts. Innovation and adaptation of teaching to the particularities of students are essential to address learning difficulties and encourage active participation.

Third, educational technology, especially interactive digital resources, has proven to be an effective tool for improving the academic performance of students with ADHD in mathematics. Customisable resources can engage students' attention, provide targeted supports and improve their understanding. However, it is crucial that teachers are trained in their effective use and that this technology complements, rather than replaces, the work of the educator.

Taken together, these findings highlight the importance of inclusive, quality education that is tailored to the individual needs of all learners, regardless of their specific challenges. By addressing curriculum adaptation, innovation in teaching methods and the use of educational technology, it is possible to move towards a more equitable and inclusive education that benefits all learners.

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