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Educational Robotics and Attention to Diversity: A Case Study

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Abstract: In this study we focus our research on the case analysis of an eleven-year-old boy and his close relationship with technology, specifically robotics. The methodology of the study is experimental in nature, with the aim of improving the subject's attention span through robotics, thereby favouring his educational process and, consequently, his overall development. To this end, the attitudes, and aptitudes that this technological tool has provided the subject with are evaluated over a period of four years. Three data collection instruments were selected: questionnaire, interview, and observation. Among the conclusions we highlight, on the one hand, that the older the age and the greater the interest in robotics, the greater the individual's attention span and greater psychomotor coordination, increasing the improvement in the educational process and in their daily life. On the other hand, robotics is an effective way of orienting knowledge towards the personal and educational sphere and can provide advantages in integral development.

Keywords: *Attention to diversity, primary education, robotics, technology.*

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Introduction

The article focuses on improving students' attention span through robotics. It is a reality that, despite the potential and the great increase in the use of technologies, we do not know a priori the real impact that they can have on the learning and development of students (Herodotou, 2017; Hughes-Roberts et al., 2018), and we do not even know the social and cognitive differences that can appear due to the "digital divide". There is an educational context in which students are highly unmotivated, uninterested and unwilling to learn, as the way in which learning is presented to them has nothing to do with their interests and motivations. This is why it is considered a necessity for schools to get closer to society and, with it, to new technologies, either out of school or, increasingly, in school activities.

There is, therefore, a need for change in the classroom, altering traditional and unidirectional practices towards more alternative ones where educational technology takes on great strength by providing different resources and didactic materials, finding two-way teaching-learning processes and taking into account the diversity of the student body. Robotics as a mediating element for the achievement of learning can be an excellent instrument for the educational inclusion of all students, developing their personal and social environment (Lindsay, 2020). In this line, in this study we analyse the case of an eleven-year-old boy diagnosed with attention deficit hyperactivity disorder (ADHD) and his improved attention span through educational robotics.

Educational Robotics and Attention Deficit Hyperactivity Disorder (ADHD)

There is currently an urgency to adapt to the new times and social demands, so schools must undertake a process of reflection and innovation on these changes, motivated by information and communication technologies. In this sense, a wide variety of research and studies are emerging from the Spanish and international panorama that seek to develop the relationship of these technological tools with all social spheres, considering what these media contribute to the development and acquisition of teaching (Arabit-García & Prendes-Espinosa, 2020; Friesel, 2013; González-González et al., 2021; Hervás-Gómez et al., 2021; Iphofen & Kritikos, 2019; Vivas-Fernández & Sáez-López, 2019;) and to inclusive education (Encarnação et al., 2016). In this context, digital competence requires a series of attitudes and values that

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enable adaptation to the new demands brought about by technologies (Fernández Miravete, 2018), with robotics constituting a very appropriate technology to favour the acquisition of competences, such as emotional and digital competences (González-González et al., 2021).

Nowadays, it is increasingly common to find the integration of robotics as an educational and/or pedagogical tool in schools. This is important mainly for two reasons: on the one hand, Primary School students who are in the concrete operations stage and already have sufficient ability in cognitive skills (Piaget, 2014), educational robotics becomes a suitable educational resource. On the other hand, robotics fits perfectly with the constructivist perspective of learning, allowing students to learn in an active and even playful way by building objects and experimenting with abstract concepts in a meaningful and functional way, allowing interest in school work to increase (Fachantidis et al., 2020).

In this way, robotics could become one of the keys for Primary School students to learn to use technological tools and to think logically and critically (Vivas-Fernández & Sáez-López, 2019). Educational robotics is a new interdisciplinary teaching system that covers different areas of the curriculum and allows students to actively learn by means of mechanical, electronic and technological devices or tools.

Over the last 10 years, robotics has undergone constant evolution, awakening great motivation in children in Infant and Primary Education (Llopis, 2017), making it a key element for the development of the educational process in the classroom, since, due to its factors and capacity for adaptation, it provides beneficial advantages. Thus, it improves communication and peer interaction (Pivetti et al., 2020), social problems (Lindsay, 2020), emotional problems (Roberts-Yates & Silvera-Tawil, 2019), motivation (Knight et al., 2019), among others. Authors such as Moorthy and Pugazhenthii (2017) found that the use of the robot improved students' attention.

Currently, in the Spanish context, the official curriculum for the Primary stage establishes that pupils must develop digital competence and technological competence in a cross-cutting manner in all areas of knowledge (Arabit-García & Prendes-Espinosa, 2020). The Real Academia Española (n.d.) defines the term "Robotics" as a technique that applies computer science to the design and use of devices that, in place of people, perform operations or work, usually in industrial facilities.

Educational robotics is a new interdisciplinary teaching system that covers different areas of the curriculum and allows active learning by students through mechanical, electronic and technological devices or tools (Martínez et al., 2016). Authors such as García & Reyes, 2012, p. 47) understand it "as an area of pedagogy that introduces some aspects of robotics and process automation into educational processes as a mediating element for the achievement of learning".

In our study, we focus on "attention" as a fundamental element for the construction of learning. However, for students to be able to pay attention in an interested way, they must first have a certain motivation towards the task, and in this case, this extrinsic motivation is provoked by robotics (Hervás-Gómez et al., 2021). In this line, recent studies highlight the relationship between robotics and motivation (Merino-Armero et al., 2018; Sánchez-Sánchez, 2019; Sánchez et al., 2020), as well as the ability to favour integration, inclusion and normalisation processes (González-González et al., 2021; Ocampo & Lizasoán, 2019).

The problem of inattention has been studied a great deal at present due to the high rate of students who present a deficit that hinders the proper development of the educational process, which is why it causes concern in education. Children with ADHD have difficulty paying attention at school and at home. They are often more active and impulsive than usual. These behaviours contribute to significant problems in relationships, learning and behaviour. This deficit produces a functional impairment with a negative impact on quality of life, which is apparently invisible in day-to-day life, but has a serious impact on the psychological, social and academic well-being of the subject who suffers from it (Hernández et al., 2017). Authors such as Jarque (2012) argue that an adequate approach to the process of assessment and intervention of this disorder must take into account the contexts where the child develops (school, family and community), an approach also coined by authors such as Rodríguez-Salinas et al. (2006); therefore, to treat this disorder at school, a multidisciplinary team is required.

We are therefore talking about using a technological medium to be able to build a positive learning process in the classroom, continuing to work with the family so that it is also beneficial for their personal development. Taking all of the above into account, the idea presented in this article is based on improving the attention span of students diagnosed with ADHD disorder through robotics. In this sense, the research questions we ask ourselves are the following:

Is it possible to improve the attention span of students with attention deficit through robotics?

Does this improvement favour the construction of the educational process and, therefore, their integral development?

Methodology

Taking into account the research questions, the aim of our research has been to improve the attention span of a student diagnosed with ADHD through robotics. Regarding the methodology of the study, we can say that it presents a mixed approach (quantitative-qualitative), with a descriptive nature that allows us to respond to our theoretical needs

through different sources of information. The design of the study is experimental in nature, selecting the triangulation technique to obtain quantitative data through the questionnaire, and qualitative data through the interview and observation.

As it is a case study, we focus on a subject who is currently eleven years old, and who has been the subject of the study from the ages of seven, eight, nine and ten years corresponding to the school years 2016/17, 2017/18 and 2018/19, 2019/2020.

Data Collection Instruments

We used three instruments to collect information: questionnaire, interview and observation. With regard to the first, an ad-hoc questionnaire was selected with different questions categorised into two dimensions (digital literacy in primary school and skills and abilities developed with ICT).

For the validation of the questionnaire (content validity), a group of experts composed of 8 university professors (4 specialists in attention to diversity and 4 in educational technology) was selected. For their selection the "Expert Competence Coefficient" or "K-Coefficient" procedure was used, obtained by applying the following formula: $K = 1/2 (Kc + Ka)$, where Kc is the "Coefficient of knowledge" or information that the expert has about the subject or problem posed; and Ka is the so-called "Coefficient of argumentation" or substantiation of the criteria of the experts (Cabero et al., 2015). In our case, the coefficient K was higher than 0.8 in 6 of the 8 selected experts, denoting a very acceptable degree of competence. The experts' estimates were made in successive rounds, anonymously, in order to try to achieve consensus, but with maximum autonomy on the part of the participants (Delphi method). The reliability of the questionnaire was calculated by means of the reliability coefficient known as Cronbach's Alpha, where quite high values were obtained in terms of overall reliability (0.895).

The interview used was of the direct type, due to the close relationship with the subject of the case. In relation to the observation, it should be said that this was a non-systematic observation.

Procedure

We developed the methodology as follows: we began the study of the case study subject by reviewing the literature on ICT in order to verify the positive evidence regarding their use in educational contexts and in everyday life (Cabero-Almenara & Llorente-Cejudo, 2010), detailing statistically significant improvements in the overall development of the subject. Based on this approach, four academic years ago (2016/17) we began a case study of a student who was highly motivated by technology and had attention deficit. The subject has been in contact with technological toys (with lights, sound, movement, etc.) since the first months of life. During his period in infant education, a lack of attention was observed in the child (both by the family and by the educators); both parties decided to carry out a diagnosis and treatment to work on improving this deficit, with the support of technology. It is when the child turns six years old, after the subject insists on the subject, that he/she start in extracurricular activities focused on robotics (creation of Lego with movement sensors, creation of robots, 3D printer, computer programmes...), and it is from this year onwards when we begin to develop the present study.

To establish the validity and reliability of our study we followed the principles of credibility, transferability, dependability and confirmability (Lincoln & Guba, 1985). The credibility of our study is demonstrated by all encounters with the study subject. To facilitate the transferability of the results, descriptions were made as detailed as possible, as can be seen in table 4. To ensure the dependability of the data, the data analysis was carried out by 2 researchers. The confirmability of the data was done by a researcher external to the research, who reviewed the data collected and the interpretation of the data by the author of the paper, providing feedback and ensuring the validity and transparency of the information.

Results

Based on the data obtained, we can present the results achieved in the study from a reflective and critical perspective and approach the context in which the action takes place. We present the data in Tables 1, 2, 3, and 4.

Table 1. Pre-test Score of the Questions in a First Moment Corresponding to the Second Year of Primary Education

Pretest	overall scores
Dimension 1: Digital literacy in primary education	
1=Not at all; 2=Slightly; 3=Quite a lot; 4=A lot	
	Percentages
1.1. Are you able to write a document in the word processor?	2
1.2. You manage files in folders and save the information.	3
1.3. You work with autonomy in the activities proposed in the Interactive Whiteboard.	2
1.4. You write comments on the blog	1
1.5. You have the autonomy to write and edit a blog or wiki entry.	1

Table 1. Continued

Pretest	overall scores
Dimension 2: Developed ICT skills and abilities	
1=Not at all; 2=Slightly; 3=Quite a lot; 4=A lot	Percentages
2.1. Distinguish relevant and important information	1
2.2. You develop critical thinking skills in relation to the information you handle.	1
2.3. Acquire autonomy in the development of assignments	1
2.4. You show initiative and entrepreneurial spirit	1
2.5. You develop oral expression skills	1
2.6. You know how to work in a team, in a collaborative way.	1
2.7. You are able to solve problems in the learning process.	1
2.8. You develop your creativity	1
2.9. You develop laterality skills	3
2.10. You develop written expression skills	2

As can be seen from the data in table 1, the data are well below the average level, where in most of the dimensions the value 3 is not achieved.

Table 2. Post-test Scoring of the Questions at a Second Point in Time Corresponding to the Fifth Year of Primary Education

Postest	overall scores
Dimension 1: Digital literacy in primary education	
1=Not at all; 2=Slightly; 3=Quite a lot; 4=A lot	Percentages
1.1. Are you able to write a document in the word processor?	4
1.2. You manage files in folders and save the information.	4
1.3. You work with autonomy in the activities proposed in the Interactive Whiteboard.	4
1.4. You write comments on the blog	3
1.5. You have the autonomy to write and edit a blog or wiki entry.	3
Dimension 2: Developed ICT skills and abilities	
2.1. Distinguish relevant and important information	3
2.2. You develop critical thinking skills in relation to the information you handle.	3
2.3. Acquire autonomy in the development of assignments	4
2.4. You show initiative and entrepreneurial spirit	4
2.5. You develop oral expression skills	3
2.6. You know how to work in a team, in a collaborative way.	4
2.7. You are able to solve problems in the learning process.	3
2.8. You develop your creativity	4
2.9. You develop laterality skills	4
2.10. You develop written expression skills	3

The results of the post-test reflect much higher values than those of the pre-test, mostly ranging between 3 and 4.

Table 3. Part of the Interview with the Subject at Age Ten

Interviewer: What attracts you most to technological tools?
Interviewee: <i>I have fun, I love... creating, imagining... moving objects and listening to sounds that you can also create. I love speakers, I have a collection of about 123 speakers of different brands, shapes, sizes and colours, and every day I play with them. I also collect different Pendrives, I have about 103...in them I have a lot of information from school, documents that I invent, films, music... And finally this year, the Three Wise Men gave me the Lego Wedo 2.0 game. I have more robotics toys to build: mechanical arms, dolls that move, launchers, and others.</i>
Interviewer: How long do you remember having contact with technology?
Interviewee: <i>I don't remember. I was very young... always. My mother tells me that when she was pregnant with me, she was working on the computer. And when I was born, she was holding me in her arms and I was hitting the keys on the laptop.</i>

Table 3. Continued

Interviewer: When you were younger, it was harder for you to draw without going out of line because you were absent-minded (lack of attention) ... Do you think robotics has helped you to improve these "little problems" you had?

Interviewee: *Yes, since I was two years old I have been working on my homework with the computer, because at nursery school they taught us a lot of activities with a digital blackboard and computer. When I was seven years old, and I started with robotics, exactly with the assembly of Lego Wedo 2.0, you have to focus a lot of attention because you have to make figures with very small pieces and you have to put them in place so that when you program them with the computer they can move; I have to have a good pulse and be attentive, and if I can do this with these robots, I can also pay more attention in class (also as we work with a digital blackboard, computers, pen drives...), which I like a lot, I don't get bored because I don't get bored. which I like a lot, so I don't get bored), and I have more beautiful calligraphy (I've learned to count the squares in the notebook...), to hold the pencil properly, and robotics has helped me a lot. I've always wanted to sign up for robotics, and at home I also have the 3D pencil, the Lego Wedo 2.0, and the addresses of apps that my teacher tells me about to work with Scratch etc.*

Interviewer: What would you like to be when you grow up?

Interviewee: *I've said it before, video game designer, although I also hesitate because I would like to be a technician at Google... I'm eight years away from being 18 and they are going to buy me a car with a front and rear screen to visualise what is happening around my vehicle; there is also a big part of robotics in cars and they are built by robots. I also like to do scientific experiments (I make perfumes, bath salts...) but I have to invent something that links these experiments with robotics. My maternal grandfather died when I was three years old, and some nights I cry because I can't see him; I've been thinking for about five years now about how I can build a machine or a ship so I can go and see him... But yes, when I grow up I will have a profession related to technology.*

Table 3 shows part of one of the interviews with the 10-year-old subject, where his motivation and passion for technology can be appreciated.

Table 4. Observation Synthesis

The expert agent focuses on observing the subject from the age of seven to ten, corresponding to the academic years (school years 2016/17, 2017/18, 2018/19, 2019/2020) in his motivation for technological tools, noticing a great interest in robotics; working with this medium helps him to create and imagine new situations. He is not a child who likes to play "typical" games for his age, such as: symbolic play, games with cars and garages, simulating fights, inventing roles of television characters... This subject is more interested in getting to know the toy from the inside, manipulating it with a screwdriver to find out how it moves and what parts the toy uses; his greatest interest most of the time is in toys that have movement, that have sounds, or that he can create. Since the age of four his hobby is collecting speakers, and at the age of ten he has a collection of about 123 speakers of different brands, shapes, sizes and colours, and every day he likes to know a little more about them. He also collects Flash Drives, so he may have about 103 of different sizes, colours, etc. He knows exactly what he keeps in each one: school information, documents he invents, films, music... During these four years he is given different games related to robotics: a game to build a robotic arm, different dolls, and the Lego Wedo2.0 game, among others. We emphasise the interest and motivation towards these electronic toys, and the non-existent affinity with traditional games such as playing with cars, balls, marbles...

The expert has been observing the subject over the years, and we have detected that since he was a child he has found it difficult to draw without going out of line due to a lack of attention and impulsivity; however, over these four years we have observed how robotics helps the subject to overcome these difficulties, since with robotics, exactly with the assembly of the object, he has to make figures with very small pieces and has to put them in place so that when he programmes them with the computer or Tablet he manages to have movement and sound; He knows that he has to have a good pulse and be attentive to carry out the activity, so he is able to focus his attention, favouring greater concentration. Working with technology enhances his enjoyment, which leads to greater self-esteem, happiness and achievement. Through this greater concentration, favoured by robotics, it has helped him to acquire a more perfect handwriting (he has learned to count the squares in the notebook, to hold the pencil properly, to stop more when drawing...). Since he was little he has wanted to be enrolled in robotics classes, and now that he has been there for four years, he is very happy with the activities he is doing, complementing them also at home by having a 3D pencil, construction games and the addresses of apps that the teacher is giving him to work with Scratch, etc. In the evaluation reports of these four academic years, the following can be corroborated: He must control his impulsivity more; he does not acquire a correct posture when writing or drawing due to his motor restlessness; he shows great interest in learning new words; the directionality of his drawing is correct but still needs improvement; we recommend reinforcing calculation; he should improve his written expression; he has improved, but we must continue to insist that he expresses his ideas with greater order and coherence, he is very responsible; he must exercise reading; we recommend reinforcing numbering; among others. In the last evaluation report, it can be seen how he is progressively overcoming these limitations with the help of technology: he has made very positive

progress, although there are still features such as handwriting that need to be improved, highlighting his degree of responsibility. In the future, he would like to be able to design video games or become a Google technician. He is counting the days until he turns 18 and drives a car, and even has a passion for the assembly of these vehicles, as he has a large part of robotics. We highlight the cohesion between training and future professional development.

His bedroom consists of a bed, a desk and a bookshelf, where a large part of his speakers and electronic games are concentrated. Next to the bedroom is a dressing room, also with shelves, full of speakers. He treats these speakers as tools of the trade, as his goal is to become a technology professional. We emphasise the tidiness of the room and the care for objects.

At the age of seven, the most common place to play was in the living room with the family; as the years have gone by, he places his play area in his room. As he gets older, he seeks his own privacy.

In a diary he writes down his hobbies, projects, new designs. He is a child who has had a close relationship with music since the age of three; from the age of three until the age of seven he has been enrolled in a music school; and although he has always been very interested in this subject, what motivates him most is composing and creating his own music, an activity which he carries out with a mixing desk and computer. We note the good ear he has and his predisposition for music.

In general terms, during these four years (although we know that this happens from the first months of life), he is a child with a passion for technology, from which he makes the most of in order to eradicate his attention deficit and to be able to build an adequate educational process and an integral personal development. We highlight the electronic resource as a fundamental means in this favourable evolution of the subject.

In the synthesis of the observation presented here, it can be seen that the environment surrounding the subject is also permeated by technological components.

We provide images of the aforementioned robotics games:



Figure 1. Electronic game assembly

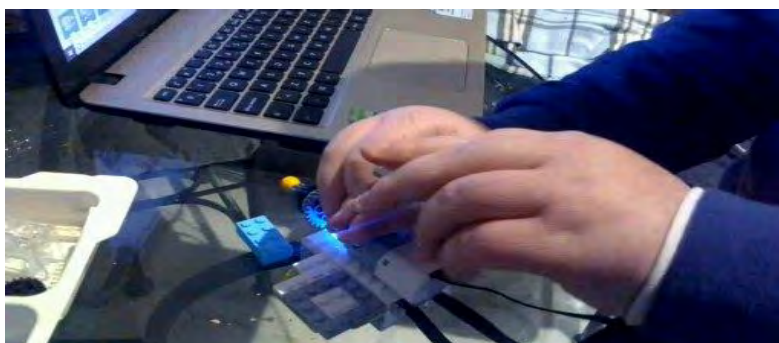


Figure 2. Manipulation of the subject with the electronic game

The triangulation between these three instruments made it possible to obtain broader and more exhaustive information in order to respond to both the objective of this study and the approach from which it originated. Thus, the following results were obtained: The questionnaire was developed in two stages (first as a pretest when the child was in the second year of Primary Education, and secondly, when he/she was enrolled in the fifth year of Primary Education). When a pretest-posttest contrast was carried out through, the following results were obtained (Figure 3):

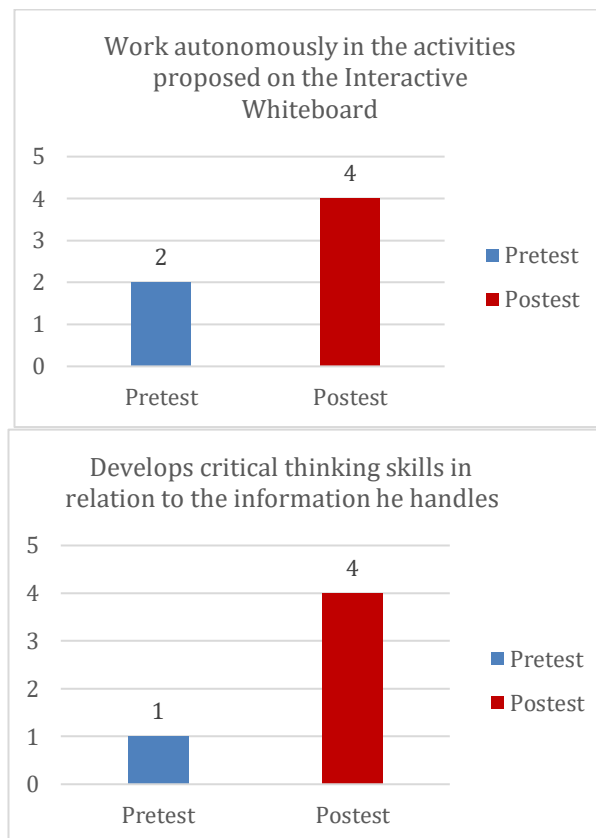


Figure 3. Pretest-Posttest contrast

Of the different questions addressed in the two dimensions in which the questionnaire is structured, we have selected two samples corresponding to question 1.3. You work independently in the activities proposed on the Digital Whiteboard (Dimension 1: Digital literacy in primary school) and question 2.2. You develop critical thinking skills in relation to the information you handle (Dimension 2: Skills and abilities developed with ICT). In both graphs, we can see the evolution between the first moment and the next, taking into account not only age, but also the motivation shown towards training in technology, as a key element to encourage attention and continue with the learning process in an appropriate way.

As in the questionnaire, the interview also reflects the great interest shown by the subject in technology, specifically in robotics. Through the conversation with the subject, it becomes clear how the concept of education is changing towards the social demand that is currently being demanded, technologies, education geared towards the labour market, and this is confirmed in the interview when the subject links interest, training and employment goals. From an early age, he shows great motivation towards the manipulation of electronic toys, which leads to the construction of learning by discovery following guidelines and a creative way of thinking; the scope of the process being a challenge in each activity, and not a mere rote learning process.

In the observation, we took into consideration the family context in which the subject develops, an environment surrounded by technological devices, which have been within the child's reach at all times. This factor may have been a determining factor for the child to work with robotics in a playful way, promoting a learning process in which the child is the protagonist, working on technological understanding. It fosters skills such as motor skills and attention, traits that we have observed in continuous evolution during these four years.

Discussion

The introduction of Information and Communication Technologies in the educational system has had the fundamental aim of facilitating the use of these tools by compulsory education students from the different ICT educational policies (Colás et al., 2017). For Sáez and Domínguez (2014), in more general terms, serious games offer new technologies and methodologies for the creation of a highly interactive curriculum. At present, and specifically, in this Covid-19 situation where technologies have served as totally necessary means, we have been able to verify the need for the insertion of these technological means in all social sectors, so it is at increasingly younger ages, which allow students, regardless of their social, physical or mental condition, to build an educational process according to their characteristics. In this case, we have explained and substantiated how ICTs have become not only a fundamental factor for the promotion and

development of society (Cabero-Almenara & Llorente-Cejudo, 2010), but also a great means to support teaching (Sáez & Ruiz, 2014), to the promotion of personal and social development (Lindsay, 2020).

We should point out that this same child was the subject of a study at the age of two (Reyes-Rebollo & Piñero, 2012), presenting at that time, the affinity of the subject with technologies, highlighting the detail of walking with his baby carriage with a computer mouse, taking this technological resource as an object of attachment.

Technological media provide constant renewal at different social levels, and at increasingly younger ages, helping us to make use of them. Distance learning, or virtual learning, allows learning and interaction with pedagogical references that allow reflection and the generation of good practices. With this study, we offer an image of technological media, specifically robotics, as an innovative resource that can be used inside and outside the classroom, as it helps to improve social (Lindsay, 2020), emotional (Roberts-Yates & Silvera-Tawil, 2019), communication (Pivetti et al., 2020), motivation (Knight et al., 2019), etc., which means that it can also be inserted into the educational classroom to help improve the teaching-learning process of students. Bearing in mind that not all students learn in the same way, the use of ICT helps students to relate the subject to the real world and to actively participate in their own learning, increasing their interest in school work (Fachantidis et al., 2020). Therefore, we believe that through the data provided in this study, we can confirm the approach of working with technological media as resources that favour full integral development (Roig-Vila et al., 2020).

Conclusions

Among the conclusions we highlight the following: on the one hand, that robotics is an effective way of orienting knowledge to the personal and educational sphere and can provide advantages in integral development. It is also presented as an effective means of learning with technological tools. On the other hand, it has been detected that the older the age and the greater the interest in robotics, the greater the attention span and the greater the psychomotor coordination, increasing the improvement in the educational process and in daily life. Likewise, robotics increases the level of motivation and therefore contributes to a greater involvement in school tasks of this type of student, contributing to an improvement in attention.:

Recommendations

Although not many studies have been found on the subject either nationally or internationally, it is assumed that this is a growing field for which more research is needed. Its introduction into the classroom is slow and complicated and its functionality has not yet been 100% tested. That is why, on the basis of this small study, we intend to carry out further research in the future, always bearing in mind its importance in today's society and its great influence on the education of people with special educational needs. Hence, its introduction in the classroom should be done from a very early age.

Limitations

The proposed system has some limitations that deserve to be considered in future work. Firstly, although our analysis is robust, the sample is limited to a single subject, hence the need for a study with a larger number of subjects.

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Authorship Contribution Statement

Fernández-Batanero, Conceptualization, writing-review and editing, critical revision of manuscript. Piñero-Virué: Analysis, writing, methodology. Rodríguez-González: Editing/reviewing, supervision, final approval. Reyes-Rebollo: Formal analysis, resources, drafting manuscript.

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