Analysis of the Impact of ICT through Apps on Students with Autism Spectrum Disorder: A Systematic Review of the Literature

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Abstract—**Several research studies have recognized the importance of the use of Information and Communication Technologies (ICT) in the academic performance of students with Autism Spectrum Disorder (ASD). Through a systematic review of the literature, we have sought to provide evidence on the impact of technology on the teaching-learning process of students with ASD, with the purpose of promoting the advancement of knowledge in this field, both for teachers and educational professionals, as well as for researchers. This analysis has identified some digital applications that improve academic performance and promote better communication, improved social relationships and improved emotional regulation in students with ASD. The conclusions of the study have provided evidence of the factors that need to be taken into account when designing apps to work with students with ASD. Appropriate selection involves understanding their needs and the functions of the apps. Interdisciplinary collaboration in app design helps teachers choose effective tools for each student with ASD. This will determine that teachers will be able to select those apps that best suit the individual needs of the students, taking into account the educational objectives proposed.**

Keywords—**Autism Spectrum Disorder (ASD), Information and Communication Technologies (ICT), autism, app, teacher, technology**

I. INTRODUCTION

Today, society operates in an environment where the use of Information and Communication Technologies (ICT) is becoming increasingly important in various fields (educational, professional, cultural, etc.). It is clear that the purpose of ICT is to improve the environment and the needs of society. The increase in technologies and their use has led to a growing interest in including ICT in the educational context, precisely with the aim of improving the academic performance of the educational community. In the educational context, ICT has enabled the development of other dimensions in terms of methodological teaching processes. This perspective favours the development of new spaces for learning and interaction [1].

On the other hand, several authors have pointed out the benefits of the inclusion of ICT in the teaching-learning process of students with educational needs, as they awaken additional motivation and interest [2]. In this sense, it is important to address the educational needs of all learners, including those with Autism Spectrum Disorder (ASD) [3].

ASD is characterized by the presence of disturbances in social interaction and relationships, as well as disturbances in communication and language. In addition, there are limitations in imaginative activity and a lack of mental flexibility [4]. Therefore, ASD is considered as a spectrum, i.e. a set of persistent symptoms. The World Health Organization [5] defines ASD as "a group of conditions characterized by some degree of impairment in social behaviour, communication and language, and by a restricted, stereotyped and repetitive repertoire of interests and activities". Such difficulties can have a significant impact on the academic performance of students with ASD.

The symptoms of the disorder may vary, i.e. not everyone manifests identical characteristics. Some people may experience milder symptoms while others may need ongoing supports, hence ASD is classified into three levels of severity [6]. This situation determines the importance of developing resources and providing supports on an individualised basis, tailored to the specific needs of each person. In this case, it is necessary that ICT applications can be adjusted to the characteristics of students with ASD, adapting to the learning pace of each student.

Given the difficulties presented by students with ASD, ICT is particularly relevant [7, 8], as it offers a large number of resources and alternatives that favour the learning process of these profiles. García *et al.* [3] consider that ICT resources help to improve communication and language. Such tools will help children to interact with their environment, thus developing their social skills, autonomy and independence.

On the other hand, due to the visual qualities of ICTs and given the recognition of the relevance of the visual in the cognitive processing of people with ASD, it can be seen how students may find the use of these technologies more motivating [9]. Furthermore, according to Pérez [10], ICTs generate a favourable environment for the management and assimilation of content, as they have the capacity to present information in a clear and organized manner, facilitating its understanding.

For Martínez and López [11], ICT offers the advantage of being able to be used in a personalized way and adapted to the individual needs of students with ASD. This makes it possible for teachers to design specific communication systems, integrating images and vocabulary that are favourable to their learning. In this case, the intervention of the teacher is essential, who will be in charge of including them in their work methodology with the aim of getting the best academic performance from students with ASD [12].

Finally, ICT can also be highly stimulating and motivating for students with ASD [13]. Many have interests in technology and electronic devices. These interests can serve

as a strategy for working on communication and learning activities [3]. Drawing on this perspective, Passerino and Costi [14] indicate that the use of ICT can raise levels of self-esteem, thus favouring the process of social interaction and communication.

Given the characteristics of the type of work, the data from the study may not provide conclusive results, but it may help to understand a little more about the importance of the use of ICT in the classroom, especially when applied to students who may present greater academic and personal difficulties, as is the case of students with ASD.

This systematic review aims to conduct an analysis of the use of ICT with a focus on effectiveness in the selection of the type of applications and use of ICT to improve the performance of students with ASD. From this perspective, the following research questions arise: Are all apps suitable for working with students with ASD? (PI01) and Do teachers have knowledge about how to choose the apps that best suit the needs of their students with ASD? (PI02).

Having formulated the different questions that have given rise to the focus of this study, we will now proceed to detail the objectives of the research work:

- To analyze the suitability of the applications used to improve the academic performance of students with ASD.
- To find out the level of teachers' knowledge in the selection of applications to improve the academic performance of students with ASD.

II. MATERIALS AND METHODS

In order to answer the questions posed for the study, the method used to carry out the research work was a systematic literature review. The following is a description of the process that was followed based on a series of searches in specialized databases relevant to the area of study.

The selection of articles was carried out according to quality standards following the criteria of the PRISMA declaration [15]. For this purpose, a bibliographic search was carried out by selecting the following databases: Scopus, Web of Science, Education Source and Educational Resources Information Center (ERIC). Scopus and Web of Science include educational scientific journals of international prestige, while Education Source and Educational Resources Information Center (ERIC) are specialized in the field of education. These databases allow users to access a variety of sources and perspectives in the field of education and offer advanced search tools that allow users to obtain more accurate and relevant results. In addition, the documents indexed in these databases have undergone a peer-review process, which increases the quality of the information.

To narrow the search, specific dates were set: studies published between 2016 and 2022. The keywords used were the following: autism; teacher and applications, in English and Spanish. In addition, the selection of studies had to be in Open Access article format.

A. Selection Criteria and Selection Results

The first search yielded 40 papers. To ensure the relevance of the selected literature, a number of inclusion criteria were established during the selection process as shown in Table 1.

Table 1. Inclusion criteria and exclusion criteria for the review

Inclusion criteria	Exclusion criteria
To address the use of ICT in the field of education for students with ASD.	Not related to the field of education.
It should provide a general review of the implications of ICT in the academic field for students with ASD.	Works on the analysis of specific digital educational resources such as specific applications.
It should include the search descriptors in the title of the article, in the abstract and/or in the keywords.	Duplicated works.
That it complies with the determined period of time (2016–2022).	Outside the established time period.
Written in Spanish and/or English.	Written in other languages.
The article must be in open format.	Closed access.

The following Table 2 gives an overview of the number of sources found in each database.

Table 2. Results of the bibliographic search by database

Database	Sources
Scopus	15
WoS	15
Education Source	5
ERIC	5

The article searches and selection process was divided into four phases (Fig. 1). The first phase was identification. This phase consisted of searching the databases mentioned above. Using the descriptors and following the inclusion and exclusion criteria, a total of 40 records were obtained. The second phase was a screening phase. In this stage, all the publications obtained were reviewed and duplicate articles (*n* = 11) were eliminated. The third phase corresponds to the suitability phase. In this phase, the abstracts and keywords were read in order to catalogue the articles according to the previously agreed inclusion and exclusion criteria. A further 23 articles were rejected because they did not meet the inclusion criteria and/or were not relevant to the study. Finally, in the inclusion phase, 6 valid publications were collected for the review.
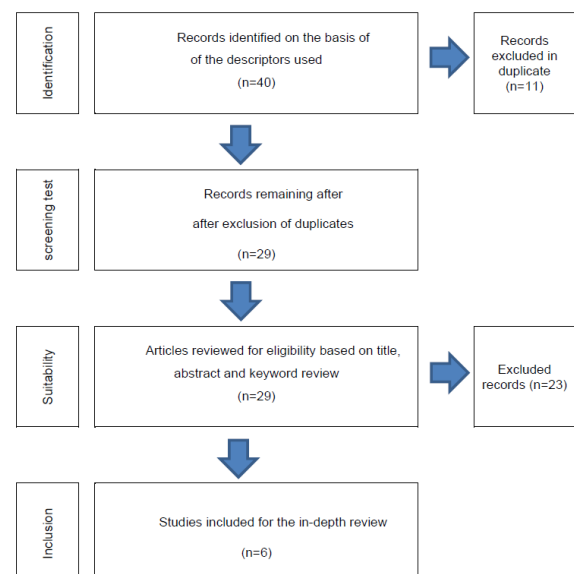

Fig. 1. Flowchart of the literature review process.

III. RESULT AND DISCUSSION

In this chapter, the 6 articles selected through the systematic review are analyzed. This analysis of the results presented allows us to address the different aspects and elements related to the research questions. In this regard, it should be noted that all the selected studies start from the same premise in terms of their justification and rationale. This premise consists of analyzing the suitability of the applications used to improve the academic performance of students with ASD, in addition to knowing the level of knowledge of teachers for the selection of applications to improve the academic performance of students with ASD [16–20]. However, each of the authors recognizes different dimensions and assumptions to analyze the impact and implication of the use of technology with students with ASD, as show in Table 3.

Table 3. Identification data and description of the studies

Title	Authors	Year
Functionality of Apps for People with Autism: Comparison between Educators from Florence and Granada	Gallardo-Montes *et al.*	2022
The Inclusion of Children on the Autism Spectrum in the Design of Learning Technologies: A Small-Scale Exploration of Adults' Perspectives	Boyle and Arnedillo-Sánchez	2022
Design and Validation of an Assessment Tool for Educational Mobile Applications Used with Autistic Learners	Sanromà-Giménez *et al.*	2021
Technologies in the education of children and teenagers with autism: evaluation and classification of apps by work areas	Gallardo-Montes *et al.*	2021
A framework of evidence-based practice for digital support, co-developed with and for the autism community	Zervogianni *et al.*	2020
What Educators Should Know About iPads and Students with Autism	Taylor and Urquhart	2018

Each of these articles provided different dimensions and perspectives to consider when working with digital resources in the classroom, especially when targeting students with ASD.

The influence of ICT on the academic performance of students with ASD is a relevant topic in educational research. Being aware that ASD is a neurodevelopmental disorder that affects different dimensions such as communication, social interaction and behaviour, it is necessary to be cautious when using different digital resources in the classroom. In this sense, we want to answer the following questions:

- Are all apps suitable for working with students with ASD? (PI01)

Nowadays, the use of digital technology has experienced exponential growth [9]. Tools such as tablets, mobile phones and iPads [20] have meant a great advance in the use of technologies. Moreover, in order to make use of them, it is necessary to have computer applications (software). This increase has led to a growing number of applications aimed at educational intervention for people with ASD. However, it is important to note that not all applications are effective or suitable for use [9].

From this perspective, there are several studies that justify the use of digital apps for people with ASD [21–23], but these investigations are often based on detailed reports of individual cases [24–26]. Furthermore, few studies focus on evaluating the effectiveness of the use of apps for people with ASD and whether they meet acceptable quality standards [17, 27, 28].

Despite the multitude of apps that exist for working with students with ASD, there has been little scientific evaluation of whether these apps actually fulfil their intended functionality [17]. The wide variety of digital media and the paucity of research evidence make it difficult to select appropriately to meet the individual needs of learners with ASD. Therefore, there is an urgent need for tools to evaluate the effectiveness of digital supports.

In view of these circumstances, the analysis of these selected studies allows us to identify which elements are necessary to design and develop an application that meets the required quality standards and can then be used reliably.

Firstly, the article by Zervogianni *et al.* [29] consider that it is necessary to develop a framework for evaluating digital supports with the aim of enabling users to select effective apps for people with ASD. Applying the Delphi methodology, the study concluded that apps should be based on a number of parameters, which should be adjusted according to the goals to be achieved in the use of the app. In this case, the dimensions included in this framework for deciding on the selection and use of apps should be measured in terms of reliability, engagement and effectiveness. From this point, it is crucial to define other criteria to be considered.

On the one hand, there are studies [16, 29, 30] that point out the importance of the participation of a multidisciplinary team in the design of apps. This allows for the creation of the most accurate resource possible. For example, the study conducted by Boyle and Arnedillo-Sánchez [16] consisted of several collaborative workshops with the purpose of helping designers in the creation of applications. These workshops involved researchers, designers, students with ASD and specialist support teachers. The interaction that took place between all those involved enabled the development of a fully functional and valid educational application for working with students with ASD. As a result of this process, an autonomous educational application was obtained that incorporated the contributions made by children with ASD.

Also, Gallardo-Montes *et al.* [31] point out that collaboration between research teams and the agents involved can influence the creation of profiles, whether of users or supervisors (teachers, experts and family members, among others). This approach favours a more personalized use adapted to the specific needs of the child with ASD.

Zervogianni *et al.* [29] also consider it crucial to use participatory research approaches that critically examine the current state of supports for people with ASD. In their study they considered it necessary to have an expert panel that included people with ASD, family members of people with ASD, professionals working with people with ASD and researchers with experience in the use and development of digital supports for people with ASD.

Taking this into account, it is concluded that it is necessary to adopt a participatory design approach that involves various actors in the creation of applications intended to work with

students with ASD, as it is understood that this product is designed by and for them. In this case, it is very important to have the active participation of people with ASD. Involving people with ASD in the application development process allows the diversity of people with ASD to be taken into account and the functions and features of the application to be adapted to the individual preferences and needs of students with ASD. With this in mind, it is possible to achieve a final product that contributes to improving the outcomes of people with ASD in areas where they may have difficulties, such as communication and/or social interaction.

On the other hand, it is necessary to use applications that are supported by scientific principles and/or research of an empirical nature. However, this remains a challenging task as most apps still lack scientific support for their validity and effectiveness [32]. Therefore, it is essential to promote collaboration between researchers and multidisciplinary educational teams as outlined above.

Finally, it is important that the design of the content of the applications is intuitive and easy to use. Not only should they be accessible, but they should also include tutorials and instructions so that any user can make use of them. However, several studies point out that these options are only found in a small number of apps aimed at children with ASD [18, 30, 31]. This shortcoming has also been pointed out by Cayton-Hodges *et al.* [33] and Hanna *et al.* [34], who state the need for clear presentation of content for successful guidance and guided use.

Moreover, to ensure that digital resources achieve a meaningful and high quality nature, it is essential that teachers are involved in the selection of applications. It is important to bear in mind that the process of selecting and using applications should not only be based on technological knowledge, but also on understanding the educational needs of students and integrating these tools into the school curriculum. In this sense, the second aspect is oriented as follows:

- Do teachers have knowledge about how to choose the apps that best suit the needs of their students with ASD? (PI02)

With the ever-increasing use of ICT resources in educational settings, it is necessary for teachers to have a solid understanding of the use of these tools in the classroom. It is also necessary for teachers to be familiar with the individual characteristics of each student with ASD in order to optimise the use of applications, ensuring that such use results in improved academic performance. Taylor and Urquhart [20] point out that teachers need to know which apps are the most useful and cost-effective to use in their classrooms with students.

According to Gallardo-Montes *et al.* [17], teacher training and experience have an impact on the selection of educational resources. As the use of apps increases, there is also a greater benefit for students. However, limited experience leads to a perception of low potential of apps or a lack of skill in their use [35–37]. This suggests that teachers need to acquire knowledge about digital resources in order to use them effectively. Perhaps this can be accompanied by the experience teachers may have in using these resources according to the type of methodologies. The study acknowledges that less experienced participants reported using fewer applications to promote communication compared to those with more experience. In addition, the educational stage in which they work, the type of content and the type of educational institutions are elements to be taken into account. In this sense, Sanromà-Giménez *et al.* [19] also highlight the importance of both initial and continuous teacher training to ensure quality education for all students [38].

On the other hand, Gallardo-Montes *et al.* [17] carried out a comparative analysis of teachers' opinions regarding the use and types of apps used with students with ASD. Among the benefits highlighted by teachers, it was observed that these applications complement the use of more traditional resources such as textbooks or the blackboard. The same authors consider that ICT offers a wide range of opportunities that, when used responsibly, can enhance and strengthen cognitive processes and the development of various skills in individuals with ASD. ICTs are also seen as motivational tools for people with ASD and provide support to reinforce and consolidate educational content and skills.

For Sanromà-Giménez *et al.* [9] it is crucial to know how to make appropriate use of applications to meet the educational needs of students with ASD. This depends largely on the ability of teachers to evaluate and select tools [39].

Finally, Taylor and Urquhart [20] state that teachers sometimes choose apps based on recommendations from peers or family members of students with ASD. That said, it is essential that all teachers develop digital skills. This will enable them to make decisions about acquiring technological resources such as tablets or mobile devices as well as software applications.

Given the wide variety of educational applications available, it is essential that teachers establish clear and objective evaluation criteria. These criteria will help them to identify the educational, pedagogical and technological characteristics that these resources should possess in order to facilitate learning. At the same time, these criteria should serve as a basis for the design of evaluation tools to guide teachers in this complex task: selecting the most appropriate application for each student and educational context, taking into account the individual student's characteristics.

IV. CONCLUSION

It should be noted that a wide variety of digital tools and applications exist, but not all of them are adapted or suitable for working with students with ASD. Appropriate selection requires an understanding of the individual needs of learners as well as the features and functionalities of the available apps. Interdisciplinary collaboration in app design is key to helping teachers know how to select and effectively use the tools that best meet the individual needs of students with ASD. It is important to note that while digital resources can be very useful, it is essential to combine them with evidence-supported educational approaches and tailor them to the individual needs of each student with ASD.

On the other hand, it is crucial that teachers are well informed and trained in the use of technology. This will enable them to know how to select applications that best suit

the needs of students with ASD.

In terms of the limitations of the study, the data from this research are not conclusive, although they provide valuable insight into the role of ICT in the educational context of students with ASD. Caution should be exercised when interpreting the results analyzed due to the exploratory nature of the study. From this point of view, it is important to note that there are not many studies that address this topic from a scientific and rigorous perspective.

As possible future research, it could be crucial to categorize the applications according to the contents to be addressed and to proceed to evaluate the effectiveness of each of them. Furthermore, it is essential to differentiate between apps used for educational or leisure purposes. The objective will determine the selection and use of apps.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Introduction, J.M.L.D. and I.G.C.; Methodology, J.M.L.D. and N.F.C.; Results, J.M.L.D.; investigation, J.M.L.D., I.G.C. and N.F.C.; writing—original draft preparation, J.M.L.D.; writing—review and editing, J.M.L.D.; supervision, J.M.L.D., I.G.C. and N.F.C. All authors have read and agreed to the published version of the manuscript.

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