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Review

Use of Augmented Reality for Students with Educational Needs: A Systematic Review (2016–2021)

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Abstract: In recent years, interest in applying Augmented Reality technology as a teaching/learning resource in education has increased. However, few studies focus on the possibilities and challenges of these tools to support learners with educational needs. In this review, we aggregate the current knowledge of how Augmented Reality technologies are applicable and their impact on the learning of students with educational needs considering the above-mentioned factors. In total, 18 studies indexed in the Scopus and Web of Science databases were analysed. The main findings of this review provide the current state of Augmented Reality research in special education and show positive results in the learning of students with educational needs.

Keywords: Augmented Reality; educational technology; special education; systematic review

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1. Introduction

Today's society is marked by the continuous evolution of technology and its integration into people's daily lives. Technological progress has managed to penetrate many areas related to human beings, such as telecommunications, medicine, industry, administration or in our own homes. One of the environments where technology has had the greatest impact is the field of education. Currently, many technological tools are used for training with great educational potential, one of them being Augmented Reality (hereinafter, AR). AR has a high motivational power and can both increase students' interest and involvement in tasks and provide support for students with educational needs.

The 2016 Horizon Report [1] ratifies its presentation to society as an emerging technology, with great possibilities for educational use, which allows the combination of digital information and physical information in real time, through different technological supports such as tablets or smartphones, to create a new reality, which is having an impact on the extension of apps for AR [2].

Within the framework of education for all learners and because of the possible potential of AR, it is worth analysing whether AR is useful in the field of special education. For all these reasons, this study aims to analyse the impact of the use of this technology on students with educational needs. In this paper we set out to explore this field through a systematic review in two of the databases with the highest impact in the scientific community (Web of Science and Scopus) on AR in the field of special education. This paper is structured according to the results of the analyses conducted, so its respective sections correspond directly to the themes identified in the thematic analyses.

In the last part of this paper, we discuss the problems identified in our review, as well as the limitations of the study. Finally, future research directions for researchers in this field are offered.

2. Conceptualisation

Among the first definitions of AR, we find the one by Azuma [3] where he conceived it as a variation of Virtual Reality (VR) whose difference lies in the possibility of observing the

real world with virtual objects superimposed in the same space, i.e., it does not isolate the user from the real world as VR does. In addition, this author considers that three essential characteristics must be met: combining the real with the virtual; integrating the two types of information in real time; and registering in 3 dimensions.

Among the most current definitions we can find the one made by the authors Fombona, Pascual and Madeira [4], where they consider AR to be an enlargement of images of reality based on having been captured by the camera of a computer or advanced mobile device that adds virtual elements for the creation of a mixed reality to which computer data have been added. Wu et al. [5] further point out that it involves experiencing phenomena that are not possible to perform in everyday school life or to participate in in real life, so the experimentation is even greater than that which can be produced in a traditional laboratory. These same authors establish different levels of AR depending on the type of interactivity, beginning with: LEVEL 0—QR codes. These are hyperlinks that take us to web spaces or provide us with information in the form of text, sound, etc. LEVEL 1—: Augmented Reality with markers. This is the most used level and uses images as a link element to obtain the augmented element. LEVEL 2—geolocated Augmented Reality. The development of devices with geolocation makes it possible to create an Augmented Reality in a specific situation. LEVEL 3—the use of Augmented Reality thanks to the use of HDM devices such as Hololens.

Another level that we find in the study of Augmented Reality is also augmented cognition [6]. It consists of the creation of new models of human–computer interactions. This line of research can be applied to people with communication problems, disabilities, or degenerative diseases such as Alzheimer's disease. We identify a series of patterns, and we will act according to the indications provided by the device.

3. Augmented Reality as a Tool for Educational Inclusion

Research is still limited on AR's impact on education [7]; however, it has shown some positive aspects: students show favourable attitudes towards it and that its use increases motivation towards learning [8]; it favours the creation of a constructivist and realistic learning context [7]; it favours an active teaching environment [9]; it arouses a high degree of satisfaction and positive attitudes in students [10,11]; its use improves learning outcomes [8,12]; it improves attention, communication and long-term memory [13]; and it can be adapted to different student profiles [14].

In this sense, AR contributes to the search for mechanisms that eliminate or try to eliminate the barriers that prevent students' active participation, promoting digital educational inclusion. Works such as those by McMahon et al. [15] also highlight the great possibilities that this tool offers for inclusion in general and specifically for students with special educational needs (SEN). This is highlighted in the study by Marín [16], which concludes that AR can provoke an unprecedented feeling of inclusive learning and increase motivation both in the student, who learns in a real way what they cannot or have not been able to access, and in the teacher, who sees progress in the transmission of content.

In recent years, there has been an increase in studies reporting the benefits and limitations of AR in education [17]. In this line and regarding these limitations, it must be said that there are more technological developments than educational practices; the novelty is leading to a lack of theoretical reflection, lack of theoretical models for its incorporation, few educational materials, limited teacher training, and little research [18].

However, despite all this, less common is work describing how AR has been used to generate more inclusive learning scenarios. For all these reasons, and because AR presents a wide range of opportunities, this review aims to analyse the impact of the use of this technology on learners with educational needs. That is, to evaluate the effectiveness of these technologies in the development of skills and knowledge of students with educational needs as reported in the current scientific literature. Furthermore, to analyse trends in scientific production through the bibliometric approach of scientific mapping with the aim

of delimiting future lines of research in this field. To guide the implementation of this study, the following research questions (Q) are posed:

Q1. What is the general state of published research on the use of Augmented Reality applied to students with educational needs?

Q2. What experiences with Augmented Reality are being carried out with students with educational needs?

Q3. What is the impact of the use of Augmented Reality in the field of special education indicated in the studies analysed?

Q4. What is the conceptual structure of the scientific literature published on the use of Augmented Reality in special education?

4. Method

The present study, which investigates the use of AR in the field of special education, aims to answer the objective and research questions posed by conducting a systematic review of the literature, as well as through various bibliometric techniques that will allow us to evaluate scientific developments in this field. To ensure the rigorousness of the study, the following stages have been developed during the review process [19]:

4.1. Stage 1. Search Strategy

The first phase of the process was to determine the databases to be used, selecting Web of Science and Scopus. The choice of these databases was based on their impact indexes in the academic world. After selecting the databases, the process of searching for documents began by applying the quality standards of the PRISMA Declaration [20], which consists of the application of four phases: identification, screening, eligibility, and inclusion.

For the filtering of the documents, the following search terms extracted from the ERIC Thesaurus were applied to the title, abstract and/or keyword field in the selected databases: Augmented Reality, special education, educational needs. Searches were conducted in the month of January 2022.

4.2. Stage 2. Selection and Exclusion Criteria

To meet certain quality criteria, eligibility criteria have been established for the selection of studies. The inclusion criteria are: (a) scientific articles in peer-reviewed journals; (b) publications in the last 6 years (2016–2021); (c) articles using AR in learners with educational needs; (d) studies conducted in an educational context.

The exclusion criteria are: (a) review articles, conference proceedings, book chapters, books, or other types of publications; (b) AR articles outside the educational setting; (c) articles that are not oriented for special education; (d) duplicate articles.

4.3. Stage 3. Study Review and Selection Process

As mentioned above, the procedure for obtaining the sample was divided into four distinct stages (PRISMA): identification, screening, eligibility, and inclusion [20]. Thus, in the first stage, identification, the search equation was established in both databases, discovering a total of 582 documents (326 in WoS and 256 in Scopus). In the second stage, screening, after eliminating duplicates (n = 151) the researchers applied the selection and exclusion criteria in the WoS and Scopus filtering options, excluding 450 documents. At the eligibility stage, a thematic content analysis was performed by reviewing all full-text documents (n = 152), excluding 134 documents. Finally, after the review, in the inclusion phase, 18 articles were selected that were relevant to the purpose of the study. Figure 1 shows the flow chart of this process.

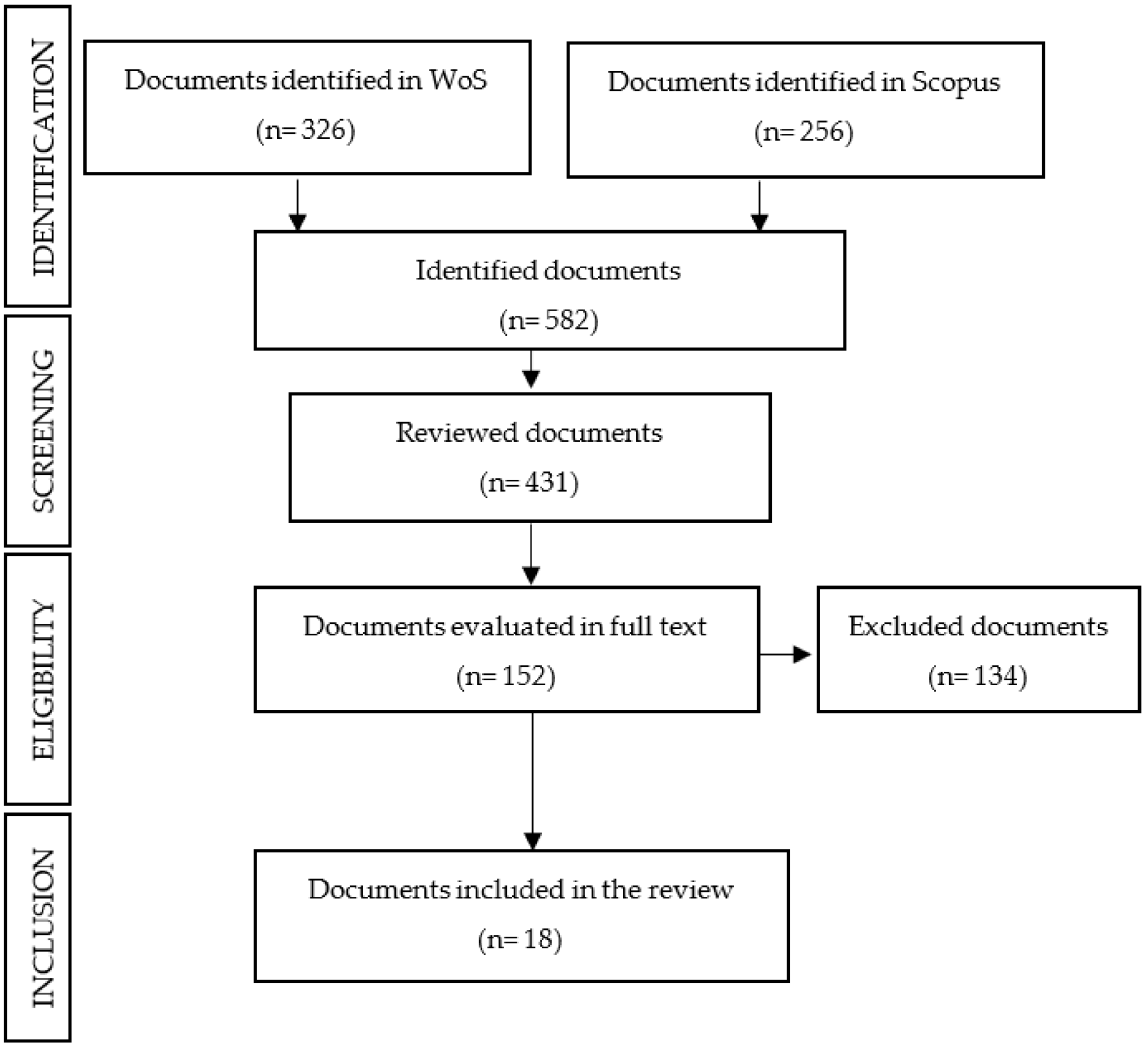

Figure 1. Flow chart according to the PRISMA declaration.

4.4. Stage 4. Data Extraction and Analysis

Once the sample had been selected, the extracted studies were analysed by the researchers. The data extraction and coding process was carried out considering the general details of the articles (Table 1): reference, methodological design, participant sample, type of disability and hardware used, with the aim of finding answers to the research questions previously posed.

Furthermore, this review uses bibliometrics to carry out the discovery of the conceptual structure of the scientific production by means of scientific mapping [21]. These maps, constructed by analysing the most important keywords, allow the delimitation of research areas [22], which have been represented using the VOSViewer software.

Table 1. Analysis of the studies analysed.

Author	Method	Population	Type of Disability	Hardware Device
Turan et al. (2021) [23]	Quan	Primary Ed.	Learning Disabilities	Mobile phone
Alqarni (2021) [24]	Quan	Primary Ed.	Not specified	Mobile phone
Badilla-Quintana et al. (2020) [25]	Quan	Secondary Ed.	Not specified	Mobile phone
Bridges et al. (2020) [26]	Quan	Higher Ed.	Intellectual disability	iPad
Kang et al. (2020) [27]	Quan	Secondary Ed.	Intellectual disability	Computer
Cakir et al. (2019) [28]	Qual	Primary Ed.	Learning Disabilities	Computer
Kellems et al. (2019) [29]	Quan	Secondary Ed.	Learning Disabilities	iPad
Savitha et al. (2019) [30]	M	Infant Ed.	Intellectual disability	Mobile phone
Widodo et al. (2019) [31]	Qual	Secondary Ed.	Intellectual disability	Mobile phone
Láinez et al. (2018) [32]	Qual	Infant Ed.	ASD	Mobile phone
Lee et al. (2018) [33]	Quan	Primary Ed.	ASD	Computer
Takahashi et al. (2018) [34]	M	Primary Ed.	ASD	Projector, camera
Carvalho et al. (2017) [35]	Quan	Secondary Ed.	Hearing disability	Computer
Smith et al. (2017) [36]	Quan	Secondary Ed.	Intellectual disability	Mobile phone
Cascales-Martínez et al. (2016) [37]	Quan	Primary Ed.	Learning disabilities	Projector, camera
Cihak et al. (2016) [38]	Quan	Primary Ed.	ASD	iPod Touch
Lin et al. (2016) [39]	Quan	Primary Ed.	Not specified	Mobile phone
McMahon et al. (2016) [40]	Quan	Higher Ed.	Intellectual disability	Mobile phone

Note: Quan = quantitative, Qual = qualitative, M = mixed.

5. Results

The content analysis of the 18 articles in the sample allowed us to clarify the following information regarding the following variables: year of publication, methodology applied, participants, hardware used and impact on learning.

5.1. Year of Publication

This systematic literature review extracted 18 articles distributed heterogeneously between the different quartiles of the two databases analysed. The review focused on scientific articles produced in recent years (2016–2021), which aimed to evaluate the impact of the use of AR in the education of students with educational needs. As we can see in Figure 2, which shows the distribution of the studies analysed, the results show that scientific production in this field is increasing. The data for the years 2020 and 2021 may be affected by the COVID pandemic, due to the closure of educational centres and the limitations of researchers to carry out fieldwork.

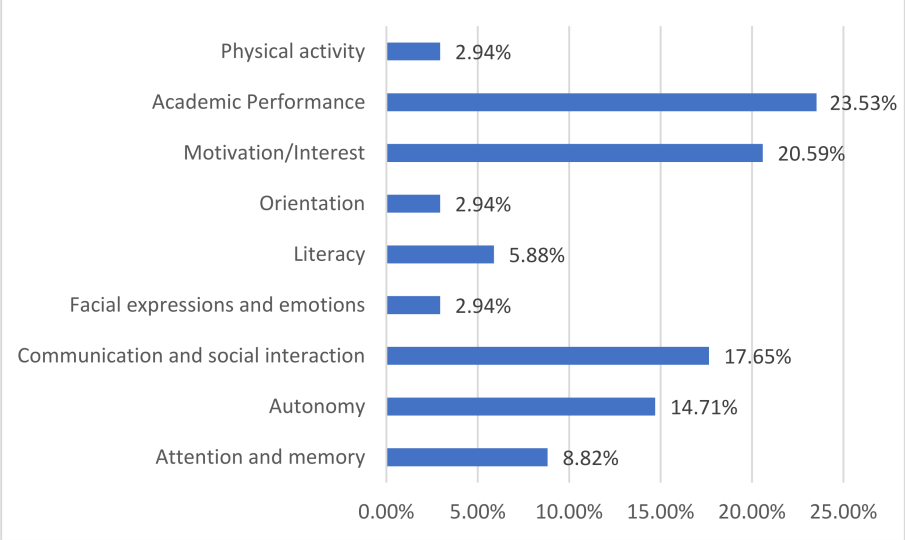

Figure 2. Benefits of using Augmented Reality.

5.2. Methodology Used

The results obtained from the analysis of the methodologies used give us an overview of how research in this field is being approached. They reveal that, among the research designs, the use of quantitative methodology predominates (72.22%). To a lesser extent are those with a qualitative approach (16.67%) or a mixed approach (11.11%).

5.3. Participants

The use of Augmented Reality is being implemented in all educational stages; however, we find that most of them focus on primary education (44.44%), followed by secondary education (33.33%). There are very few studies that focus on early childhood education (11.11%) or higher education (11.11%).

The review has focused on the application of these technologies in the field of special education, and the results show that virtual reality experiences are being carried out mainly with students with intellectual disabilities (33.33%). This is followed by experiences with students with Autistic Spectrum Disorder (ASD) (22.22%), learning difficulties (22.22%) or, to a lesser extent, hearing impairment (5.56%). A total of 16.67% of studies do not specify the type of educational need presented by the students they are aimed at.

5.4. Hardware Used

In relation to the type of technology applied, researchers have used different techniques to apply AR during their intervention. Most of the studies used mobile phones (50%) or computers (22.22%). To a lesser extent, projectors (11.11%), the iPad (11.11%) or the iPod Touch (5.56%) were used to carry out AR activities. A webcam, either integrated or external, was used in all studies to allow students to interact with the objects.

5.5. Impact on Learning

The next variable we considered in the review addresses the impact of Augmented Reality in the context of special education, i.e., delimiting the benefits and limitations of its application with learners with educational needs.

Among the benefits of using AR with these students, we can highlight the following (Figure 3): academic performance (23.53%), motivation (20.59%), communication and social interaction (17.65%) and autonomy (14.71%) are the main advantages of using AR with students with educational needs.

Among the limitations of the use of AR in the field of education, especially in the field of special education, we find the low level of teacher training (37.32%), the scarcity of available AR technology (32.23%), the lack of support from educational institutions (21.34%) and technical and accessibility problems (9.11%) in the use of AR tools.

5.6. Conceptual Networks

Finally, the analysis of the conceptual structure allows us to elucidate the lines of research on AR in special education. To this end, a co-occurrence analysis of the key words (Keyword Plus) of the studies reviewed was carried out in terms of frequency.

The map produced shows the terms that have been the focus of researchers' interest in the period 2016–2021 (Figure 3). The analysis revealed that there are three leading themes in this period. The first one addresses the use of AR technology with learners with educational needs (blue colour) with words such as student, disability, inclusive education, intellectual disability, etc. The second theme (red colour) addresses the role of the teacher, i.e., the attitudes and teacher training needed to be able to apply AR in the classroom, highlighting terms such as training, knowledge, skill, professional development, etc. The third theme (green) is related to the use of AR in the field of inclusive education and the benefits it brings, highlighting the keywords Augmented Reality, opportunity, accessibility, effectiveness, etc.

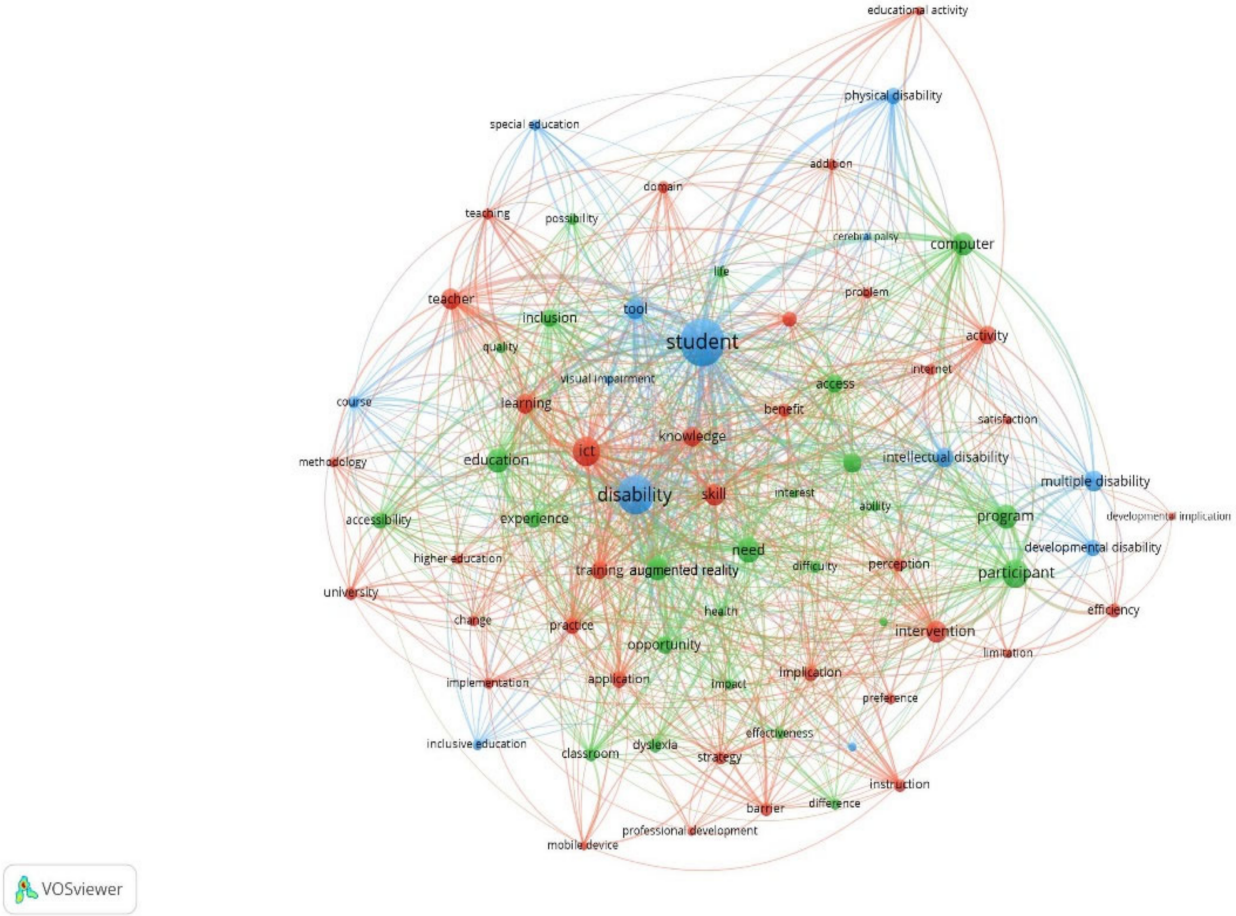

Figure 3. Labelled bibliometric map 2016–2019.

6. Discussion

This review aimed to synthesise the existing scientific literature investigating the use of AR with learners with educational needs. These studies provide valuable information on what is known about the experiences of AR in the field of special education. In the scientific literature we can find a multitude of studies that highlight the relationship between AR and the improvement of teaching and learning processes for all learners, however, there are fewer and fewer specific studies when detailing the options for learners with educational needs [5].

The results of the literature review have allowed us to approach the state of research in the field of AR applied to students with educational needs at different educational stages. In this sense, and in response to the first research question (RQ1), "What is the general state of published research on the use of Augmented Reality applied to students with educational needs?", the initial data suggest that this is a booming topic, as demonstrated by the progressive and constant increase in the production of the articles analysed from 2016 to the present [41]. As predicted, and considering the empirical studies analysed, mainly with quantitative methods (71.43%), AR is having an increasingly significant impact on the education of these students [42]. This makes it possible to use these technologies as tools to support the education of these people [43].

On the other hand, in relation to the second research question (RQ2), "What experiences with Augmented Reality are being carried out with students with educational needs?", the results of this work show us that AR can be applied in classrooms at different educational stages, from early childhood education to higher education, with students with educational needs in various areas, mainly in science, mathematics and literacy [25,29,35,37,40].

Our findings, supported by previous research [44], highlight that these technologies, through the development of different didactic strategies, favour students with different types of educational needs, especially those with intellectual disabilities and students with autism spectrum disorder [30,34,45]. This is reflected in students' interest in using such AR technologies. The reason why students with intellectual disabilities and students with autism spectrum disorders have been the most targeted group for AR studies may be due to the characteristics of this technology (increased academic performance, higher motivation, better communication and social interaction, and promotion of autonomy), as shown in this study, coinciding with previous studies [44]. These technologies are also effective with students diagnosed with learning difficulties, preventing them from being easily distracted and showing more interest in class with the support of AR [23].

It was found that in most studies, mobile devices are the preferred devices to work with AR content in special education, mainly using mobile phones, computers, or Tablet/iPad. This is because these technologies are more portable, accessible, and easier for students to handle, and provide access to information at any time, which facilitates interaction with physical objects [46]. This finding is in line with all studies of AR in education [9].

Addressing the third research question (RQ3), What is the impact of the use of Augmented Reality in the field of special education indicated in the studies analysed, we can see that the use of these tools allows the development of new learning experiences by combining elements of the virtual and real world.

Taking the study as a reference, and based on the findings obtained, we can determine that the use of AR has a positive impact on students with educational needs. Thus, we can highlight that the most positive aspects of using AR in the classroom with these students are the improvements in academic performance [38,39]. Furthermore, these experiences increase students' interest and enthusiasm in the teaching–learning process [28]. This is because students can enhance various aspects of their development by observing objects three-dimensionally as they appear more real than observed on paper [31]. Among other aspects, its use has been found to improve students' social relationships, thus facilitating their inclusion with peers [32,33].

It is worth mentioning that the results shown highlight the positive effects on the improvement of physical activity through AR play in people with different needs [36,39,40], which leads us to rethink that this type of resource can be applied to different interactive projects at different educational stages.

Although AR has been identified as an emerging technology in the field of special education, the use of specific strategies is necessary for its appropriate application by teachers. Thus, among the limitations that are of most concern is related to the lack of teacher training and the difficulties of access to these technological resources [47]. Moreover, although it is noted as an emerging tool in the field of special education, it is still difficult to generalise whether they are intended for the entire population with SEN, due to evidence of a limitation in quality and teaching experiences with students with visual impairment [11]; therefore, it would be advisable for future research to focus on this aspect.

Finally, answering the last research question (RQ4), "What is the conceptual structure of the scientific literature that publishes on the use of Augmented Reality in special education?", we specify that the conceptual structure of the sources is composed of three clusters that refer to the main thematic areas of research that are being worked on in this period (2016–2021). In this way, we can highlight the three main topics: the use of AR technology with students with educational needs, the role and training of teachers in the implementation of these technologies and, finally, the impact of the use of these tools with these students.

Ultimately, the findings of this review reveal that the use of AR as a technological resource offers positive results in the education of students with special educational needs and in their daily lives [26]. It is therefore recommended that teachers enhance their training based on AR-based learning strategies to improve the quality of life of their students.

7. Conclusions

This article has analysed 18 current articles on AR applied to learners with educational needs. The study provides an overview of research in this field and offers relevant information on the current situation. From them it can be concluded that the use of AR does not have a long history in special education, but the scientific production in this field during the period 2016–2021 is continuously growing and there are more and more areas of knowledge where this technology is used in the teaching–learning process of these students. Based on the study carried out and the objectives obtained, we can conclude that AR technology has proven to be suitable for the special education environment, improving teaching and learning opportunities and educational success for students with educational needs. To ensure these results, appropriate teacher training is required [24]. In line with this, Sustainable Development Goal (SDG) 4 on education calls for ensuring inclusive and equitable quality education for all, mentioning the need for infrastructure and tools in line with the very principles of inclusion, where technology and digital competence are essential [48,49]. The results of this study are intended to provide vital information for teachers wishing to implement AR technology in the education of students with educational needs.

7.1. Limitations of the Study

The research articles analysed in this review are selected according to the criteria selected by the researchers. Only studies published in WoS or Scopus are evaluated. Further, in this review, only "articles" have been selected as a document type. Future researchers may wish to examine other databases and other types of documents, which will enable a more detailed representation of the benefits and limitations regarding the uses of Augmented Reality technology with learners with educational needs to be established.

7.2. Futures Lines of Research

The findings obtained can be the starting point to determine the future lines of research to be developed in order to effectively carry out the implementation of Augmented Reality in the context of special education. Among the future lines to be developed are the design, implementation and evaluation of teacher training plans in emerging technologies to apply Augmented Reality in the classroom with students with educational needs at all educational stages.

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