

THE APPLICATION OF MIXED REALITY IN AUTISTIC STUDENTS FOR EDUCATIONAL SETTINGS THROUGH BIBLIOMETRIC INDICATORS

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Abstract

In today's societies, technology plays a fundamental role in the development of everyday tasks. This tool is increasingly being used in a wide variety of fields of knowledge. In recent years, the use of mixed reality is spreading in educational environments. This is because mixed reality offers the possibility to create learning situations where communication and social interaction skills can be practiced. Therefore, this tool is adjusted to a type of student that is increasingly present in the classrooms of schools, namely autistic students. As a consequence, the aim of the research is to carry out an analysis on the use of mixed reality in students with autism using all the databases of the Web of Science, in the period 2019-2024. Search words were chosen from the ERIC Thesaurus. These words were autism, autism spectrum disorder, autism spectrum disorders, high-functioning autism, low-functioning autism and Asperger. After applying the inclusion and exclusion criteria, the final sample was 58 documents. The most important results show that the United States is the largest producer of publications with 16 of the papers. Likewise, the most prolific period was the year 2024 with 13 publications, with computer science and engineering being the areas most present in the Web of Science. Finally, the most published document types are conferences and articles. As future lines, the possibility of extending the period of analysis and using other databases is proposed.

Keywords: *Mixed reality, technology, autism spectrum disorders, education.*

1. Introduction

In the educational world there are more and more students with special educational needs who require specific and individualized attention. One type of student whose prevalence has increased significantly in recent years is the autistic student, from 1 in 54 to 1 in 26 (Maenner et al., 2023). ASD comprises a range of neurodevelopmental disorders characterised by social impairments, communication difficulties and repetitive and restrictive behaviour patterns (American Psychiatric Association, 2013). Despite the difficulties presented by autistic learners, they also present great strengths such as strong memory, attention to detail and visual learning facilities (Russell et al., 2019). Taking the strengths of autistic learners as a reference, the technology that can best address the needs of autistic learners is MR. MR combines aspects of VR and AR. In addition, it allows the manipulation of virtual objects in real environments (Maas and Hughes 2020). The use of MR with autistic learners is justified for several reasons. First, MR can be used to create learning environments in which students can safely experiment (Chóez Chilibingua and Larreal Bracho, 2023). Secondly, MR adapts to the learning needs of each student favouring inclusion from different approaches according to Marín-Díaz et al. (2024). Finally, learning environments that use MR lead to greater interest in the learning of autistic students and the acquisition of educational skills (Khasawneh, 2023).

Based on the justification of the importance of the use of MR with autistic people, the general objective of this paper is to analyse the scientific production of the application of MR in autistic students during the period 2019-2024 based on a series of bibliometric indicators, and the following research questions are posed in order to fulfil this objective:

- Which country is the largest producer on this subject?
- What has been the most prolific period of publication on this subject?
- What is the most widely used type of document in the field of study?
- What are the areas of research most frequently considered by the Web of Science in the topic of study?

2. Method

A descriptive-retrospective bibliometric design has been used in this study. The descriptive-retrospective bibliometric design allows the selection and organisation of the documents analysed (Montero & León, 2007). This method is implemented through the following phases. Firstly, the search and selection of information is carried out. Secondly, the documents are classified according to the descriptors and, finally, the extracted data are analysed (Rosa et al., 1996).

2.1. Sample

The sample consists of 58 articles published during the period 2019-2024 and indexed in all Web of Science databases: Web of Science Core Collection, BIOSIS Citation Index, Current Content Connect, Data Citation Index, Derwent Innovations Index, FSTA, Grants Index, Inspec, KCI-Korean Journal Database, MEDLINE, ProQuest, SciELO, Zoological Record.

The search and selection process took place in January 2025, while the individual reading and analysis phase took place in the period February-March 2025.

2.2. Design and procedure

The following keywords were entered into the associated text box of the Web Of Science in order to search for the documents in the sample, taking into account the terminology of DSM-IV and DSM-V:

(‘Autism’ or ‘autism spectrum disorder’ or ‘autism spectrum disorders’ or “asperger” or ‘autistic students’ or ‘high-functioning autism’ or ‘low-functioning autism’) AND (‘mixed reality’).

After applying the lines of code, 72 documents were obtained, and after applying the inclusion criteria, these were reduced to 58 documents. The documents were filtered following the PRISMA methodology (Page and Moher, 2017). The following criteria were applied as inclusion criteria: year 2019-2024, documents related to mixed reality and autism. While the exclusion criteria used were: repeated documents, documents without access, documents working on other technologies, documents not related to autism and categories other than: Education Educational Research, Social Science Discipline, Computer Science, Automation Control Systems Engineering, Social Science Other Topics and Information Science Library Science. The final sample analysed consisted of 58 documents.

3. Results

The results extracted using the variables explained in the previous section are detailed below.

3.1. Top producing countries

The following results were found with regard to the top producing countries. The United States is the largest producer with 27.58% (16 articles). In second and third place are Spain and China with a total of 8 articles each (13.79%). In fourth place is Taiwan with 6.89% (4 articles).

3.2. Number of articles published by year of publication

The results indicate that the year with the highest number of publications is 2024 with 13 papers, representing 22.41% of the total. The second most productive year is 2020 with 11 papers, representing 18.96% of the total number of publications. The third and fourth most productive years are 2022 and 2023 with a total of 9 papers each, representing 15.51% of the total.

3.3. Type of document most published

With regard to the type of document most frequently published, we find the following. The most published type of article is conferences with 41.37% (24 documents). The second most frequently published type of document is articles with a total of 20 documents (34.48%). In third place we find congresses with 17.24% of the total number of documents (10 documents).

3.4. Categories of the Web of Science

The Computer Science category includes 47 articles. Likewise, the Engineering category contains 33 articles. Finally, the third category with the highest number of papers is Education Educational Research with 22 papers.

4. Discussion

Throughout the development of this research, the aim has been to analyse the scientific production on mixed reality and autistic students according to a series of indicators.

4.1. Top producing countries

In reference to the results obtained on the top producing countries, they reveal a clear predominance of the United States as the country that produces the most papers in this field, with 27.58% of the articles (16 in total). These results reflect the dominant role of the United States in the research and development of innovative educational approaches, given that US institutions have been pioneers in the implementation of RM, which has generated an abundance of research from this country. This is consistent with the country's extensive investment in education and technology, as well as its leadership in promoting interdisciplinary pedagogical approaches (Beers, 2019). In second and third place, Spain and China share an output of 8 articles each, representing 13.79% of the total. Spain's significant presence in this field may reflect a growing interest on the part of researchers in the application of emerging technologies for better and more innovative education (Prendes-Espinosa et al., 2021).

In recent years, there has been an increased awareness of the importance of educational inclusion in Spain, which may be motivating academics to explore new methodologies, such as mixed reality, to support learners with special educational needs as shown in the article by Mera-Macías (2022).

4.2. Number of articles published by year of publication

The results obtained in this analysis reveal a growing trend in the production of articles over the years, with a notable increase in 2024, where 13 publications were recorded, representing 22.41% of the total. This increase may be a consequence of new plans for the development of digital competence and the need for teacher training (Recio Muñoz et al., 2020). The second most productive year is 2020, with 11 articles (18.96%). This year coincides with the beginning of the COVID-19 pandemic, which could have influenced the direction of research and the urgency to publish relevant findings in a context in which ICT played a very important role in education as teachers had to use a multitude of digital resources, techniques and educational platforms, thus arising the need for research on all types of technologies (Jiménez 2020).

4.3. Most published document type

Regarding the most published document type, the results reveal that conferences are the most prevalent document type, representing 41.37% of the total number of publications. This trend suggests a clear need for rapid dissemination of findings in a rapidly evolving field. The high proportion of conferences reflects the culture of collaboration and the desire to receive immediate feedback from the scientific community (Huanca, 2024). In contrast, research articles, which constitute 34.48% of publications, indicate a significant interest in the production of original knowledge, albeit to a lesser extent. This is because academic conferences are considered important vehicles for generating scientific and social impact (Hauss, 2021).

4.4. Web of Science categories

Regarding Web of Science categories. The results reveal that the category containing the largest number of papers is Computer Science, which comprises 47 papers out of the total. This finding suggests that research in the field of computer science is experiencing significant growth, which can be attributed to the rapid evolution of technology and its impact on various areas of society such as education (Segovia-García, 2024). Computer science has not only established itself as a fundamental field in academic research, but has also permeated other disciplines, such as education (Abdullah, 2024). In this sense, the potential of RM in education has been widely studied from two approaches: as a teaching support to renew methods and as a didactic resource to improve students' learning processes (Moreno-Guerrero et al., 2022).

5. Conclusions

This study has shown that scientific production on the use of mixed reality in working with autistic students during the period 2019-2024 has grown steadily in recent years. Based on this study and the results obtained, the following conclusions are presented:

- The United States is the country that produces the most documents on this subject.
- 2024 was the year with the highest number of documents published in relation to working with autistic students and MR.
- The most published document type is conferences.
- The Web of Science category that hosts the most papers on RM and autistic learners is Computer science.

In conclusion, the implementation of RM for working with autistic learners represents a valuable opportunity to innovate and improve the learning experience. This study highlights the need to continue to explore new methodologies that effectively integrate technology into the classroom, promoting a more inclusive and accessible environment. It is suggested that future research should extend the date range studied and augment the information gathered with that extracted from other databases such as Scopus.

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