Bibliometric Analysis based on Scientific Mapping of Augmented Reality in Nursing

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Abstract

The present scientific article focuses on the bibliometric analysis of augmented reality implementation in the field of nursing. Using this methodology, relevant bibliographic data such as scientific articles, keywords, countries, institutions, and specialized journals is collected and examined to identify trends and research patterns related to the use of augmented reality in nursing. This analysis reveals a growing interest and attention in the utilization of augmented reality in nursing practice. There has been a consistent increase in scientific production over the years, indicating a greater exploration and application of this technology in the field of study. Furthermore, the results of the bibliometric analysis reveal the main thematic areas of research where augmented reality is applied, leading to the creation of innovative and cutting-edge lines of investigation. These areas include the training and education of nursing professionals, clinical simulation, improving accuracy in procedures and diagnoses, and enhancing communication and patient care. Additionally, this research facilitates the establishment of collaborative networks and fosters future joint investigations.

Keywords: Bibliometric analysis, Scientific mapping, Trends, Collaborative networks, Nursing practice.

Introduction

In recent years, there has been a growing interest in the application of (Deng & Romainoor, 2022) in the field of nursing. Augmented reality represents a technology that blends the physical environment with virtual elements, providing healthcare professionals with the ability to visualize additional information in real-time (Ghamari & Sharifi, 2021). This not only contributes to improving clinical decision-making but also facilitates communication with patients. In this context, bibliometric analysis stands out as a valuable tool for evaluating and understanding the scope and evolution of research in this field (Harper y otros, 2020).

Bibliometric analysis is employed as a methodological approach to assess and analyze scientific production, addressing aspects such as the number of publications, most relevant journals, influential

authors, leading institutions, and predominant research topics (Talbi & Boudemagh-Souad, 2022). By applying this methodology to the study of augmented reality application in nursing, a broad and impartial perspective of the existing scientific literature can be obtained, allowing the identification of emerging trends and knowledge gaps (Boumali & Tamiine, 2022).

The growing interest in scientific production as a measure of quality and as a criterion for comparing the growth and development of a discipline or field of knowledge has strengthened bibliometric studies (Ullah y otros, 2022). These studies, although focused on productivity based on quantitative data, which should not be considered the sole indicator of quality (García y otros, 2022), can be used as a criterion to estimate at least the level of dissemination, provided they are used reasonably and interpreted appropriately (Yang & Huang, 2022).

Furthermore, it is undeniable that these studies hold significant value within scientific literature as they guide the reader in academic aspects such as the most popular topics in a specific journal (Wu y otros, 2020), the level of collaboration in published articles, or the citations received by certain articles, among others (Yang, C.; Huang, C.; Su, J., 2020). However, due to the current interest in criteria and quality measured through indicators such as bibliometric studies or others, this subject has become a matter of controversy, as pointed out by several authors (Rodríguez-Abad y otros, 2023) (Cunha y otros, 2023) (Bloom y otros, 2023).

The purpose of this article is to conduct a comprehensive evaluation through bibliometric analysis on the implementation of augmented reality in nursing (Aranda-García y otros, 2023). By collecting and extensively analyzing relevant scientific literature, the aim is to explore the current state of research, identify the most important achievements, and highlight the challenges and future opportunities in this field (Hernon y otros, 2023).

This study will be based on a systematic search in relevant academic and scientific databases, using precise search terms related to augmented reality and nursing. Inclusion and exclusion criteria will be implemented to select the most relevant articles, and aspects such as the quantity and temporal distribution of publications, the most recurrent research topics, the main publishing journals, and collaboration among authors and institutions will be examined (Crowley & Daniels, 2023).

Through this bibliometric analysis, the aim is to provide a comprehensive and up-to-date view of the application of augmented reality in nursing, with the purpose of offering healthcare professionals, researchers, and policymakers a clear understanding of current and future trends in this field (Boumali & Tamiine, 2022). Additionally, this study aims to serve as a starting point for further research and as a guide to identify priority areas of investigation that drive the development and effective implementation of augmented reality in nursing practice (Zhao, 2023).

This document analysis will provide information about the growth and development of the discipline under study, as well as the research potential of the involved groups and institutions. In this context, metric studies have acquired great importance in scientific and management policies due to the increase in the culture of evaluation and accountability (Abbas y otros, 2023).

Scientific knowledge is considered a strategic value, as tangible results are sought. Bibliometric studies focus on the quantitative treatment and analysis of scientific publications, being an essential tool for understanding research activity today (Crowley & Daniels, 2023). They provide data on the scientific situation of a country or research topic, allowing the evaluation of the performance of scientific activity and its impact on the scientific community (Yu-Chih y otros, 2023).

The proposed bibliometric analysis in this article aims to provide a comprehensive and structured view of the current state of research regarding the application of augmented reality in nursing (Rodríguez-Abad y otros, 2023). The knowledge acquired through this study will contribute to expanding scientific

knowledge and improving nursing care by incorporating this innovative technology (Greenway y otros, 2023).

Augmented Reality and Nursing

Augmented Reality (AR) refers to the visualization of the real-world physical environment through a technological device. It combines tangible elements of the physical world with virtual elements, creating a real-time augmented reality (Maravilla y otros, 2023). It consists of devices that add virtual information to the existing physical information, meaning they superimpose a virtual synthetic layer onto the real world (Ahuja y otros, 2023). Unlike virtual reality, where the user is immersed in a completely virtual environment, augmented reality overlays a computer-generated visual reality onto the material reality of the physical world, allowing the user to perceive a combination of both realities (Asante y otros, 2023).

By using technologies like computer vision and object recognition, it is possible to turn real-world information surrounding the user into interactive and digital content. Artificial information related to the environment and objects can be stored and retrieved, creating an additional layer of information that overlays the view of the real world.

In the field of education, augmented reality offers the opportunity to present 3D videos or animations to explain the mechanisms of action of a medication, action protocols (Ahuja & Polascik, The digital metaverse: Applications in artificial intelligence, medical education, and integrative health, 2023), graphs of clinical trials, and complex concepts of pathophysiology. All these elements are associated with real scenarios or objects (Liang y otros, 2023). Simulation with 3D models allows students to observe and interact with anatomical parts of the body, exploring them in different directions and rotating them up to 360 degrees to gain additional perspectives (Ahuja & Polascik, 2023).

All this information and interactivity take place in the virtual plane, meaning it is displayed on the screen of a mobile device, tablet, or large screen in front of an audience. The advantage is that multiple people can participate simultaneously, unlike virtual reality, which is an individual experience.

Methodology

This research has a descriptive cross-sectional design focusing on scientific production in the health field, specifically nursing and its application of augmented reality. Several sources were used for direct consultation, such as the lens.org platform, where scientific productions can be visualized, focusing on bibliometric criteria such as authors, production indices, research networks, and patents.

The unit of analysis is scientific productions about augmented reality in the context of nursing. The search was conducted using specific descriptors such as: care, nursing models, nursing theory, technology, and augmented reality. Finally, 532 scientific productions were found, including 15 cited patent works, 37 patents, and a total of 4,185 citations of scientific works.

Table: Number of validated documents

Scholar works	Works cited by Patents	Citing Patents	Patent citations	Works cited by scholar	Scholar citations
532	15	78	78	320	4.185

The analysis was carried out using scientific mapping, employing various variables for examination, such as the journal, topic, authors' institutional affiliation, article type, year of publication, number of authors, study subjects, and study focus. Finally, descriptive statistics were applied to analyze the

results. The bibliometric indicators examined included productivity, citations, content, and methodological aspects.

Below are the parameters applied for data search, selected through the previous review and verification process.

Table 1. Search parameters

Data bases	Microsoft Academic	PubMed	OpenAlex	PubMed Central	Core
Results	272	266	253	149	65
Consultation period	2015 - 2023				
Consultation date	20 de mayo de 2023				
Type of production	journal article, book chapter, conference proceedings article, news, conference proceedings				
Types of journals	All types				
Search fields	Title, abstract, authors, and keywords				
Search terms	"Augmented Reality" and "Nursing" "Augmented Reality" and "Studying nursing" "Augmented Reality" and "e-learning nursing"				

Out of the 679 scientific productions worldwide, 5 areas were considered: augmented reality, psychology, human behavior, education, and e-learning.

Results

The results of this research begin with the timeline of all scientific productions published worldwide, as described below:
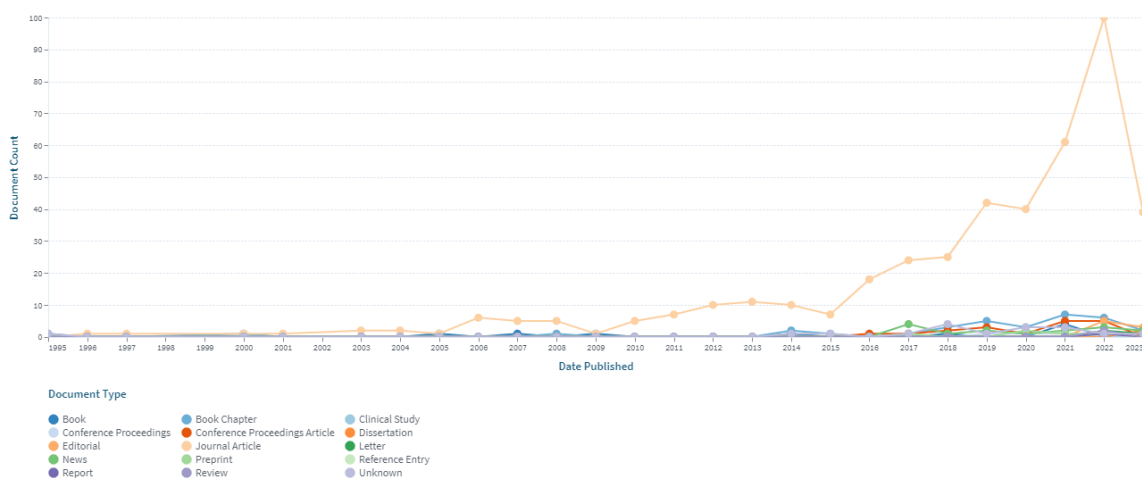

Figure 1: Timeline of scientific production

In 1996, two scientific productions were published focusing on the two study themes: "Nursing's Future: Ubiquitous Computing, Virtual Reality, and Augmented Reality" and "27 Future: Ubiquitous Computing, Virtual Reality, and Augmented Reality" by author James P. Turley, with a total of 345 citations.

From the years 2000 to 2010, a total of 29 journal articles and 4 books were published, with notable scientific productions including "An interface for mutual disambiguation of recognition errors in a multimodal navigational assistant," "Future of computer-aided surgery by collaborating academy and industry," "Transformation of flow in rehabilitation: the role of advanced communication technologies," and "Virtual reality or virtual dreaming — isolation is no barrier," with a total of 567 citations to date.

From the year 2011 to 2020, there were a total of 194 articles, with the years 2019 and 2020 having the highest production with a total of 82 productions with impact factor. Additionally, 3 conferences and 8 book chapters indexed in databases with impact factor (IF) were developed. The productions with the most impact in cocitation is "The Use of Augmented Reality Technology in Medical Specimen Museum Tours" with 62 references and 32 cocitations, "State of the science: the doll is dead: simulation in palliative care education," and the Congress "Annual Congress of the European Association of Nuclear Medicine October 13 - 17, 2018 Düsseldorf, Germany." There are also two patents named "Method for Blocking Uptake of Prostate-Specific Membrane Antigen (Psma)-Targeted Radionuclides by Exocrine Organs" and "Radioactive Microshperes for the Treatment of CNS Tumours."

From the year 2021 to the present, there are a total of 200 journal articles, with the year 2022 seeing a higher number of research, totaling 100. Universities such as Deakin and Duke University, Netherland Organization for Applied Scientific Research, and Taipe Veterans General Hospital stand out in these productions, with works like "The Use of Different Technological Methods for Teaching Basic Suturing Skills to Medical Students: A Literature Review," "The role of 3D digital applications in Manual Therapy Education – A scoping review," "Augmented Reality in Physical Therapy: Systematic Review and Meta-analysis," "Application of Artificial Intelligence in Medicine: An Overview," and "HCI (9) - Extended Reality, Pedagogy, and Career Readiness: A Review of Literature." These productions have around 2300 cocitations.

Table 3: Percentage of countries with a scientific production index

Country	Productions number	% Production
United States	75	11,05
United Kingdom	29	4,27
Australia	26	3,83
China	20	2,95
Germany	17	2,50
Canada	16	2,36
Japan	15	2,21
Spain	10	1,47
Netherlands	10	1,47
Denmark	9	1,33
Thailand	5	0,74
Brazil	4	0,59
Mexico	2	0,29
Chile	1	0,15
Colombia	0	0,00
Ecuador	0	0,00

In Table 3, 16 countries can be identified with scientific productions focused on augmented reality and nursing. The United States leads the list with a total of 75 scientific productions, representing 11.05% of the total; similarly, the United Kingdom has 29 scientific documents, accounting for 4.27%, and Australia with 26 productions, representing 3.83%. Following these are countries such as China, Germany, Canada, Japan, Spain, and the Netherlands, which have a significant percentage of productions ranging from 2.95% to 1.47%.

Regarding Central and Latin America, Mexico has 2 high-impact productions, accounting for 0.29%; Brazil has 4 scientific documents with a representation of 0.59%; Chile has 1 document; while Colombia and Ecuador do not have high-impact scientific productions focused on the field of health and ICT.
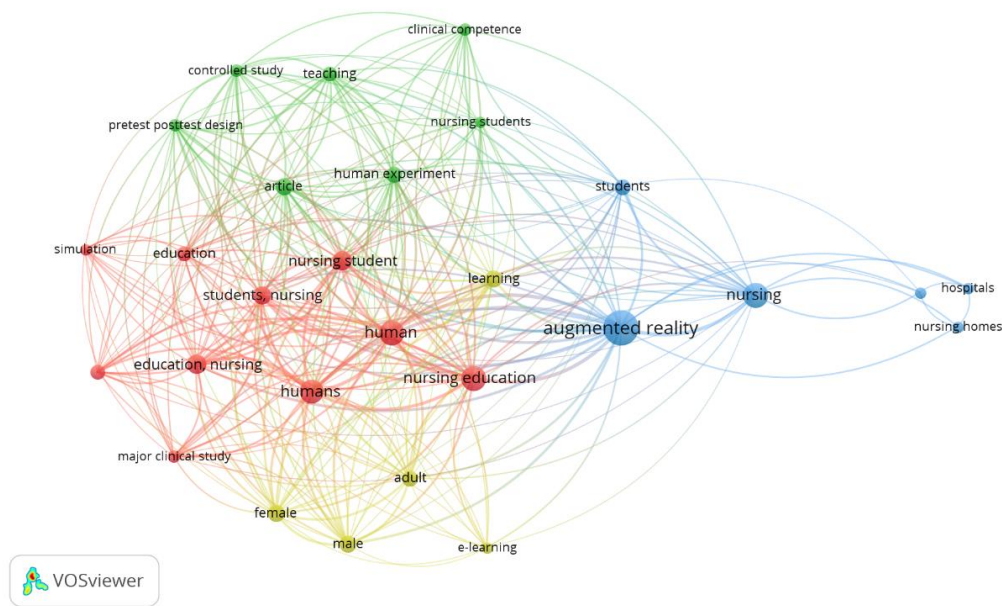

Figure 2: Co-occurrence keyword mapping

In Figure 2, which shows the co-occurrence network regarding keywords, three keywords can be identified as fundamental in constructing the co-occurrence network: "Augmented reality," "Nursing," and "Students."

The keyword "Augmented reality" has a total of 28 co-occurrences and a total link strength of 140 revisions. The keywords that are part of this network are: "human" (15) with a link strength of 146; "learning" (7) with a link strength of 72; and "Humans" (13) with a link strength of 132.

Regarding the keyword "Nursing," there are a total of 15 co-occurrences and a link strength of 71. The keywords that are part of this network are: "adult 6" (65) with a link strength of 65; "teaching 5" (62) with a link strength of 62; "procedures 5" (53) with a link strength of 53; "female 7" (75) with a link strength of 75; and "nursing education 15" (131) with a link strength of 131.

Lastly, it can be observed that the third keyword, "Students," has co-occurrences with the following keywords: "nursing student 9" (111) with a link strength of 111; "nursing education 15" (131) with a link strength of 131; "education 5" (55) with a link strength of 55; "education, nursing 9" (95) with a link strength of 95; "clinical competence 4" (40) with a link strength of 40; and "e-learning 3" (20) with a link strength of 20.
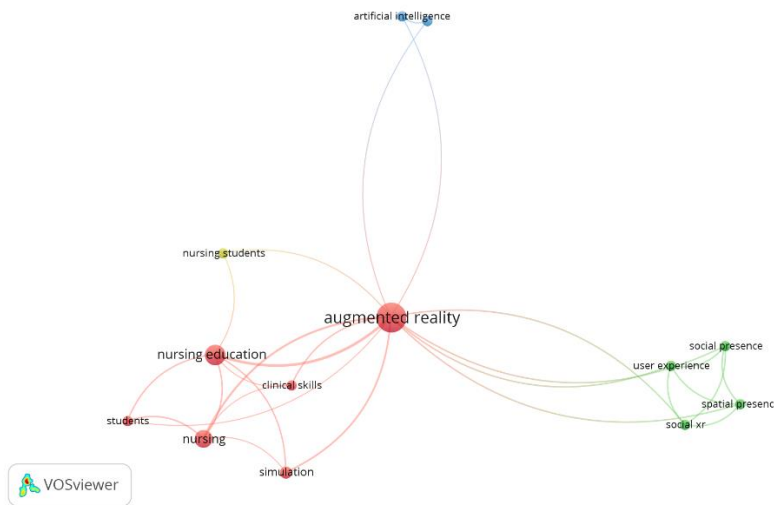
Figure 3: Co-occurrence subnetwork mapping

As can be seen in the sub-network of Figure 3, where the lines of research related to the two fields of study in this bibliometric analysis are considered, it can be identified that augmented reality is the broadest network from where information is obtained for the development of scientific productions. It also has a co-occurrence with the keyword "nursing students," which is associated with "nursing education." Additionally, augmented reality is correlated with "simulation" and "clinical skills."

On the other hand, fields of study related to nursing and user experience, spatial and social presence in relation to learning technologies, as well as a direct relationship between artificial intelligence and augmented reality can also be considered.

Table 4: Number of created clusters

Clusters numbers	Co-occurrence strength
Cluster 1	
education	55
education, nursing	95
human	146
humans	132
major clinical study	50
Nursing education	131
Nursing student	111
Procedures	53
Simulation	28
Students, nursing	102
Cluster 2	
Article	87
Clinical competence	40
Controlled study	58
Human experiment	72
Nursing students	27

| Pretest postest design | 58 |
| Teaching | 62 |

Cluster 3

Augmented reality	174
Hospitals	10
Nursing	71
Nursing homes	10
Students	43
User experience	12

Cluster 4

Adult	65
E-learning	20
Female	75
Learning	72
Male	75

In Table 4, the number of clusters created according to the co-occurrence network established in Figure 3 is shown. A total of 4 information clusters are identified, along with the strength number that these keywords have in scientific productions worldwide. The final result aligns with the previous mapping and provides the following information:

Cluster 1 includes the most used keywords: Human (146), Humans (132), Nursing education (131), and Nursing student (111). Cluster 2 consists of three frequently used keywords: Article (87), Human experiment (72), and Teaching (62). Cluster 3 is the strongest in the bibliometric analysis as it contains the keyword used for this study: Augmented reality (174), Nursing (71), and Students (43). Finally, Cluster 4 exhibits a tendency in the co-occurrence of keywords such as: Female (72), Male (75), Learning (72), and Adult (65). These values demonstrate the strength of the keywords used in scientific productions.
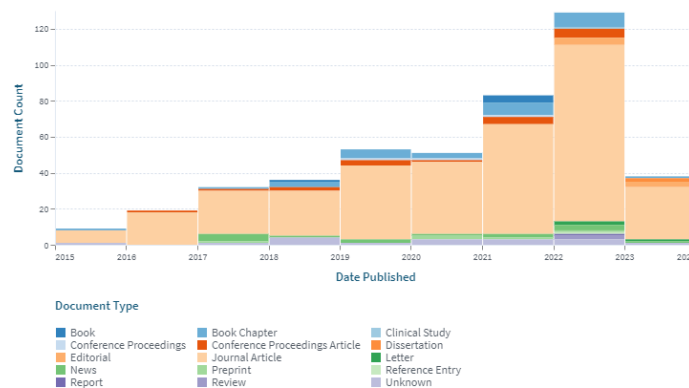

Figure 4: types of documents

From the year 2015 to 2024, there is a trend in scientific productions focused on augmented reality and the field of nursing, with a total of 343 journal articles with impact factor. The year 2022 had the highest number of publications, totaling 98, followed by 61 articles in 2021. During these years, the Covid-19 pandemic was one of the contributing factors that led to a greater use of digital resources and consequently a rise in Health 4.0.

In this analysis, it can be observed that the articles with the highest citation index are as follows: "Technology in nursing education: Augmented reality," published in the Pamukkale University Journal of Engineering Sciences with a total of 175 references; "Augmented Reality in Physical Therapy: Systematic Review and Meta-analysis," published in the JMIR Serious Games with 75 references; "Online access to diagnostic reports seen in the perspective from breast cancer patients" is the article that has two patents titled "Method for Blocking Uptake of Prostate-Specific Membrane Antigen (Psma)-Targeted Radionuclides by Exocrine Organs" and "Radioactive Microshperes for the Treatment of CNS Tumours," both published in 2021, with 57 and 22 references, respectively..

Figure 5: Co-citations of authors

Finally, in Figure 5, a word cloud displays the authors with the highest scientific production in articles with impact factor, including:

Mike Joy, who has a book in 2018 and three scientific articles in 2018, 2022, and 2023. His article titled "Augmented Reality in Supporting Healthcare and Nursing Independent Learning" has 111 co-citations.

Michelle Aebersold, with a total of 4 scientific productions in 2018, 2020, and 2022. Her focus or research lines include augmented reality, computer science, nursing education, and healthcare. Her network of co-authors includes Monica Weber, Jenna Regan, Andrew Darr, and Leila Cherara.

Ebtehal Quqandi, with a total of 4 productions between books and journal articles in 2018 and 2023. She is affiliated with the University of Warwick and the University of Stanford. Her article titled "Augmented Reality in Supporting Healthcare and Nursing Independent Learning" has 75 co-citations. She collaborates with Mike Joy, Melanie Rushton, and Ian Drumm.

Dawn Dowding, with a total of 144 scientific productions, an H-index of 36, and 3,935 co-citation references. Her collaboration rate is 88% of efficiency. She is affiliated with The University of Manchester and Columbia University. The article with the highest references is "An agenda for clinical decision making and judgement in nursing research and education," with a total of 118 references.

Discussion

Currently, research focuses on various educational themes. These include the study of motivation in learning (Asante y otros, 2023), inclusive education, the development of training applications and tools, as well as the significant effects of using augmented reality (AR) in the healthcare educational field.

It is essential to conduct research that addresses interdisciplinary methodologies and technologies, as well as innovative teaching practices in the teaching and learning process in the field of Health, specifically in Nursing. It is also necessary to evaluate the impact of AR on academic performance, explore the potential of AR-oriented games, and use appropriate programming languages for developing AR applications on mobile devices.

Determining whether AR contributes to overall student performance is fundamental, as there are significant opportunities to expand the use of technology in the classroom, particularly in the specific field of nursing (Boumali & Tamiine, 2022). Additionally, it is essential to make comparisons between virtual reality and augmented reality and create inclusive learning scenarios that foster the participation of all students.

Lastly, research in other industrial companies that have implemented AR should be promoted to compare results and leverage the advancements achieved in these contexts.

Conclusions:

In this article, a comprehensive analysis of all documentation related to augmented reality (AR) in the nursing field from 2015 to 2023 was carried out. The objective was to identify the beginnings of this technology and determine the quantity of documents written in recent years addressing this topic. It is important to highlight that several documents related to AR have been reviewed, but to date, no bibliometric analyses have combined two important databases, such as WoS and Scopus, to show collaboration networks among the most prominent authors.

In recent years, there has been a growing interest from the scientific community in AR research. This is reflected in current publications, which have experienced an annual increase of 22%. Regarding the most contributing journals in this field, Home Health Care Management & Practice, Journal of Advanced Nursing, International Journal of Nursing Studies, and Journal of Clinical Nursing stand out. Additionally, it has been identified that four countries (United States, United Kingdom, Australia, and China) account for approximately 23% of the publications, demonstrating their leadership in advancing this area.

The conducted study reveals the existence of two thematic clusters related to augmented reality in the context of health, particularly in nursing. These clusters address student motivation in nursing learning and the outcomes of AR in various fields. It is noteworthy that most research in these two subareas is conducted in European and Asian countries, while research in countries in the Americas is in its early stages.

Research Lines:

As future work for this study, the following research lines were established, focusing on the field of Nursing, taking into account the entire bibliometric analysis and its further exploration.

Student Motivation in Nursing Learning:

- Enhancing students' experience with RA-based activities.
- Impact of RA with mobile applications on teaching and recognition in nursing subfields.
- Educational technology and its contributions to patient focus and care in augmented reality environments and the use of CT scans.
- RA applications in motivating nursing students' learning.

RA Applications in Different Nursing Subfields:

- STEM-based learning and augmented reality in autonomous learning.
- RA as educational inclusion in nursing.
- RA in students' achievements and attitudes towards scientific education.
- RA in bioscience education to enhance learning experience for students.

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