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IMPROVEMENT OF STUDENTS ACHIEVEMENT BY USING INTELLIGENT TUTORING SYSTEMS - A BIBLIOMETRIC ANALYSIS AND REVIEWS

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ABSTRACT

Intelligent tutoring systems (ITS) have emerged as a promising technology for improving students' achievement by providing personalized and adaptive learning experiences. This research presents a bibliometric analysis and review of the literature on the use of ITS for improving students' achievements. Using the creation and visualization of bibliometric networks software (VOSviewer), this investigation extended all studies from 2012 to 2022. In February 2023, a total of 88 publications were analyzed as recorded in the Scopus database, finding the most compelling topics addressed by the database using relevant keywords and criteria. The analysis aims to identify the research trends, influential authors, journals, institutions, countries, research areas and publications, and gaps in the literature related to ITS and student achievement. The results indicate a growing interest in the use of ITS for promoting student achievement, with a focus on personalized learning, artificial intelligence, and machine learning. The analysis identified influential authors, journals, institutions, countries, research areas and publications that have contributed to our understanding of the relationship between ITS and student achievement. However, the analysis also revealed several gaps in the literature, including the need for more research on the use of ITS for learners with diverse backgrounds or special needs and the implications of this research for the development of more effective instructional practices. The findings of this study can guide the development of more effective ITS and instructional practices and highlight areas for future research and development in this field. Overall, this study contributes to a better understanding of the potential of ITS in improving student achievement and promoting more efficient and effective learning.

Keywords: *Intelligent Tutoring Systems, Personalized Learning, Student Achievement, Adaptive Learning, Cognitive Science, Bibliometric Analysis*

1. INTRODUCTION

In recent years, intelligent tutoring systems (ITS) have been increasingly popular in the education sector due to their ability to provide personalized learning experiences for students. These systems use artificial intelligence and machine learning algorithms to adapt to individual student needs and provide immediate feedback, which can improve learning outcomes and increase student achievements. With the growing importance of ITS, there has been an increase in research on this topic [1].

This bibliometric analysis aims to provide a comprehensive overview of the research trends and patterns related to using intelligent tutoring systems to improve student's achievements. Bibliometric analysis is a quantitative method using bibliographic data to evaluate research output and track trends over time.

The analysis included studies published in peer-reviewed journals and conference proceedings. By

identifying the most influential publications, years of publications, authors, institutions, and countries, this analysis will provide insights into the development of research in this field. Additionally, the study will identify gaps in the literature and suggest areas for future research.

The results of this analysis can be used to inform the development of more effective intelligent tutoring systems and instructional practices, which can ultimately improve student achievements and promote more efficient and effective learning.

The aims of this research are to utilize bibliometric and visualization analysis to assess papers indexed in Scopus that employ intelligent tutoring systems to increase student achievement.

Moreover, all data in the present study were gathered from Scopus, the world's top abstract and citation database of peer-reviewed literature. As a result, numerous top publications on intelligent tutoring systems and the use of artificial intelligence in education were included in this study data. This study allows us to understand how intelligent tutoring systems' research interests have changed over time. Moreover, this study visualized and explored scientific partnerships among major contributors in applying intelligent tutoring systems to increase students' results, which were not before studied. Exclusively, we wanted to discuss the following research questions:

1. What is the distribution of publications over the previous decade by years that use intelligent tutoring systems to increase students' achievement?
2. What are the most important journals and authors that employ intelligent tutoring systems to help students increase achievement?
3. Which countries and research areas are most effective in terms of applying intelligent tutoring systems to enhance student achievement?
4. What have been the significant research keywords in the past decade for using intelligent tutoring systems to increase student achievement?
5. How many relevant publications have been produced by institutions that utilize intelligent tutoring systems to increase student achievement?

2. PROBLEM STATEMENT

Despite the benefits of intelligent tutoring systems (ITS) in enhancing student learning and achievement, there remains a need to assess the effectiveness of ITS on improving student performance. Moreover, there is a lack of comprehensive research on the bibliometric analysis and review of ITS and its impact on students' achievement. Therefore, there is a need to conduct a study to evaluate the effectiveness of ITS in improving students' academic performance, while also exploring the literature on ITS to identify trends, gaps, and future directions for research in this area.

3. MATERIALS AND METHODS

This study attempts to highlight the profile of research carried out over the previous decade to increase students' success by employing intelligent tutoring systems. The study used bibliometric and visualization tools in tandem to achieve this objective. Moreover, bibliometric analysis is centered on tracking research on a given issue and exposing the conclusions by assessing these studies according to numerous features [2]-[15].

To get high-quality studies, relevant publications in the Scopus database were included in the study, eliminating any conference review or book chapter. Keywords were searched in the title, abstract, and keyword sections during the scan on 15/02/2023.

Of the articles obtained through the search, English and full-text articles were included in the study. As terms and phrases that recall them, "students AND achievements AND intelligent AND tutoring AND systems" have been used.

Scopus was used to find journals that use intelligent tutoring systems to improve student achievement in this study because it includes intelligent tools for visualizing, analyzing, and tracking study output in various fields such as Computer Science, Social Science, Mathematics, Engineering, Psychology, Arts, and Medicine [16[-[30].

Furthermore, in order to ensure the relative importance of the analyzed articles that use intelligent tutoring systems to improve student achievements, we performed manual screening to omit irrelevant publications using the criteria provided in Table 1. As a result, 88 publications remained for further analysis. Table 1 shows the exclusion and inclusion criteria. In addition, Figure 1 displays the analytic research framework.

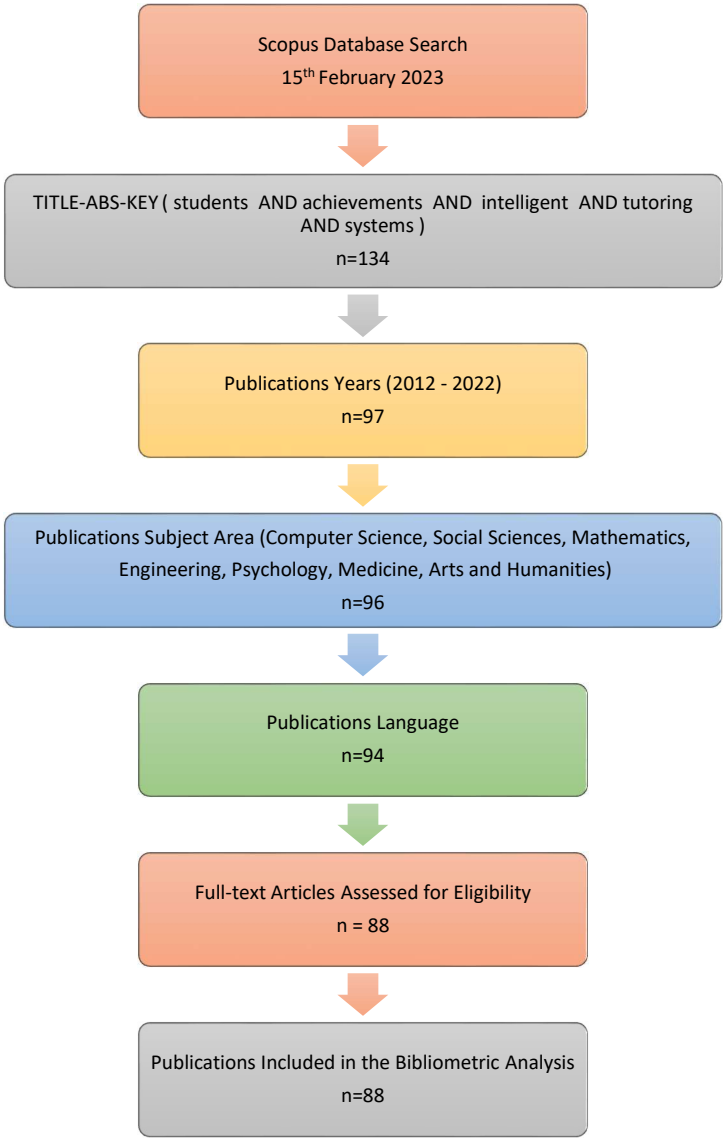

Figure 1. Analytic research framework

4. EXCLUSION AND INCLUSION CRITERIA

Table 1. The data screening inclusion and exclusion criteria

Inclusion criteria	• Education-related. • Articles published in peer-reviewed journals. • Full-text articles. • Year range between 2012 and 2022. • Articles published in English.
	• Subject areas (Computer Science, Social Science, Mathematics, Engineering, Psychology, Arts, and Medicine).
Exclusion criteria	• Articles that have these subject areas (Business, Management and Accounting, Physics and Astronomy, Materials Science, Energy, Economics and others).

	• Conference Review • Book Chapter • Nonindexed Publications.

5. THE BIBLIOMETRIC ANALYSIS

The study also employed the bibliometric analysis approach. The most used keywords, the most cited journals, the most published journals, the journals that published the most studies on the subject, the countries that did the most studies on the subject, the publication cooperation between countries, the keywords used and their relationship, the most cited authors, their relationship, the journals that were jointly cited, and the most published areas were examined using bibliometric analysis. The network visualization in the investigation was shown using the VOSViewer software, which is one of the most extensively used tools for visualizing bibliometric networks.

The purpose of the bibliometric analysis is to provide an overview of research trends and patterns related to intelligent tutoring systems and their impact on student achievements. The analysis aims to identify commonly studied topics, influential authors and publications, and gaps in the literature. Results can inform the development of more effective ITS and instructional practices and guide educator decisions [31]-[40].

The research contributes to a better understanding of ITS potential in improving student achievements and promoting efficient and effective learning. The analysis offers valuable insights into the growing importance of ITS in the education sector [41]-[50].

6. FINDINGS AND RESULTS

The study's goal is to show the characteristics of studies that have used intelligent tutoring systems to improve students' achievement during the previous decade. The review's findings were reviewed in relation to the research questions.

5.1 RESEARCH QUESTION 1

What is the distribution of publications over the previous decade by years that use intelligent tutoring systems to increase students' achievement? To address the first finding, a study of the publication year of the publications throughout the past decade was performed. Whereas, the highest number of published research papers was in 2014 with a total of 15 research related to the use of intelligent tutoring systems to improve student achievement, followed by 2015 with a total of 12 research, then followed by 2018 and 2021 with a total of 9 research each. The year 2012 and 2022 are the least years in publishing research related to the use of intelligent tutoring systems to improve student achievement, with a total of 2 research papers for each. Figure 2 shows how the additional publications were distributed over the rest few years.

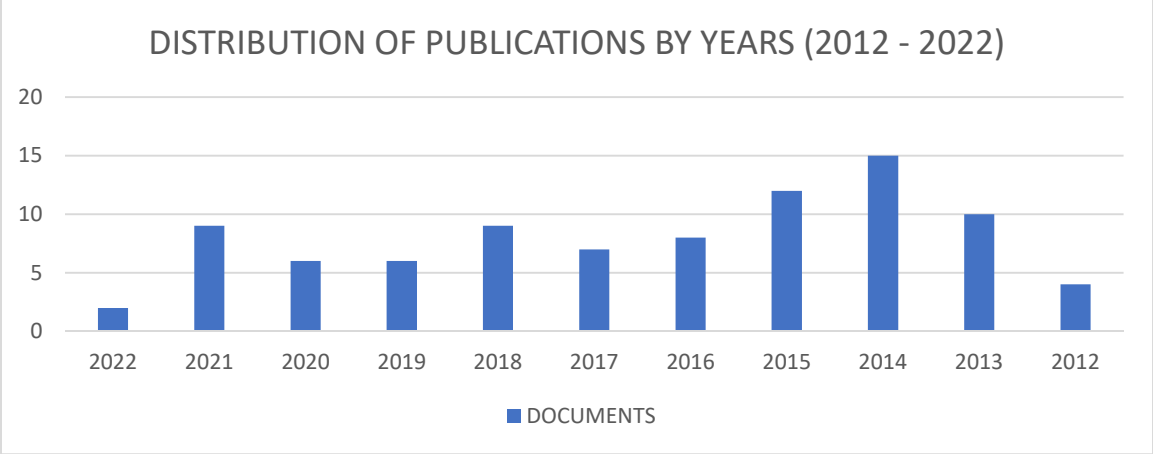

Figure 2. Distributions Of Publications By Years (2012 - 2022)

5.2 RESEARCH QUESTION 2

What are the most important journals and authors that employ intelligent tutoring systems to help students increase achievement? The analytic criteria for the most cited journals were "Total Publication," "Total Citation," "Cite Score of the journal," "The Most Cited Article," "Times Cited," and "Publisher," as shown in Table 2.

Table 2. The Top 10 Most Productive Journals On Students' Achievements And Intelligent tutoring systems over the last decade (2012 – 2022)

Journal	TP	TC	Cite Score (2021)	The Most Cited Article (Reference)	Times Cited	Publisher
Lecture Notes in Computer Science	81,183	172,674	2.1	UlyssesNER-Br: A Corpus of Brazilian Legislative Documents for Named Entity Recognition	92	Springer Nature
ACM International Conference Proceeding Series	44,179	44,929	1.0	Pandemic, Higher Education, and a Developing Country: How Teachers and Students Adapt to Emergency Remote Education	17	ACM
Computers and Education	822	16,299	19.8	From dual digitalization to digital learning space: Exploring the digital transformation of higher education	33	Elsevier
Educational Technology and Society	210	1,513	7.2	Two Decades of Artificial Intelligence in Education: Contributors, Collaborations, Research Topics, Challenges, and Future Directions	35	International Forum of Educational Technology, National Taiwan Normal University and Society
Journal of Educational Psychology	313	3,125	10.0	Achievement Emotions and Academic Achievement: Reciprocal Relations and the Moderating Influence of Academic Buoyancy	20	APA
CEUR Workshop Proceedings	20,716	22,097	1.1	Preface to the Sixth Workshop on Natural Language for Artificial Intelligence (NL4AI)	14	CEUR Workshop Proceedings
Computers in Education Journal	26	28	1.1	COVID-19 Technology Student Success Challenges: Influence of Tools and Strategies	1	American Society for Engineering Education
Computers in Human Behavior	1,607	23,983	14.9	What is XR? Towards a Framework for Augmented and Virtual Reality	43	Elsevier
Educational Technology Research and Development	489	2,643	5.4	Effects of online strategies on students' learning performance, self-efficacy, self-regulation and critical thinking in university online courses	9	Springer Nature
Academic Radiology	911	5,805	6.4	Assessment of the Willingness of Radiologists and Radiographers to Accept the Integration of Artificial Intelligence Into Radiology Practice	23	Elsevier

Note: TP = Total Publications, TC = Total Citation.

Table 2 shows that the most productive journal for using intelligent tutoring systems to improve student achievement was "Lecture Notes in Computer Science" with 81,183 total publications and 172,674 total citations, followed by "ACM International Conference Proceeding Series" with 44,179 total publications and a total citation of 44,929, and "Computers and Education" with 822 total publications and a total citation of 822. Table 2 also shows the distribution of the most productive journals on the use of intelligent tutoring systems to increase student achievement.

RQ2 analyzed the most productive authors in the field of student achievement and intelligent tutoring systems research. The analytic criteria for the prolific authors in the study area of employing intelligent tutoring systems to increase student achievement were "Author," "Total Publications," "h-index," "Total citations," "current affiliation," and "country," as shown in Table 3.

Table 3. A list of the 15 most productive authors in the field of intelligent tutoring systems research and student achievements.

No.	Author	Year of 1st Publication	TP	h-Index	TC	Current Affiliation	Country
1	Azevedo, Roger [19],[22],[47]-[49]	1995	223	45	5,322	Info University of Central Florida, Orlando	United States
2	Bernacki, Matthew L. [5]-[7]	2010	49	19	824	Info The University of North Carolina at Chapel Hill, Chapel Hill	United States
3	Conati, Cristina [47],[49]	1993	144	34	2,867	The University of British Columbia, Vancouver	Canada
4	McNamara, Danielle S. [66]-[68]	1991	389	58	7,325	Info Arizona State University, Tempe	United States
5	Snow, Erica L. [66]-[68]	2013	39	11	288	Info Imbellus, Westwood,	United States
6	Taub, Michelle [19], [48]-[49]	2012	58	16	607	University of Central Florida, Orlando	United States
7	Binti Ahmad, Rodina [27]	1999	106	19	1,168	Universiti Malaya, Kuala Lumpur	Malaysia
8	Aleven, Vincent A.W.M.M. [5]-[6]	1991	249	42	4,892	Carnegie Mellon University, Pittsburgh	United States
9	Baker, Ryan Shaun Joazeiro D. [45],[65]	2003	318	48	5,914	Info University of Pennsylvania, Philadelphia,	United States
10	Chang, Maiga [50][84]-[85]	1998	181	15	793	Athabasca University, Athabasca	Canada
11	Chatterjee, Anurima [15],[46]	2014	2	1	2	Educational Initiatives Pvt. Ltd., Hyderabad	India
12	Fathi, Moein [30]	2015	7	6	143	Tartu Ülikool, Tartu	Estonia
13	Heffernan, Neil T. [1][65]	1998	209	33	2,452	Worcester Polytechnic Institute, Worcester	United States
14	Hernández-González, Sergio [42]	2013	12	4	46	Universidad Veracruzana, Xalapa	Mexico
15	Hooshyar, Danial [29]-[30]	2014	60	19	743	Tallinna Ülikool, Tallinn	Estonia

Note: TP = Total Publications, TC = Total Citation.

Table 3 shows 15 influential authors in the field of intelligent tutoring systems study and student achievement. Furthermore, the most prolific author was "McNamara, Danielle S." with 389 publications, the highest h-index of 58, and a total of 7,325 citations, and the author is from the United States. Following that is "Baker, Ryan Shaun Joazeiro D." with a total of 318 publications, an h-index of 48, and a total of 5,914 citations, and the author is also from the United States. Following that is "Aleven, Vincent A.W.M.M." with a total of 249 publications, an h-index of 42, and a total of 4,892 citations, and the author is from the United States. Furthermore, the top three H-index rankings stayed the same as ordered by publishing count. Table 3 also includes other productive authors in the field of using intelligent tutoring systems to improve student achievements.

Figure 3 shows the charts of the 15 most productive authors regarding using intelligent tutoring systems to improve student's achievements. The chart shows that "Azevedo, Roger" has the most published in the field of research regarding the use of intelligent tutoring systems in improving student achievement, with 5 publications. Followed by "Bernacki, Matthew L.", "Conati, Cristina", "McNamara, Danielle S.", "Snow, Erica L." and "Taub, Michelle", respectively, with 3 publications each[7]-[16].

Figure 3. A list of the 15 most productive authors regarding using intelligent tutoring systems to improve students' achievements

5.3 RESEARCH QUESTION 3

Which countries and research areas are most effective in terms of applying intelligent tutoring systems to enhance student achievement? The analysis criteria for the most prolific countries in the research field of using intelligent tutoring systems to improve student achievement were "country," "Total Publications," and "most prolific academic institution," as shown in Table 4 and Figure 4.

Table 4. List of the 15 most prolific countries in the research area of using intelligent tutoring systems to improve students' achievements

Rank	Country	TP	Most prolific Academic Institution	Rank	Country	TP	Most prolific Academic Institution
1	United States	29	North Carolina State University	9	South Korea	3	Korea University
2	Canada	11	University of British Columbia	10	Turkey	3	Çanakkale Onsekiz Mart University
3	Taiwan	11	National Taiwan University of Science and Technology	11	Lithuania	2	Vilniaus Gedimino Technikos Universitetas
4	China	7	Hangzhou Normal University	12	Malaysia	2	Universiti Tenaga Nasional
5	Philippines	5	Ateneo de Manila University	13	Netherlands	2	Universiteit van Amsterdam
6	India	4	Educational Initiatives Pvt. Ltd	14	Serbia	2	University of Belgrade
7	Mexico	4	Universidad Veracruzana	15	South Africa	2	Tshwane University of Technology
8	Spain	4	Universidad de la Laguna				

Note: TP = Total Publications.

Table 4 and Figure 4 demonstrate the top 15 prolific countries in the field of using intelligent tutoring systems to improve student achievement, as well as the topic distributions of the top prolific countries/regions and institutions. From a country perspective, the majority of the mentioned countries/regions showed consistent interest in all study topics concerning intelligent tutoring systems and student success. In contrast, particular trends attracted the interest of different countries/regions. For example, the most prolific country was the "united states," with a total publication count of 29 at "North Carolina State University". They were followed by "Canada" and "Taiwan," each with 11 publications from the "University of British Columbia" and the "National Taiwan University of Science and Technology," respectively. Furthermore, other prolific, productive countries are conducting studies on the use of intelligent tutoring systems to improve student achievement. Table 4 displays the data and statistics [41]-[50].

Figure 4. Analysis results of prolific countries of the research that use intelligent tutoring systems to improve students' achievements

Figure 4 shows the study findings of productive countries in the use of intelligent tutoring systems that improve student achievement. Thus, in contrast to countries/regions, institutes listed in

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the figure showed more interest in particular subjects, the most productive country was "united states," followed by "Canada," and "Taiwan" followed by "China". Furthermore, Table 4 indicates the top 15 prolific countries in the study field, which include the Philippines, India, Mexico, Spain, South Korea, Turkey, Lithuania, Malaysia, the Netherlands, Serbia, and South Africa. Beginning According to the studies, countries/regions within the same institutions and continents within the same countries/regions with similar study interests tend to collaborate more in the research field that employs intelligent tutoring systems to improve student achievement.

5.4 RESEARCH QUESTION

What have been the significant research keywords in the past decade for using intelligent tutoring systems to increase student achievement? The analysis method "Co-occurrence" and the unit "Authors keywords" were chosen for the bibliometric analysis of the most commonly used keywords. As shown in Figure 5, 260 keywords were found from the data collection in this study.

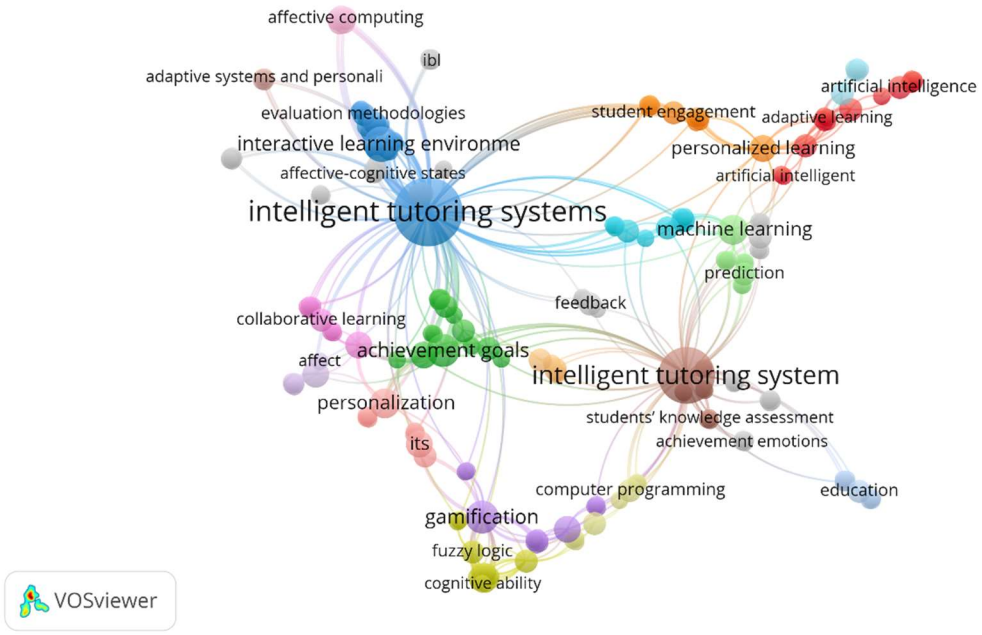

Figure 5 Analysis results of publications by keywords

When looking at Figure 5, the keywords used in the studies are "intelligent tutoring systems" (Occurrences "Oc" = 33), "intelligent tutoring systems" (Oc = 20), "interactive learning environments" (Oc = 6), "gamification" (Oc = 5), "achievement goals" (Oc = 5), "machine learning" (Oc = 4), and "personalization" (Oc = 4). Personalized learning, assessment, pedagogical agents, personality traits, emotions, and ITS followed. When the keywords of the articles are investigated, it is seen that roughly 69% (n = 115) use words such as "intelligent tutoring system" and "assessment". Furthermore, bibliometric analysis prefers keywords such as learning behavior, learning diagnosis, m-learning, and student knowledge study.

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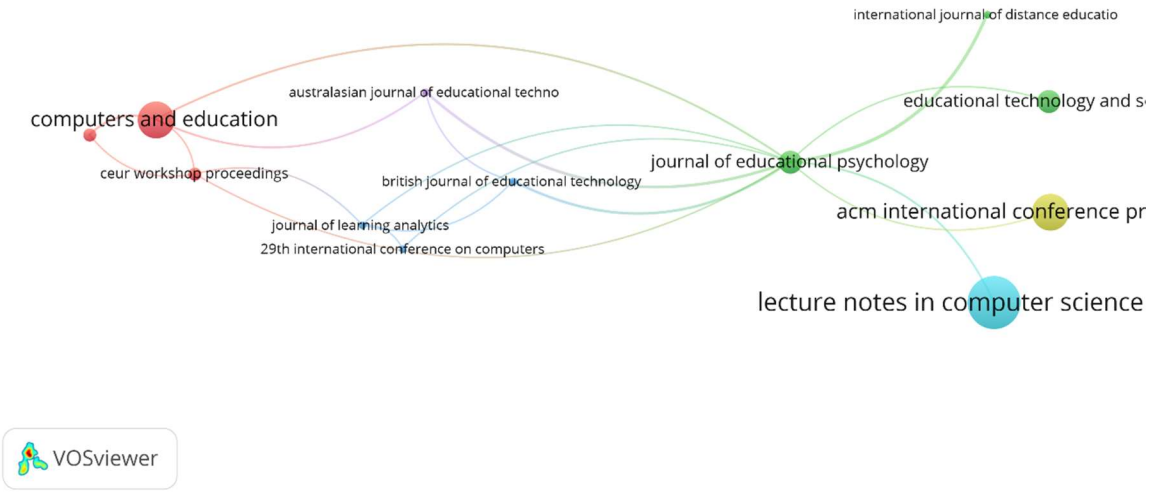

Figure 6. Most cited journals (citation)

When looking at Figure 6, the first four journals with the most citations are listed, firstly, "Lecture Notes in Computer Science" (article title: "UlyssesNER-Br: A Corpus of Brazilian Legislative Documents for Named Entity Recognition", citation = 92), secondly, "ACM International Conference Proceeding Series" (article title: "Pandemic, Higher Education, and a Developing Country: How Teachers and Students Adapt to Emergency Remote Education", citation = 17), thirdly, "Computers and Education" (article title: "From dual digitalization to digital learning space: Exploring the digital transformation of higher education", citation = 33). Finally, "Educational Technology and Society" (article title: "Two Decades of Artificial Intelligence in Education: Contributors, Collaborations, Research Topics, Challenges, and Future Directions", citation = 35). Figure 6 shows the results of the Most cited journals (Co-Citation) study (Items = 12, Cluster = 6, Links = 18, and TLS = 36).

5.5 RESEARCH QUESTION 5

How many relevant publications have been produced by institutions that utilize intelligent tutoring systems to increase student achievement? Figure 7 shows the top 10 educational institutions with regard to the use of intelligent tutoring systems to improve student achievement, as the educational institution with the highest publication of research related to the use of intelligent tutoring systems to improve student achievement is "NC State University" with 5 publications, followed by "Arizona State University", "University of Memphis", and "Ateneo de Manila University" with 4 publications each. Finally, figure 7 shows the distribution of the number of research papers among the rest of the educational institutions.

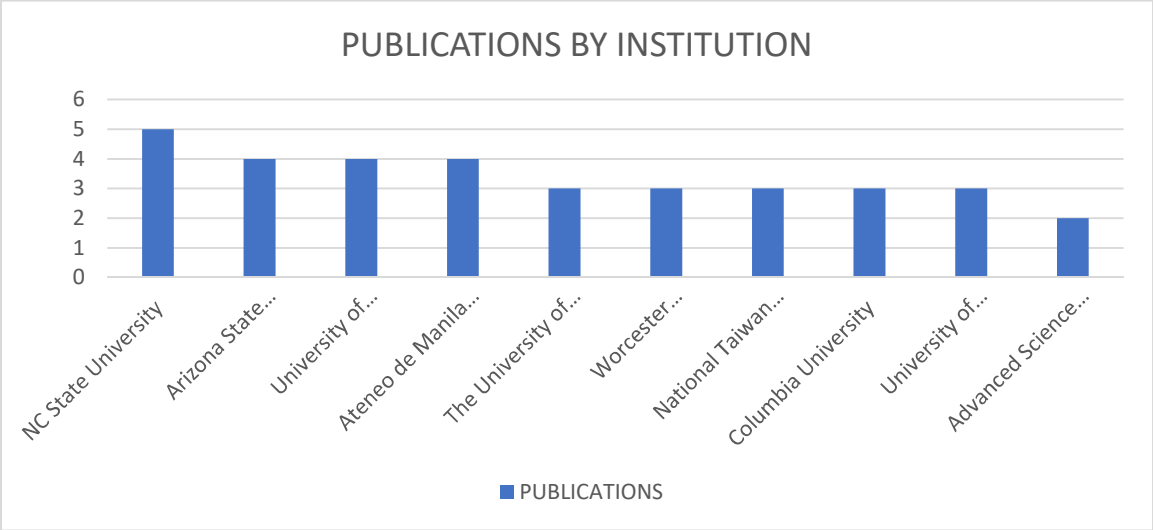

Figure 7. Top 10 educational institutions regarding using intelligent tutoring systems to improve students' achievements

7. DISCUSSIONS

This research review, based on 134 research articles retrieved from the Scopus database, provides an overview of using intelligent tutoring systems to improve student achievement through content analysis and bibliometrics. As an area of study, this trend analysis of the research review shows a growing interest in the research of using intelligent tutoring systems to improve students' achievements. Such an analysis of the publishing sources indicates the use of intelligent tutoring systems to improve students' achievements is welcomed in various fields such as Computer Science, Social Science, Mathematics, Engineering and others fields, and their implications in education in general. (See Figure 8).

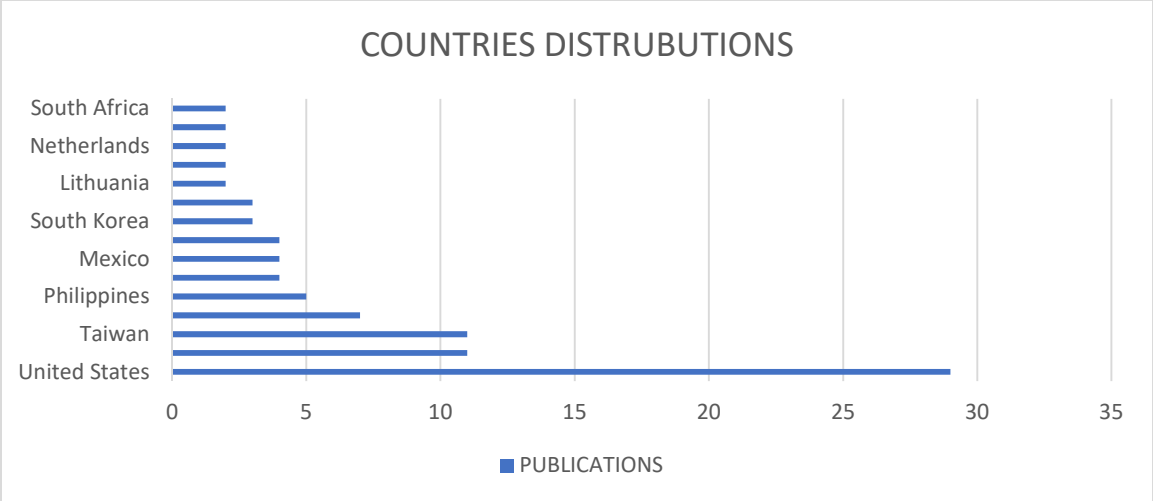

Figure 8. Country distribution and total publications

The "United States" provided approximately 32% of the analyzed literature, with "North Carolina State University" being the most prolific educational institution. Furthermore, scientific cooperation analysis indicates that countries/regions with a greater interest in worldwide cooperation (e.g., the United States, Canada, Taiwan, and China) are more likely to develop quicker. Collaborations among the same institutions or regions are also much more

important. The most relevant research subject in this study was the use of intelligent tutoring systems to improve student achievement. There are several common tendencies and trends in using Intelligent Tutoring Systems (ITS) to improve student achievement, including: (1) Personalization: ITS can be customized to meet the individual needs of each student, providing personalized feedback, and tailored instruction to help students learn at their own pace, (2) Adaptive learning: ITS can adapt to the learning style and progress of each student, providing a personalized learning experience that maximizes learning outcomes, (3) Gamification: ITS can incorporate gaming elements, such as points, badges, and leaderboards, to engage students and make learning more fun and interactive, (4) Collaborative learning: ITS can facilitate collaborative learning experiences, allowing students to work together on projects, share ideas, and receive feedback from their peers, (5) Big data analytics: ITS can collect and analyze large amounts of data on student interactions and performance, providing valuable insights into student learning and areas for improvement. These trends are driven by the need to improve student achievement by providing personalized, engaging, and effective learning experiences. As technology continues to evolve, ITS is expected to become even more sophisticated and effective, enabling educators to provide students with a more personalized and engaging learning experience that maximizes student achievement.

8. CONCLUSION AND IMPLICATIONS

The results of this bibliometric analysis provide a comprehensive overview of the research trends and patterns related to intelligent tutoring systems and student achievements. 88 publications were analyzed from the Scopus database after applying the rules of inclusion and exclusion using bibliometrics and content analysis. The analysis showed that there was a great interest in the field of research using intelligent tutoring systems to improve student achievement in the past decade, especially in 2014 with 15 publications and in 2015 with 12 publications, then a slight decline occurred in the following years until research returned strongly again in 2021 with 9 publications, especially in the period of the Corona pandemic and the increase in the need for intelligent tutoring systems to increase student achievement in the educational process. We found that the most productive countries in the field of research that use intelligent tutoring systems to improve students' achievement are the United States with 29 publications, followed by Canada and Taiwan with 11 publications for each. In addition, "NC State University" was the most productive institution that publishes research in the field of using intelligent tutoring systems to improve students' achievement with 5 publications and followed by "Arizona State University", "University of Memphis" and "Ateneo de Manila University" with 4 publications for each. The analysis identified several prolific authors and influential publications that have contributed to our understanding of the relationship between intelligent tutoring systems and student achievements. "Azevedo, R." was the most published author in the field of research and the use of intelligent tutoring systems in improving student achievement. The most commonly studied topics include the design and implementation of intelligent tutoring systems, the effectiveness of these systems in promoting student achievements, and the challenges and opportunities associated with the use of these systems in educational settings. The analysis also revealed several gaps in the literature, including the need for more research on the use of intelligent tutoring systems for learners with diverse backgrounds or special needs, the ethical considerations related to the use of these systems, and the implications of this research for the development of more effective instructional practices. Overall, this analysis highlights the growing importance of intelligent tutoring systems in the education sector and the potential for these systems to improve student achievements and promote more efficient and effective learning. The results of this analysis can be used to inform the development of more effective intelligent tutoring systems and instructional practices, as well as to identify areas for future research and development in this field.

9. LIMITATION

This study has some limitations. Initially, the Scopus database was only used to gather statistics. As a result, it does not include all academic publications. As a result, publications from other databases, such as the “Web of Science”, may not have been included in this study. Furthermore, the most current Scopus articles for 2023 were ignored.

Since we are at the beginning of the year, it is difficult to collect accurate statistics for it now. Nonetheless, such constraints are unlikely to have an effect on the trends and patterns found in this study. Furthermore, only "intelligent* tutoring*systems*" and "students* achievements*" were used as precise search keywords to retrieve data. In this study, more specific search terms were used, with an emphasis on improving student achievement through the use of intelligent tutoring systems rather than possible methods that could be included.

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