A Bibliometric Review of Studies about the Acceptance of Artificial Intelligence Technologies in Teaching and Learning in Higher Education

Carlos Hernán Flores-Velásquez (iD)*, **Soledad Olivares-Zegarra** (iD),
Carlos Dávila-Ignacio (iD)
Facultad de Ingeniería y Gestión,
Universidad Nacional Tecnológica de Lima Sur, Perú*

José Antonio Arévalo-Tuesta (iD)
Facultad de Ciencias Económicas,
Universidad Nacional Federico Villarreal, Perú

Guillermo Morales-Romero (iD), **Nicéforo Trinidad-Loli** (iD)
Facultad de Ciencias,
Universidad Nacional de Educación Enrique Guzmán y Valle, Perú

Beatriz Caycho-Salas (iD)
Facultad de Ciencias Empresariales,
Universidad Nacional de Educación Enrique Guzmán y Valle, Perú

Irma Aybar-Bellido (iD), **Maritza Arones** (iD)
Facultad de Ciencias de la Educación y Humanidades,
Universidad Nacional San Luis Gonzaga, Perú

Florcita Aldana-Trejo (iD)
Facultad de Ciencias Administrativas,
Universidad Nacional del Callao, Perú

Abstract. The growing incorporation of artificial intelligence (AI) tools in higher education (HE) has led to the use of indicators that allow the real impact of these tools to be identified in the teaching and learning process. In this sense, this study developed a bibliometric review on the acceptance of AI technologies in HE, providing an analysis of indicators on scientific production, with the aim of identifying prevalent thematic areas and knowledge gaps. From a methodological point of view, this study was carried out using a quantitative approach with a descriptive

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* Corresponding author: Carlos Hernán Flores-Velásquez, *chfloresv73@gmail.com*

level, utilising 56 publications drawn from the Scopus database. The results show a sustained evolution with a growing trend in scientific production since 2021. The most predominant thematic area is evaluation of the acceptance of AI technologies in HE, making greater use of the Technology Acceptance Model (TAM) and the Unified Acceptance and Use of Technology theory (UTAUT). Therefore, it was concluded that the existing literature shows a sustained interest in investigating the acceptance of AI technologies due to the importance of determining the impact generated by their applications in different contexts or scenarios of the reality of HE in regard to the extent that AI technology is developed. This is because, on some occasions, its application does not necessarily lead to meeting the expectations raised in the teaching and learning processes. Finally, the gaps that need to be addressed in future research are "cultural and contextual diversity in AI acceptance", "emerging models of AI acceptance", and "critical elements influencing the acceptance of AI technologies", in HE.

1. Introduction
In recent years, it has become evident how AI is contributing to generating various successful applications in different areas of society, including higher education (Chávez, 2021; Vera, 2023); the rapid advance of AI is generating a series of significant implications, aimed at improving teaching-learning processes (González-Sánchez et al., 2023; Parra-Sánchez, 2022). Along these lines, education has been suddenly forced to move towards a new educational model, which represents a challenge for all those who comprise the educational system (Pintado et al., 2023). This new educational model gained great importance in 2020, since the teaching-learning process underwent a radical and mandatory change in the face of the pandemic caused by the SARS-CoV-2 virus (Albuja & Guadalupe, 2022; Zamora & Mendoza, 2023); which, added to the technological advances of AI, has given rise to new forms of teaching and learning that go beyond the physical limits of the classroom (Cano et al., 2023; Valverde, 2021). AI allows for virtual educational scenarios that adjust to the specific learning process of each student (Gómez, 2022), providing the ability to address some of the greatest challenges in education, that is, to develop innovative teaching and learning practices, and to accelerate the progress of inclusive, equitable and quality education (García, 2021; Lara et al., 2023).

As such, the commitment of universities in this context is to adapt educational models based on social and industrial requirements in accordance with Industry 4.0 (Valencia-Arias et al., 2023; Vázquez et al., 2022). However, it is important to highlight that the implementation of AI in education requires careful planning and adequate training for both teachers and students (Moreira et al., 2023). Thus, many international organisations have been focusing in recent years on the relevance of digitally literate educational agents so that they can introduce technologies in the classrooms (Ayuso-del Puerto & Gutiérrez-Esteban, 2022). Therefore, it is relevant that the actors in the teaching-learning process successfully adapt to the technologies; this leads to using an evaluation model

that verifies the acceptance or rejection of the technology used (Muñoz & Espinoza, 2022).

Indeed, when facing a new technology, there are different factors that influence acceptance (López et al., 2021). Due to the different evaluation models and the various instruments to evaluate, unification is necessary in the criteria related to the use of data collection instruments around this topic (Pino, 2022). One of these models is the TAM model, which attempts to predict people's behaviour through variables such as intention and attitude towards the use of technology (Morales-Sierra et al., 2021; Mora-Cruz et al., 2023; Ramos & Ortiz, 2022). The acceptance generated by the technological implementation makes it possible to interpret satisfaction based on both the usefulness and the perceived ease of use (Pimbo-Tibán et al., 2023). Perceived usefulness is defined as the degree to which a person believes that the use of the specific technology tool would improve their performance (Chaljub et al., 2022; Jiménez-Martínez, 2021). Perceived ease of use, on the other hand, refers to the degree to which a person believes that the use of the technological tool will be effortless (Pimentel & Ibarra, 2022; Şimşek & Ateş, 2022). The TAM model posits that, if a user finds the technology easy to use, then the technology is perceived as useful (Villalba-Condori et al., 2021). Thus, the TAM model has seen variations and updates of variables; however, countless investigations have used this model, which attest to its validity (Roig-Vila et al., 2022).

Returning to the context of the use of AI, just at the time when universities were in full recovery of face-to-face academic activities, a technological innovation emerged that would mark a before and after, which is called generative AI (Gallent-Torres et al., 2023). Generative AI is a branch of AI that refers to the generation of text, images, video or sound, from data that already exist and that are generated in response to commands or prompts (Sánchez & Carbajal, 2023). Generative AI seeks to understand the distribution of data characteristics by each class with the purpose of artificially generating similar data (Chávez et al., 2023). Until now, the term creativity was applicable only to human reasoning; however, for more than a year, generative AI tools have made it possible to generate creative images from user input and others, like ChatGPT, answer philosophical and existential questions (Linares et al., 2023). ChatGPT is based on an advanced large language model (LLM) called Generative Pre-trained Transformer (GPT) (García-Peñalvo et al., 2024). Despite its short life, ChatGPT has quickly gained notoriety around the world due to its accessibility and versatility, with evidence of increasingly frequent use in the educational field (Ossa & Willatt, 2023). However, one of the main limitations of ChatGPT is the lack of ability to understand the full context of a conversation, which can lead to inaccurate or incomplete responses (Marín, 2023).

In this sense, the purpose of this study was to explore thematic gaps in relation to the acceptance of AI technologies used in the teaching and learning process in higher education. For this reason, for the development of this article, the methodology of a bibliometric review study is followed, taking as a data source the existing studies in the Scopus database, published between 2019 and 2023,

with the purpose of addressing current studies regarding the use of AI technology in the field of university education. The study describes bibliometric indicators in quantitative form, with the purpose of discovering the trend and evolution in the publication of studies on the topic under analysis, as well as identifying the journals, authors and countries that have been making significant contributions to the field so as to ultimately specify which thematic areas are the most prevalent on the topic under study. This will contribute to other researchers having a base knowledge for the development of upcoming studies, such as systematic review or meta-analysis, based on the fact that so much research has already been developed or addressed in relation to this thematic area. As such, the research questions (RQs) which contribute to the conduct of this study are specified below.

• RQ1: What has been the trend and evolution in the publication of studies on the acceptance of artificial intelligence technologies used in teaching and learning, in higher education?

• RQ2: Which journals, authors and countries have contributed significantly to the literature on the acceptance of artificial intelligence technologies used in teaching and learning, in higher education?

• RQ3: What are the most prevalent thematic areas regarding the study of the acceptance of artificial intelligence technologies used in teaching and learning in higher education?

2. Method of extraction of scientific publications

The publication extraction method used to develop this bibliometric review study has been validated in the study carried out by Chamorro-Atalaya et al. (2023), in which three stages were used to achieve the appropriate selection of publications that would later be included in the bibliometric analysis. This method contributed to following a procedure that leads to reducing the possible bias present in the identification, selection and inclusion of publications or studies regarding the acceptance of artificial intelligence technologies used in teaching and learning, in higher education.

2.1 Stage 1: Determination of the topic under study, scope and identification of publications

In this first stage, the research topic was determined, which is focused on identifying the most prevalent thematic areas in scientific production regarding the acceptance of artificial intelligence technologies used in teaching and learning, in higher education. Therefore, it was important to establish the temporal scope of published studies that were part of the analysis of their bibliometric indicators. Considering that, the studies to be analysed must be current and involve current research because the study focuses on applications in artificial intelligence; therefore, publications published between the years 2019 to 2023 were considered. In addition, these studies can be scientific articles, conference papers, or book chapters. Table 1 shows the main descriptors that were considered for the development of the search equation in the Scopus database. At this stage, 97 scientific publications were identified.

Table 1. Search equation and inclusion and exclusion criteria

Main descriptors	Search equation
• Technology acceptance • Adoption of technology • Artificial intelligence • Higher education • University	(TITLE-ABS-KEY ("technology acceptance" OR "user acceptance" OR "TAM" OR "adoption of technology") AND TITLE-ABS-KEY ("artificial intelligence") AND TITLE-ABS-KEY ("higher education" OR "university" OR "e-learning" OR "online learning"))

2.2 Stage 2: Projected publications

This second stage consisted of carrying out the process of screening or filtering the scientific publications obtained in the first stage, thereby selecting publications that focus on the topic of study, guaranteeing quality and relevance for the bibliometric review. This process consisted of applying certain inclusion and exclusion criteria. Within the inclusion criteria, it was specified that the published studies must be focused on applications of artificial intelligence in higher education institutions, and they must also be open access. Regarding the exclusion criteria, it was taken into account not to consider scientific publications such as theses or letters to the editor, as well as those studies with restricted access. As a result of the application of the inclusion and exclusion criteria, 76 scientific publications were selected at this stage.

2.3 Stage 3: Publications included in the bibliometric analysis

In this third stage, a more detailed review was carried out; this time focused on the coherence of the topic under study with the titles, summaries and conclusions of the publications selected in the second stage. Through the process, 20 publications were removed, leaving 56 scientific publications included for bibliometric analysis. Figure 1 shows the method used to extract scientific publications, in which each of the three stages described is distinguished by colour.
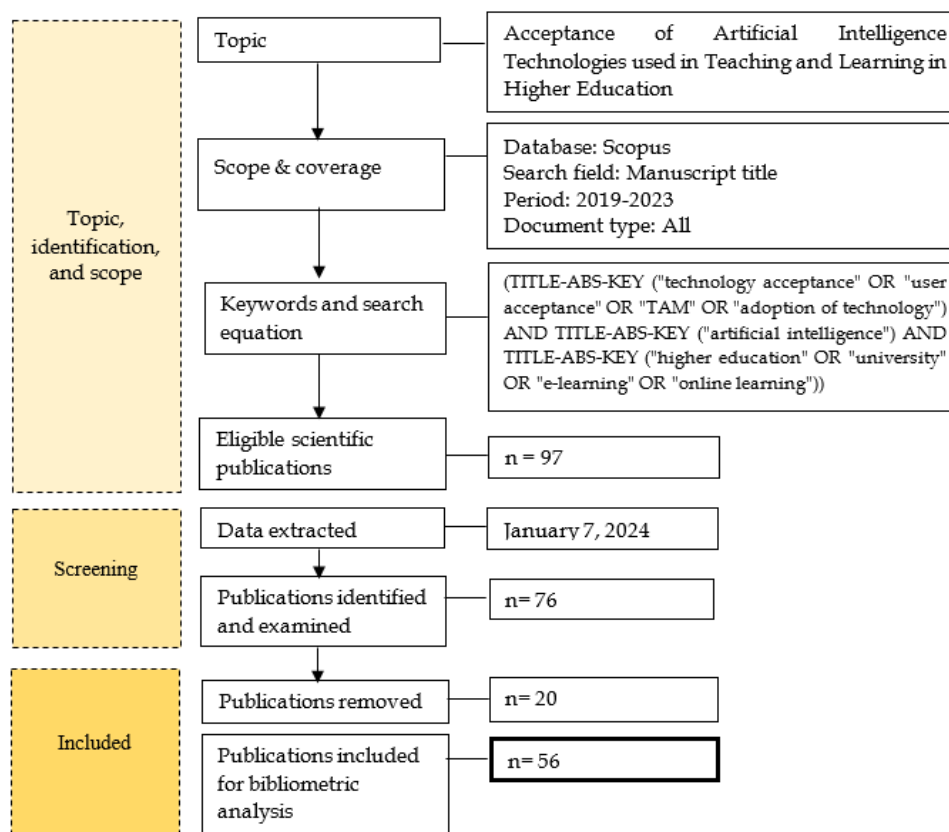
Figure 1. Method used to extract scientific publications

3. Results and discussion

It should be noted that, in this review study, the bibliometric data extracted from the scientific publications finally included for the analysis stage were processed through the VOSviewer and Bibliometrix applications; this was in order to obtain results that are in accordance with the objective of the study. The results obtained based on each research question are described below.

3.1 What has been the trend and evolution in the publication of studies on the acceptance of artificial intelligence technologies used in teaching and learning in higher education?

In relation to the trend and evolution in the publication of studies on the acceptance of AI technologies used in teaching and learning, in higher education it was identified that, between the years 2019 to 2023, there was an upward trend in the number of studies published. The evolution showed a variation in the number of studies over the five years, with 2023 having the highest number of publications, this being equal to 25, followed by 2021 in which 13 studies were published. That is to say, of the 56 publications under analysis, there was a concentration of manuscripts expressed in a percentage equal to 87.5% between the years 2021 to 2023, so the trend was definitely significant. Figure 2 shows the trend and evolution of published studies, the equation best describing the behaviour of scientific production being a second-order polynomial model whose coefficient of determination R^2 is 0.8573, which represents that the model explained 85.73% of the observed variability. However, this polynomial

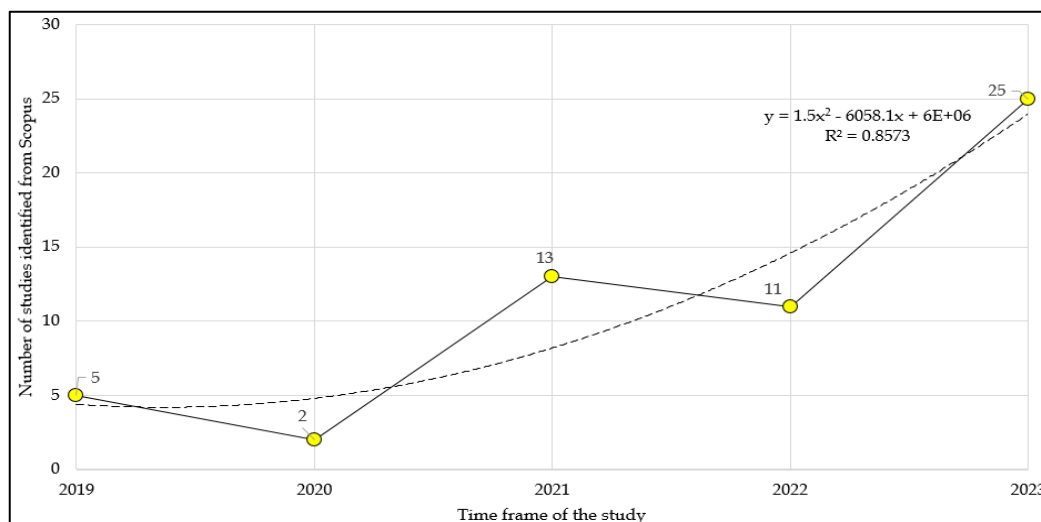equation presented a positive direction of 1.5, which indicated general growth in the analysed period.

Figure 2. Trend and evolution of studies published between 2019 and 2023

The average number of citations of the studies analysed by year of publication was also analysed, wherein it was possible to identify that for the acceptance of AI technologies used in teaching and learning, in higher education, the year with the greatest number of citations was 2021 with 226 citations, followed by 2022 with 105 citations. Furthermore, when analysing the average of citations by published studies, it was identified that the highest average occurred in 2021 with 17.38 citations. Likewise, when analysing the average of citations for the years that the study was published, it was identified that in 2020 and 2021 the highest averages were reached, these being 7.75 and 5.79, respectively. Table 2 shows all the results obtained regarding the average number of citations, by study and by year of publication.

Table 2. Average citations, by study and by year of publication

Year	Average citations per study	Average citations per years of publication	Number of citations per year
2019	8.4	1.68	42
2020	31	7.75	62
2021	17.38	5.79	226
2022	9.55	4.78	105
2023	0.76	0.76	19

From the results shown, the increase in scientific production in these last two or three years is evident, coinciding with the year of the emergence of generative artificial intelligence and its various applications in higher education. This sustained interest in researching the acceptance of AI technologies reflects the importance, recognition and relevance that today's academic and scientific community afford to the use of these technologies and how they are being accepted and adopted in the teaching-learning process. In this regard, in their bibliometric review study on different disruptive technologies used in education Saltos et al. (2023) affirm that the topic of disruptive technologies in education

has been the subject of great interest in the scientific literature in recent years, identifying a growing trend from the studies analysed towards the use of technological tools such as artificial intelligence. Along the same lines, Maphosa and Maphosa (2023), in their review study on the use of AI in higher education, point out that the trend in the publication of studies between 2012 and 2017 remained below ten publications per year. However, between 2019 and 2021, growing interest was reflected, which emphasises attention to the use and acceptance of AI in teaching and learning processes. Likewise, Talan (2021), in his review study on the acceptance of AI technology, points out that, between the years 2003 to 2014, there was very little scientific production; however, between the years 2019 to 2021 a growing trend is shown; this is possibly linked to the interest in the various applications that are being generated in the field of higher education and particularly in the area of science, in which it is principal to discuss the satisfaction and acceptance of the various AI technologies. According to what has been indicated, these studies manage to analyse scientific production taking the year 2021 as the maximum limit, and, although they point out that, in those years, there was already a growing trend in studies on the topic under analysis, it is in the years up to 2021 that a very significant and relevant increase in scientific production is seen to have been generated.

3.2 RQ2: Which journals, authors and countries contribute significantly to the literature on the acceptance of artificial intelligence technologies used in teaching and learning, in higher education?

In relation to the journals that have been contributing significantly to the literature on the acceptance of AI technologies used in teaching and learning in higher education, it was identified that the journals with the greatest number of publications published in the study period are "Computers and Education: Artificial Intelligence", "Education and Information Technologies" and "IEEE Access", all with three publications on the topic under study. Furthermore, the impact H-index of these three scientific journals are 17, 61 and 204, respectively; all located in the Q1 quartile according to SCImago Journal Rank (SJR). Taking these findings into account, it can be stated that the number of publications from these three journals considered significant is low. However, their high impact suggests considering them as relevant vehicles for the dissemination of future research in this field of study. Table 2 shows the journals with the highest number of publications.

Table 2. Bibliographic sources with the highest number of publications

Scientific journal	h-index	Quartile (SJR)	Number of publications extracted
Computers and Education: Artificial Intelligence	17	Q1	3
Education and Information Technologies	61	Q1	3
IEEE Access	204	Q1	3
ACM International Conference Proceeding Series	137	Not yet assigned quartile	2
Frontiers in Psychology	157	Q2	2

Lecture Notes in Computer Science	446	Q3	2
Procedia Computer Science	109	Not yet assigned quartile	2

Likewise, when carrying out an analysis regarding the scientific studies with the highest number of citations, it was identified that the works developed by Damerji and Salimi (2021), Dekker et al. (2020), Nazari et al. (2021) present 58, 49 and 47 citations, respectively, these being the publications with the highest number of citations. The number of citations mentioned suggests that the topic of acceptance of AI technologies used in teaching and learning in higher education has been attracting attention and is being the subject of analysis and research. This assessment shows that, by having a relatively considerable number of citations, even though these studies were published in 2021, they reflect their contribution to the construction of the state of the art on this topic of study. Table 3 shows the authors with the highest number of citations.

Table 3. Authors with the highest number of citations in the field of study

Author	Total Citations
Damerji and Salimi (2021)	58
Dekker et al. (2020)	49
Nazari et al. (2021)	47
Al Shamsi et al. (2022)	37
Kashive et al. (2021)	31
Wang et al. (2021)	28
Malik et al. (2021)	25
Harmon et al. (2021)	24
Cruz-Benito et al. (2019)	24
Wu et al. (2022)	19
Kim and Shim (2022)	18
Roy et al. (2022)	14
Rico-Bautista et al. (2020)	13
Sánchez-Prieto et al. (2019)	10

In addition, of the 56 studies analysed, the countries that have contributed the most to the study on the acceptance of AI technologies in teaching and learning in higher education were identified as China, India, the USA, Germany, Saudi Arabia, Australia, the Philippines and the United Arab Emirates. China is the country that leads this list with 57.14% of the total publications, followed by India with 33.93% of publications and the USA with 21.43% of the total publications. These results suggest a global diversity in the study of this topic, with a significant concentration in Asia. Figure 3 shows the number of studies published by country of origin.
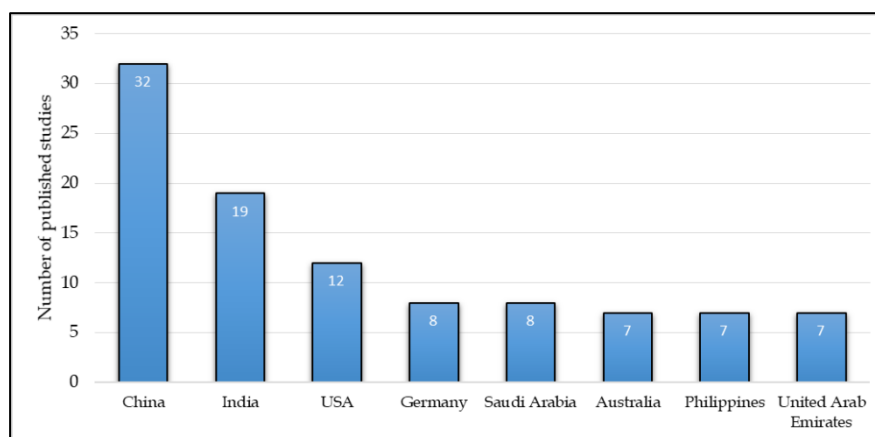
Figure 3. Number of studies published per country

Taking into account the results obtained, in their bibliometric research on the applications of AI in university education, Bicen et al. (2023) point out that the journal with the greatest contribution in this field of study is "Education and Information Technologies". This supports the results obtained in this study since we identified this scientific journal as one of the three journals with the greatest contribution to the field of study. Likewise, in relation to the country with the greatest contribution to the field of study of AI in higher education, Hinojo-Lucena et al.'s (2019) bibliometric review study reveals that the country with the greatest contribution is the USA. Although it partly coincides with the result obtained in this study by identifying that countries such as China, India and the USA are the ones that contribute the most, it is necessary to point out that the timeframe of the cited study covered the years 2007 to 2017; therefore, it is understandable not to coincide precisely with the country that makes the greatest contribution. In this regard, Metli's (2023) research on bibliometric analysis on AI in education determined that the two countries with the greatest contribution to the topic of study are China and the USA. It should be noted that this study takes the years from 1980 to 2022 as its period; therefore, it supports the result obtained in this study.

3.3 What are the most prevalent thematic areas in the study of the acceptance of artificial intelligence technologies used in teaching and learning in higher education?

In relation to the most prevalent thematic areas on the study of the acceptance of artificial intelligence technologies used in teaching and learning, in higher education, in a preliminary analysis of the 56 manuscripts selected for this bibliometric review study, it was identified that the most prevalent bigrams in the titles of scientific publications are: "Artificial Intelligence", "Technology Acceptance", "Acceptance Model", "Perceived Ease", "Perceived Usefulness", "Model TAM", "Technology Adoption", and "University Students". However, the bigrams that show a greater prevalence, and in a sustained manner, in the study period are the Artificial Intelligence, Technology Acceptance and Acceptance Model bigrams. These bigrams suggest sustained attention to models of acceptance of AI technologies, providing insight into the evaluation and adoption of these technologies in the realm of higher education. Table 4

shows in detail the prevalence of the most significant bigrams of the scientific studies reviewed.

Table 4. Bigram prevalence

Bigrams	Prevalence per year				
	2019	2020	2021	2022	2023
Artificial Intelligence	6	8	24	36	57
Technology Acceptance	3	4	10	18	44
Acceptance Model	2	2	6	13	30
Perceived Ease	0	0	8	10	23
Perceived Usefulness	0	0	6	8	21
TAM Model	0	0	3	8	16
Technology Adoption	1	2	9	10	13
University Students	3	4	7	9	14

Next, the co-occurrence network of keywords in the summaries of the scientific publications under analysis was obtained through the VOSviewer application, obtaining that the keyword "Artificial Intelligence" stands out as the most recurrent term with 35 occurrences and a total link strength of 84, indicating its centrality and prominence in the field of study. This is followed by terms such as "Education computing" and "Students", both with strong co-occurrences, suggesting an important intersection between educational computing and the student experience in the context of AI. Likewise, the presence of keywords such as "Technology Acceptance model", "learning systems" and "e-learning" highlights the specific attention to models and systems of acceptance of AI technologies in higher education environments. The co-occurrence of "ChatGPT" and "Chatbot" suggests an interest in the implementation of conversation systems in artificial intelligence
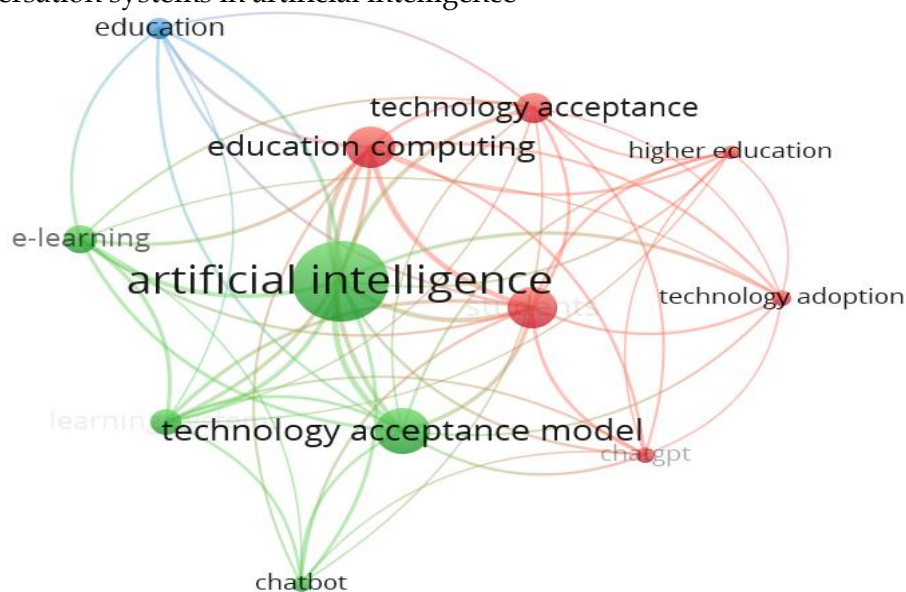

Figure 4. Keywords most frequently identified from the summaries

Another aspect that was analyzed was the co-occurrence in the manuscript summaries, in which, as a result, four groupings could be identified, in which a strong link between specific bigrams is evident. Among those that highlight the clusters with the greatest strength of linkage, these are Cluster 1: Technology Acceptance Model, Chatbot artificial intelligence, generative artificial intelligence, AI artificial intelligence and ICT communication technologies; and Group 2: Technology adoption model, TAM adoption model, AI-based artificial intelligence, PLS-SEM equation modeling and equation modeling approach.
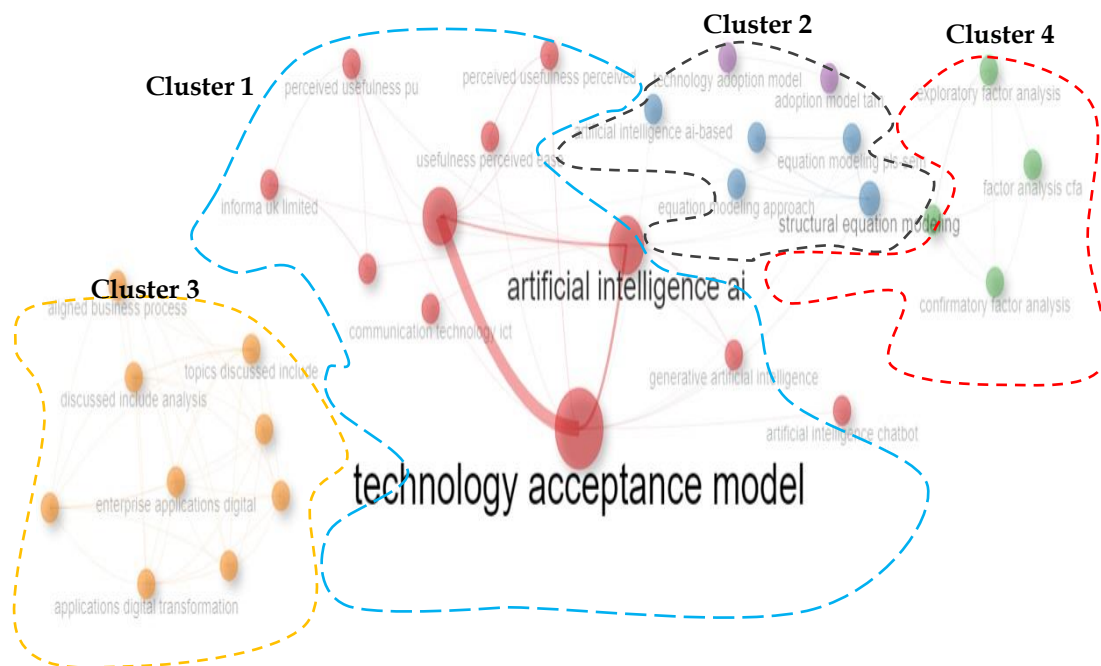

Figure 5. Network of co-occurrence in the abstracts, grouped by link strength

In this way, the most prevalent thematic areas identified are "Evaluation of the acceptance of AI technologies in higher education, making greater use of the TAM Model and UTAUT (Unified Theory of Acceptance and Use of Technology). The second topic area is "Acceptance of the use of Chatbots to address problems that improve student performance". Finally, the third thematic area is the "Acceptance of services and evaluations driven by AI in higher education"; I understand services such as evaluation of academic performance, student assistance and support, customer service system and teaching evaluation. In this regard, Akhmadieva et al. (2023) point out in their bibliometric review study on AI in education that the results show considerable enthusiasm for the use of AI to boost student engagement, improve teaching approaches and raise learning achievements. Therefore, it is necessary to evaluate the degree of acceptance to identify if students are satisfied with the inclusion of technology and how they are being adopted in their traditional learning activities. Likewise, Chatterjee and Bhattacharjee (2020), in their study of AI adoption in university institutions, point out that the various applications of AI technologies in higher education have generated new perspectives for the teaching and learning process; therefore, it is relevant to investigate and explore its adoption from different approaches seeking to establish the factors that

determine its acceptance. Along the same lines, Zhai et al. (2021), in their review study on AI, established that the topics that are covered to the greatest extent are those that focus on online education, seeking to implement a tutoring platform, a tutoring system, and a virtual laboratory, all of them with the purpose of improving teaching and learning. Although many studies focus on the acceptance and adoption of AI at the student level, it is necessary to point out that there are also studies in which they are based on the acceptance of the use of the teacher, who ultimately are what formally determines the use in AI technologies in higher education. In this regard, Darayseh (2023) points out that the willingness of teachers to adopt AI technologies impacts their attitude towards the use of AI in teaching, in which the perceived usefulness factor guarantees that they use it to improve quality of learning.

4. Conclusions

From the bibliometric review study carried out regarding the acceptance of AI technologies used in the teaching and learning process in HE, it was determined that the evolution of scientific production shows a variation in the number of studies throughout the five years, with 2023 being the year in which it presents the greatest number of publications. That is to say, of the 56 publications under analysis, there is a concentration of manuscripts expressed in a percentage equal to 87.5% between the years 2021 to 2023. In other words, there is a growing and significant trend in scientific production. It was also determined that the journals that contribute significantly to the literature on the topic under study are "Computers and Education: Artificial Intelligence", "Education and Information Technologies" and "IEEE Access". While the works developed by Dekker et al. (2020), Damerji and Salimi (2021) and Nazari et al. (2021) are those that present the highest number of citations during the study period. Furthermore, the countries with the highest contributions are China, India, the USA, Germany, Australia, Saudi Arabia, the Philippines and the United Arab Emirates. China is the country that leads this list with 57.14% of the total publications reviewed, followed by India with 33.93% and the USA with 21.43%. In relation to the most prevalent thematic areas regarding the topic under study, it was determined that these are application and acceptance of AI technologies in higher education, making greater use of the TAM Model and UTAUT (Unified Theory of Acceptance and Use of Technology), acceptance of the use of chatbots to address problems that improve student performance and acceptance of AI-powered services and assessments in higher education, and I understand services such as academic performance assessment, student attendance and support, customer service system and teacher evaluation. Therefore, it is concluded that, in recent years, there has been a sustained interest in investigating the acceptance of AI technologies due to the importance and relevance of determining the impact generated by its application in different contexts, or scenarios of the reality in which it is developed in HE, since, on some occasions, its application does not necessarily lead to it meeting the expectations set in the teaching and learning processes. Finally, the gaps identified and that must be addressed in the future are "cultural and contextual diversity in the acceptance of AI", "emerging models of acceptance of AI" and "critical elements that influence the acceptance of AI technologies", in HE.

5. Limitations of the study

The limitations of this bibliometric review study are linked to the inclusion and exclusion criteria defined in this article. In this way, considering that only publications from the Scopus database were taken into account, due to its extensive coverage of publications regarding acceptance of the application of AI technologies, it is possible that scientific data in relevant studies published in other databases such as ERIC, Web of Science, or Science Direct have been omitted. As such, it is recommended that future research integrate other databases, which will allow increasing the number of studies so as to have a broader analysis of the prevalent thematic areas and gaps in the field of study.

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