


GENERATIVE ARTIFICIAL INTELLIGENCE: EDUCATIONAL REFLECTIONS FROM AN ANALYSIS OF SCIENTIFIC PRODUCTION

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Abstract

Generative Artificial Intelligence (AI-Gen) in education is a challenge for educational administrations due to the benefits and risks of its use. This research seeks to analyse the scientific production of AI-Gen in the educational field. The method used was a bibliometric analysis of descriptive and quantitative documents from the Web of Science database. The VOSviewer statistical programme was used to identify the keyword clusters and to create the network map. The results of this study ascertain that 2023 is the birth of AI-Gen research in education and has since produced a total of 178 papers, where Australia heads the ranking of countries with studies on this subject matter. The ChatGPT phenomenon materialises as a focus of study in the majority of cited research. The study includes seven keyword clusters, where the IA-Gen cluster which is related to terms such as challenges, risks and opportunities are highlighted. Following the discussion, the main conclusion of the study denotes that further research is required on the use of AI-Gen during the teaching-learning process in several educational stages to prevent plagiarism and to obtain a comprehensive understanding of this technology as an educational resource.

Keywords – Generative artificial intelligence, Education, Innovation, Ethics, Risks.

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1. Introduction

The introduction of Artificial Intelligence (AI) in society and work has changed the way people interact in both developed and developing countries (UNESCO, 2022). Due to the rise of Big-Data and the exponential growth of computing power (Haenlein & Kaplan, 2019), innovation in AI-driven services such as OpenAI's ChatGPT, Google's Gemini or Microsoft's Copilot (Akter, Hossain, Sajib, Sultana, Rahman, Vrontis et al., 2023) have become the single most important factor of business success in the Fourth Industrial Revolution we are immersed in (Li, Zhang, Niu, Chen & Zhou, 2023; Yang & Kim, 2023). AI is a general and broad term that refers to a set of methods, capabilities, and limitations, many of which are often not always clearly stated by researchers, educators, technology companies, or other AI developers (Gillani, Eynon, Chiabaut & Finkel, 2023). Although artificial intelligence (AI) has a numerous definitions, focus is given herein to the definition given by Rouhiainen (2018) which states that AI is "the

ability of machines to use algorithms, learn from data, and use what they learn in decision making just as a human would” (Rouhiainen, 2018: page 17).

Digital media and social networks have a massive presence in today’s society to which children have access to, and this has a significant impact on students and their intellectual, cognitive, ethical and social development (Meng, Li, Malik & Umer, 2022). For this reason, AI is a subject which generates ignorance and concern in the educational field, both among teachers and students, and it is necessary to study with scientific evidence the path and use that AI has and where we are heading.

1.1. Generative Artificial Intelligence in Education

Unlike AI which is tasked with automating repetitive tasks (Isusqui, Villavicencio, Inga, Gutiérrez, Díaz & Amaya, 2023), Generative Artificial Intelligence (AI-Gen) refers to AI systems that generate new datasets such as text, images, audio, video, music or software code (Fengchun & Wayne, 2023) with the objective of producing innovative and creative results based on training data (Mannuru, Shahriar, Teel, Wang, Lund, Tijani et al., 2023). These systems have garnered significant attention in society (Lee, Han, Lee, Lee, Kim, Kim et al., 2023) and have the potential to bring about the greatest evolution in education (Quy, Thanh, Chehri, Linh & Tuan, 2023). Such tools do not have any conceptual knowledge or conscious understanding, as these only use word transitions and are based on mathematical probabilities of data and word classification (Cress & Kimmerle, 2023).

AI-Gen permeates our daily routines, our professional lives and is transforming several sectors, including education (Dignum, Penagos, Pigmans & Vosloo, 2021). The emergence of these technological tools that are here to stay, reason why education cannot remain on the sidelines therefore, it is critical to understand the advantages, disadvantages, possibilities and challenges posed by their use by both students and teachers (García, 2023; González-Alonso, 2023) as it is a tool set to reshape educational practices and assumptions (Cain, 2023). AI and automation are extolled as some of the technologies that will change the future of digital learning and work (Chaka, 2023). The emergence of AI-Gen has raised concerns as regards plagiarism detection, but likewise presents opportunities for educators to exploit the opportunity of AI-Gen to build conducive learning environments (Eager & Brunton, 2023).

The emergence of ChatGPT in 2022 rocked the core of education systems and all teachers, academics and those people involved in one way or another in education (Fengchun & Wayne, 2023; Prendes-Espinosa, 2023) and likewise represents an extremely controversial issue in the academic community (Fayed, Mansur, de Carvalho, Behrens & de Cesar-Netto, 2023). Tools such as these have received a great deal of attention from researchers, policy makers, the media and the educational community, that is, teachers and students. Many people willingly and frequently use ChatGPT for text production (Cress & Kimmerle, 2023) by simply typing a prompt, that is, a phrase or question that is meant to elicit a response from the machine. It is important to consider the structure, format and type of information included in the prompt to attain optimal results (Morales-Chan, 2023). Sometimes, it is necessary to modify the questions to obtain the desired and appropriate responses, according to the training model of the tool (Figure 1).

AI-Gen in education is a potentially significant tool for transforming teaching and learning methods (Montenegro-Rueda, Fernández-Cerero, Fernández-Batanero & López-Meneses, 2023). AI-Gen should not replace the process of learning, but rather should supplement the teaching process through STEAM projects which contemplate learning that combines curricular content and digital competence (Dúo-Terrón, Moreno-Guerrero, López-Belmonte & Marín-Marín, 2023). In this regard, this resource should be integrated into the classroom in a way that empowers students to imagine how to shape the unknown future in an innovative and responsible manner (Fischer & Dobbins, 2023). Students should not be inclined to rely on AI but rather learn about the subject (Darvishi, Khosravi, Sadiq, Gašević & Siemens, 2024). The way forward is to establish a hybrid model where humans exercise critical thinking, creativity, collaboration, leadership, etc., while AI provides support in a teaching and assessment environment (Cordon-García, 2023).

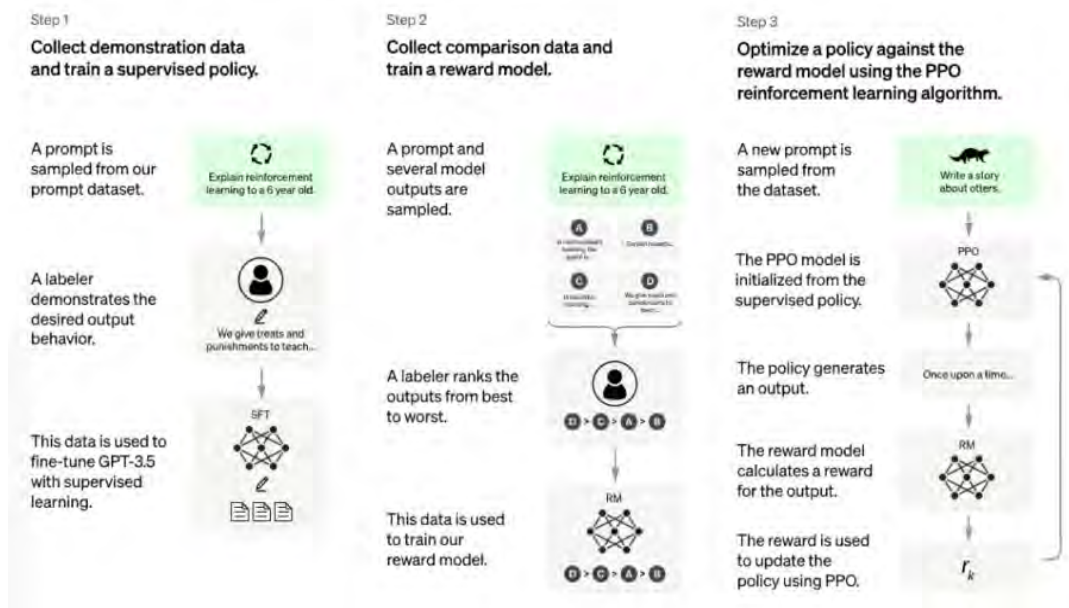


Figure 1. ChatGPT Training. <https://openai.com/blog/chatgpt>

Educational methodology must incorporate innovative and useful digital tools that AI itself offers (Evans, 2023). Machine Learning (ML) has increasingly become an important subject in computer science for students to learn (Zhu, 2019) and develop computational thinking through the basic foundations of AI. The introduction of cross-curricular projects with ML in schools can be a fundamental step forward to educate conscious and critical citizens (Rodríguez-García, Moreno-León, Román-González & Robles, 2020b). That is, teaching about AI with the objective of training students in the fundamentals of AI-Gen from a programmer's perspective with programmes such as Teachable Machine, LearningML or Machine Learning for Kids. Furthermore, given its significant influence on our digital society and reliance on technologies from an early age (Rodríguez-García, Moreno-León, Román-González & Robles, 2020a) teaching and learning computer science-based disciplines is an optimal strategy to assist teachers and students in acquiring the basic principles of programming, robotics and AI in a transversal manner.

1.2. Benefits, Ethics and Risks

The driving force of digitalisation, the influence of algorithms and the advent of AI-Gen have undeniable strengths, nevertheless there are weaknesses which require to be addressed (Cress & Kimmerle, 2023). Accordingly, it faces new educational challenges and challenges (Sanchez-Vera, 2023) because the younger generation is exposed to AI-Gen from an early age and their education is of utmost importance (Liu & Kromer, 2020). AI-Gen will face challenges in the future of education that educational administrations must address such as analytics in the teaching-learning process, data protection, ethics and cyber security (Camacho, Minelli & Balanya, 2022).

Today, AI-Gen is a disruptive technology (Lopezosa & Codina, 2023) that is present in countless applications and in many everyday and professional fields, especially in education with minors. For this reason, institutions need to adapt both to the changes in their processes and to the modification in curricula caused by AI (Almaraz-López, Almaraz-Menéndez & López-Esteban, 2023). AI-Gen is a support for humans (Franganillo, 2022), if it is well understood, reducing the effort and time required for task creation.

The use of AI-Gen entails risks and biases and it is necessary to understand the challenges and implications for education (Morduchowicz, 2023). Several AI-Gen based tools have emerged recently, including OpenAI's ChatGPT or DALL-E, Google Gemini, Microsoft's Copilot, Midjourney or Stable Diffusion. This technology generates controversy in the educational community and concerns as regards

its potential to be used for plagiarism and undermine students' ability to think independently (Ellis & Slade, 2023). The example of ChatGPT or DALL-E, which can generate realistic text or images based on user prompts, pose ethical challenges to academic integrity, authorship and publication (Nam & Bai, 2023). For this reason, the Spanish Presidency of the Council of the European Union (2023) is working on these ethical guidelines to ensure that AI systems marketed in the EU are safe and uphold fundamental rights. In education, it derives from the use of personal data in AI applications used in the teaching-learning process (European Commission, 2022).

2. Justification and Objectives

Society in 2022 is marked by the emergence of AI, nevertheless the impact of the creation of text, image or video models by teachers and students for various purposes will be remembered in the educational field. The inclusion of these tools in education is a challenge for professionals and researchers as it produces changes and transformations in the teaching-learning methodology or assessment methods. At the same time, the use of these AI-Gen-based mechanisms entails both benefits and risks.

The impact of AI-Gen-driven educational technology in education is underexplored (Darvishi et al., 2024). For this reason, this research analyses the scientific production on AI-Gen in the educational field with the purpose of identifying the trends of the papers (Ariza & Quevedo-Blasco, 2012). In this fashion, it lays down the foundations of the evolution thus far and guides researchers and educational administrations on future lines of research. Accordingly, this study has two objectives, which are as follows:

- To ascertain the evolution of scientific production on IA-Gen, languages, countries, affiliations, citations, authors and types of the most important documents.
- To identify the most relevant keyword clusters in the scientific literature on IA-Gen in education.

3. Method

3.1. Research Design

The design of this study is based on a descriptive and quantitative bibliometric research method (Moreno, 2019) from the Web of Science (WoS) database. Firstly, an analytical method has been used to analyse and quantify the data obtained, which has a relevant role in the field of research (Martínez, Cobo, Herrera & Herrera, 2014) in order to classify and identify the scientific production and evolution of the AI-Gen in education. It likewise enables the undertaking of search, registration and prediction actions in the scientific literature (Hirsch, 2005).

Network maps have been created using the VOSviewer software (Van Eck & Waltman, 2010). This programme has enabled generating bibliometric networks (Flis & Van Eck, 2018) of all keywords from scientific papers related to IA-Gen in education, analysing and extracting a co-occurrence report from all of these, that is, there by identifying the lexical units and clusters of the extracted papers. In this fashion, it is possible to predict issues that could be considered in the educational field for future lines of research (Ramos, Jiménez, del Castillo, Acosta, Muñoz & Herrera, 2020).

3.2. Procedure and Data Analysis

The study has followed a meticulous protocol divided into various stages in order to minimise bias and data analysis during the study (Parra-González, Segura-Robles, Vicente-Bújez & López-Belmonte, 2020). On 1 January 2024, articles containing IA-Gen are searched separately in the WoS database. The following terms in English, with and without hyphens 'Generative artificial intelligence' or 'Generative AI' are entered into the search bar from all fields. The main WoS database and all collections (BIOSIS Citation Index, BIOSIS Previews, Current Contents, Connect, Derwent Innovations Index, KCI-Korean Journal Database, MEDLINE, Preprint Citation Index, ProQuest and Scielo) are selected as it includes a repository with a significant number of high impact scientific productions.

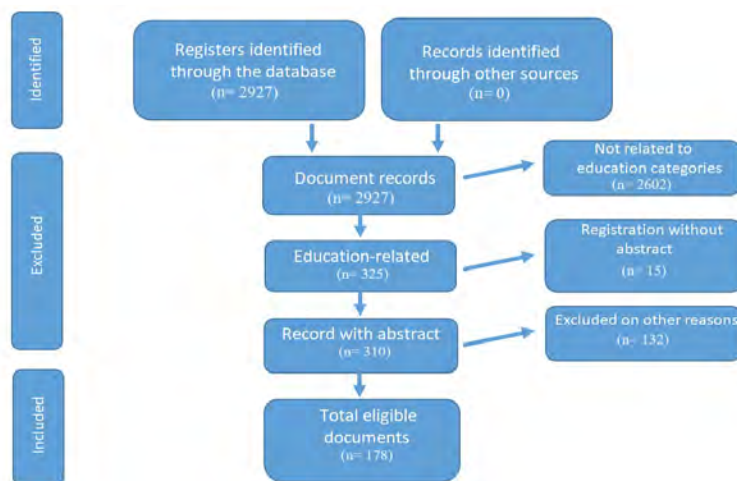


Figure 2. PRISMA Protocol

Before proceeding to the analysis and extraction of results, a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol was applied (Figure 2), which is one of the most appropriate tools for selecting and filtering the quality of the publications (Rodríguez, Moreno & López, 2020; Sánchez-Serrano, Pedraza-Navarro & Donoso-González, 2022) with different inclusion and exclusion criteria in the variables that show the results obtained (Martínez et al., 2014).

The first results ascertained were 2,927 papers from 220 distinct WoS categories. Subsequently, documents whose categories were related to education (n=325) such as Education Educational Research and Education Scientific Disciplines were included. Next, the plain text file was downloaded from the WoS and articles without abstracts were identified for exclusion (n=15). Finally, the abstracts were reviewed to exclude those papers not related to the field of education (n=132) for various reasons such as biochemistry, tourism, nursing, molecular biology, dentistry, psychiatry, anatomy, architecture, industry, business, etc. No records of duplicate documents were identified. In total, articles related to education were included in the study (n=178).

In order to extract the results corresponding to Objective 1, the search for IA-Gen terms is limited to the periods between 1 January 1998, the date on which Google first appears (Romero, San Román & Oceja, 2018), and 31 December 2023. Subsequently, other inclusion criteria have likewise been established to ascertain the performance of scientific production related to years of publication, bibliographic citations, research areas, types of documents, categories, publishers, journals, authors, languages and countries (Table 1).

Indicators	Total entries	Inclusion criteria
Year of publication	n= 178	1998-2023
Languages	n= 2	All
Countries	n= 51	$x \geq 12$ publications
Affiliations	n= 268	$x \geq 5$ publications
Citations	n= 178	Top three most cited documents
Authors	n= 460	$x \geq 3$ publications
Type of documents	n= 6	All

Table 1. Production indicators and inclusion criteria

For Objective 2, the keyword network map in Vosviewer, the following procedure is carried out. First, the ‘creation of a bibliographic network map’ option and its reading of data from the WoS in ‘.txt’ file format was selected. Next, the type of co-occurrence analysis was selected, using a unit of analysis consisting of all keywords and a total count method. In this step, an Excel document called Thesaurus is introduced,

which is used to group similar keywords for various reasons such as synonyms, similar words written in singular and plural or a set of compound words written with and without hyphens. In this fashion, a more meaningful and thorough keyword network and keyword clusters are extracted. Finally, from the total number of keywords ($n=575$), a minimum number of co-occurrence ($x>2$) and total link strength ($x\geq 6$) is filtered out and a total of 36 keywords are selected for the study.

4. Results

4.1. Results in Relation to the First Objective of the Study

It is noteworthy that the entire scientific production of the AI-Gen in the field of education in 2023 stands at 178 papers. Therefore, 100% of this analysis is undertaken during 2023. Only two languages are used in the publications, English being by far the most commonly used language with 174 papers (97.75%) and Spanish with 4 papers (2.25%).

Among the most influential countries with IA-Gen contributions in education, the USA ($x=45$) stands out, followed by Australia ($x=26$), China ($x=22$) and England ($x=12$). These 4 countries account for 57% of the total scientific production, the rest being distributed among 47 countries. Figure 3 shows the production percentages of these countries.

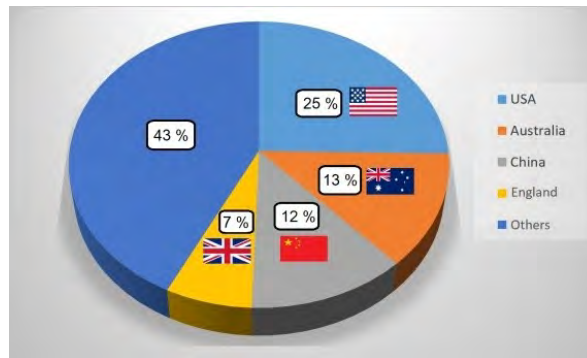


Figure 3. Countries with most productions

Furthermore, the universities and affiliations which have undertaken the highest volume of research on AI-Gen in education belong to Deakin University (Australia) with 6 papers (3.37%). This is followed by 4 universities with 4 publications representing 2.08% each. These are; Monash University of Melbourne, the State University System of Florida, the University of Hong Kong and the University of Tasmania. Despite the fact that all papers are published in 2023, certain articles have a considerable number of citations considering their brief publication timeframe. In Table 2, the three most cited papers are highlighted.

Title	Authors	Year	Citation
Chatting and Cheating: Ensuring academic integrity in the era of ChatGPT	Cotton, Cotton & Shipway	2023	89
What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education	Tlili, Shehata, Adarkwah, Bozkurt, Hickey, Huang et al.	2023	83
What is the impact of ChatGPT on Education? A rapid review of the Literature	Lo	2023	72

Table 2. Most cited papers

A total of 460 authors are included in the results among the 178 papers analysed, all corresponding to 2023. Crawford, J. stands out with 4 articles, that is, 2.25%. This is followed by 6 researchers with 3 papers

each (Chan, C.K.Y.; Cowling, M., Denny, P., Henriksen, D., Leinonen, J. and Mishra, P), each representing 1.685% of the total scientific production.

The types of documents most commonly used by researchers are articles (n=139), which represent 78.09%. This is followed by Early Access (n=61), Review Article (n=20), Editorial material (n=12), Proceeding paper (n=6) and Correction (n=1).

4.2. Results in Relation to the Second Objective of the Study

The results show that AI-Gen in education specifies 7 distinct clusters in Table 3. Of the 36 items representing the five keywords with the highest level of co-occurrence are ChatGPT, AI, higher education, AI-Gen and large language models (LLM).

Clusters	Keywords	Co-occurrence	Total Link strength
1	ChatGPT	105	318
1	Academic integrity	16	57
1	Automated written assessment	12	37
1	Students	11	54
1	Plagiarism	7	19
1	Knowledge	4	10
1	Ethics	2	7
1	Human-machine collaboration	2	10
2	Large Language Models (LLM)	26	127
2	OpenAI	7	32
2	Machine Learning	4	24
2	Computer Programmer	2	20
2	Computer Science Education	2	8
2	Copilot	2	20
2	Deep learning	2	20
3	Digital learning	5	34
3	Teaching	4	23
3	Competence	3	19
3	Automation	2	6
3	Awareness	2	14
3	4th Industrial Revolution	2	6
4	Artificial Intelligence	94	280
4	Higher Education	34	129
4	Chatbots	17	65
4	Innovation in education	5	27
4	Critical thinking	4	12
4	Human-computer interaction	2	7
5	Generative AI	33	124
5	Challenges	3	12
5	Risks	3	17
5	Opportunities	2	12
6	Education	20	73
6	Prompt	5	12
7	Education technology	6	27
7	Trends	2	9

Table 3. Keyword clusters

The results with the various keyword cluster relationships and their correlation strength are represented in the following network map (Figure 4).

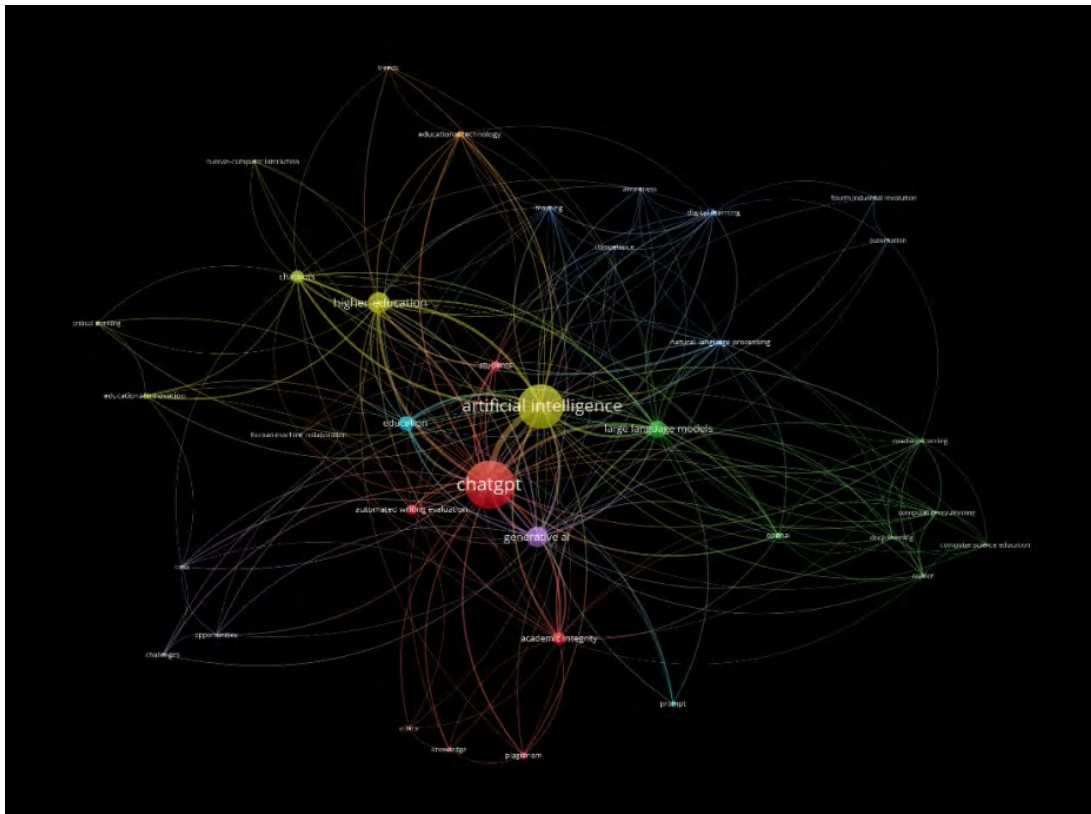


Figure 4. Keyword network map

5. Discussion

If 2022 is remembered as the year of the emergence of AI-based digital tools in society with a behaviour and evolution difficult to predict, garnering the attention of social networks, traditional and digital media according to García (2023), and Prendes-Espinosa (2023), 2023 is remembered as the starting point of the production of papers on AI-Gen prompting educational innovations and with the first publications in the scientific field in the fourth industrial revolution as pointed out by the studies of Li et al. (2023) and Yang and Kim (2023), where US and Australian universities head this research. This fourth digital stage is associated in the study results with terms such as digital learning, teaching, competences, automation and awareness because the use of digital technologies and devices are transforming our reality.

This technology in education has become an innovative and promising tool that can enhance the learning experience and foster greater interaction between students and teachers according to the results of this study and the research of Montenegro-Rueda et al. (2023) where the term ‘human-machine collaboration’ is included in several clusters. In education there is a need to ensure and uphold academic integrity, prevent plagiarism and maintain the ethics of text work production as noted by Ellis and Slade (2023). This ethics is considered in academia as a policy concern related to ethical writing in basic education, higher education, even in university research itself with the limitations and integrity of authorship as noted in Nam and Bai’s study (2023).

Among the studies with the highest citation rate of AI-Gen in education, the term ChatGPT stands out (Cotton et al., 2023; Lo, 2023; Tlili et al., 2023). A technology that, due to its growing popularity and accessibility, requires a significant transformation in pedagogical methods. In this regard, the cluster and network map results of this study demonstrate that the term ChatGPT is related to in the educational scientific literature with academic integrity, automated writing assessment, students, plagiarism, knowledge,

ethics and human-machine collaboration. Therefore, when considering who is the author of a text, image, video or music created with AI-Gen, is it the user or the machine?

In this regard, the author agrees with Nacipucha, Benites, Montaña and Corrales (2023) on the teaching role in the educational context and the use of AI-Gen is crucial to improve educational practice and foster new teaching methodologies, beyond requesting the delivery of texts that may be plagiarised, texts learned by heart, or the creation of deepfake videos using AI or voice cloning as specified in the study by Franganillo (2022). On the one hand, teaching the risks that these behaviours pose for humans through education in values and criticism. And on the other, it is essential to consider replacing conventional assessment activities and methods that require automation with those tasks that are competency-based and creative, such as the creation of infographics, the relationship of the content with its context or the use of portfolios to comprehensively record the entire learning process.

Focusing on the results of this study where the term education is associated with prompts, the authors agree with Evans' study (2023) that the majority of people do not understand the process by which AI-Gen derives its conclusions and even believe that AI has a mind of its own (sentient). Added to this is the worrying fact that teachers themselves, with little or no knowledge or understanding of what goes on in the AI black box, allow themselves to make educational recommendations on the use of prompts as if these were magic formulas in AI-Gen-based programmes, without using critical thinking and verifying the machine's responses.

These concerns can be addressed from initial educational stages and by attending to the cluster of this research related to the term IA-Gen with terms such as risks, opportunities and challenges. These concepts and knowledge can be learned from a programmer's perspective with educational ML software based on the creation of educational projects from the Primary Education stage. Through data trained with software such as LearningML by the students themselves, students can perceive through cross-curricular projects why a machine has predictions which are erroneous for humans, that is, biases. This method of learning AI-Gen follows the line of research of Rodríguez-García et al., (2020b) and is consistent with the results of this study, where the term ML is associated with specific terms in order to understand AI-Gen such as computer science, programmer or large language models (LLM).

These AI challenges are synonymous with assuming a responsible role on the part of educational institutions and centres to effectively meet the educational demands of a constantly evolving and increasingly digitised society in line with Camacho et al. (2022). Notwithstanding the fact that knowledge as regards AI is generally subject to the computer-technological field due to the complexity of its systems, in the educational field teachers and students must have basic knowledge as regards its operation to know how AI-Gen-based programmes respond, becoming producers and consumers of AI-Gen with a critical and responsible attitude.

6. Conclusions

The conclusions of this study are that 2023 is considered as the starting point of research on AI-Gen in education with the first 178 papers where Australia, China and England head the ranking of studies as regards this subject matter. Within AI-Gen in education, the ChatGPT phenomenon materialises as a focus of study in the most cited research. In the study, 7 keyword clusters are identified, highlighting the term IA-Gen, which is the subject matter of this study and is related to terms such as challenges, risks and opportunities. Furthermore, ChatGPT has included related terms such as academic integration, students, plagiarism or ethics, among others. Finally, the term education is related to prompts. Unquestionably, we are facing a scenario of uncertainty that is difficult to manage due to the exponential growth of AI, where anyone with a device connected to the Internet can use AI-Gen. Therefore, if these tools are available to children and adults in society, schools through an innovative methodology should be the first link to educate and teach with and in relation to AI-Gen in a critical and creative manner.

Following the results of this study, we have a comprehensive research of AI-Gen in education that represents the creation of an educational technological tool. This fact represents the basis for future lines of research by universities, administrations and educational policies in order to optimise the benefits and reduce the risks of the use of AI-Gen under responsible ethics by all the people who make up the educational community.

As a limitation of the study, only the WoS database was used; therefore, this study could be more concrete and consistent if other databases were incorporated. Finally, as a result of the discussion and conclusions of this study, as future lines of research it is necessary to conduct research on the use of AI-Gen in the teaching-learning processes in various educational stages, curriculum areas and evaluation methods used by teachers when using these tools to prevent plagiarism in order to obtain a comprehensive understanding of this technology.

Conflict of Interest Declaration

The author declare that they have no potential conflict of interest with respect to the research, authorship and/or publication of this article.

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