10th International Conference on Higher Education Advances (HEAd'24)
Universitat Politècnica de València, València, 2024
DOI: https://doi.org/10.4995/HEAd24.2024.17276

The use of ChatGPT in Chemistry: the bibliometric analysis

Custódia Fonseca
Campus de Gambelas, Department of Chemistry and Pharmacy, Faculty of Sciences and Technology, University of Algarve, Faro, Portugal

How to cite: Fonseca, C. 2024. The use of ChatGPT in Chemistry: the bibliometric analysis. In: 10th International Conference on Higher Education Advances (HEAd'24). Valencia, 18-21 June 2024. https://doi.org/10.4995/HEAd24.2024.17276

Abstract

ChatGPT (Chat Generative Pre-Trained Transforme) is a recent technology developed by OpenAI that interacts in a conversational way to user prompts. This tool was released in November 2022 and was immediately seen by someone's as a threat to integrity regarding student assessment, and by others as an ally in teaching/learning and research. This article aims to provide an overview about ChatGPT and Education through a bibliometric analysis from 2023 to January 2024. An analysis and review of ChatGPT and chemistry education is also carried out. The results show that the USA has more authors with publications on the topic and Medicine / Health is the major area. When it comes to Chemistry Education, the 12 publications on the topic consider Chat GPT a tool to be used, but the answers given in ChatGPT must be verified as there is a high percentage of errors and inaccuracies.

Keywords: *Artificial intelligence; Education; Bibliometrics; Computer-based Learning; Chemistry Education.*

1. Introduction

In recent years there has been a great development of digital technologies (such as virtual reality and augmented reality) and artificial intelligence, which have been incorporated in different contexts in teaching/learning process in different areas of knowledge. ChatGPT (Chat Generative Pre-Trained Transformer) is an online artificial intelligence (AI) chatbot developed by OpenAI, launched in November 2022 (*ChatGPT*, n.d.). In other words, in simple terms, it is a language that generates answers to questions asked by users in a natural, humanlike way. ChatGPT can be used by students to obtain answers to questions specific to their work, to write an essay or a report about laboratory or non-laboratory work, perform mathematical calculations and tables and even write computer code. This generative artificial intelligence has created a buzz in academia concerning the potential negative impacts might cause to education. There are articles published in the media talking about the possibility of writing essays by ChatGPT,

however demonstrating/proofing that this has occurred is difficult to occur, as ChatGPT does not have any proof of the text generated by it. However, this cheating is not illegal. However, there are those who have another perspective on the subject and consider using ChatGPT as a learning companion and as a teacher and research assistant. Therefore, it remains unclear whether these technologies could be adopted to benefit teachers' teaching and student learning or could constitute a disadvantage or even a risk to their use. This study aims to map the global scientific publications related to the use of ChatGPT in education in general and in particular in chemistry education.

2. Materials and Method

2.1. Literature Search

The method used to develop this work includes the following major stages:

1- *Planning*: defining the major research questions

2- *Search*: defining the database sources of literature search, search strings employed in the search strategies, and inclusion and exclusion criteria, followed by the literature search and selection

3- *Literature analysis*: analysis of the include papers and interpretation of results.

The major research questions that this study addresses are the following:

A- Regarding education, which scientific areas have ChatGPT been used in?
B- What countries do the publications come from? Which Publisher is most active regarding the topic of ChatGPT and education?
C- Regarding the study of the use of ChatGPT in chemistry, what topics, activities, studies and implications are covered?

The scientific publications analyzed in this study were identified and collected in Web-of-Science (WoS) using the field tag Topic (TS), which searches in fields Title, Abstract and Keyword of the publication. The search strategy employed the use of terms “ChatGPT” AND Education, Chemistry Education. This search strings were used in combination and the retrieved articles were further extracted to Excel.

2.2. Study Selection

It was not necessary to apply restrictions regarding the year of publication since ChatGPT was only launched at the end of 2002, so the published articles are obviously in the time range from 2023 to January 30th, 2024. In addition, the exclusion criteria were: (1) non-English studies; (2) restricted to document type article, early access and review article (3) studies that were not

education or chemical education studies; and (4) studies with scopes outside the current review focus (or not related to chemistry topics) (Figure 1).

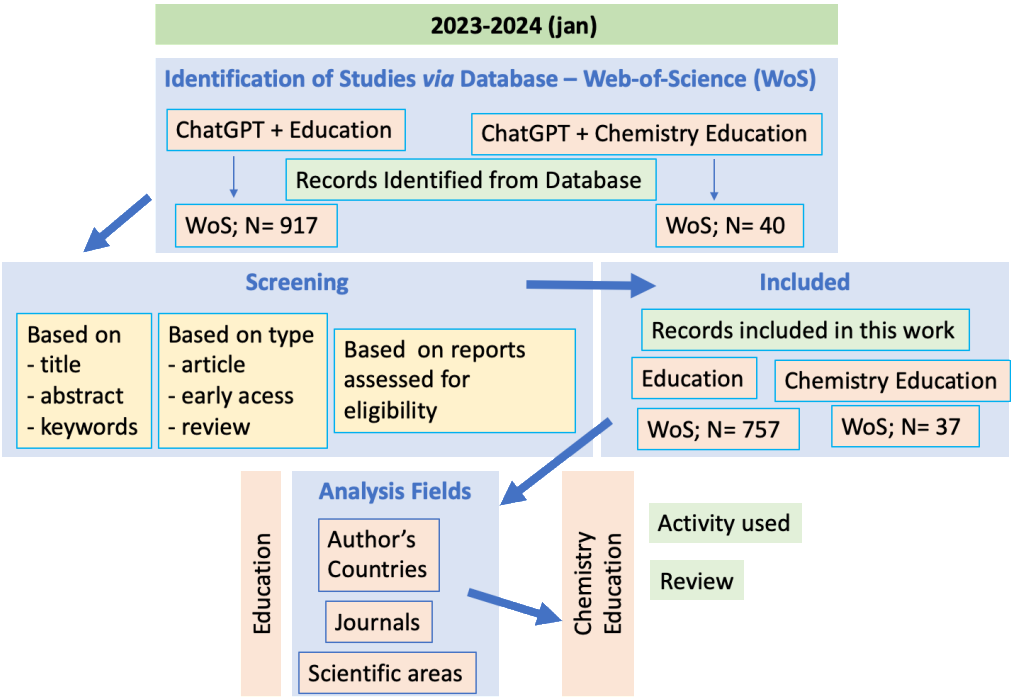

Figure 1. Method Flowchart

3. Results

The appearance of ChatGPT at the end of 2022 caused a great frenzy in the academic community, leading to 757 publications on this topic in 2023. The journals that published about ChatGPT and education are indexed in 132 areas of research. The data represented in Figure 2, the research areas represented are the only ones with fourteen or more articles. In represented area Medicine/health, are included publications from different specialties such as radiology, ophthalmology, etc., which is the major area with 39% of the publications represented. The following scientific area comprises two areas, the Education δ Educational Research plus Education Scientific Disciplines, and has 38% of publications. Multidisciplinary chemistry accounts for only 3.5%.

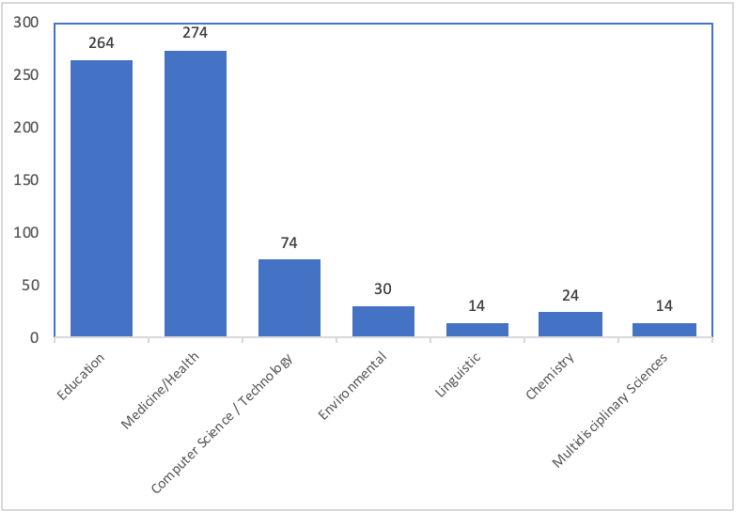

Figure 2. Research areas with fourteen or more articles about ChatGPT and Education

Both in Education and in Chemistry Education, the journals with the majority of publications about ChatGPT are in the area of education, in the first case Medical Education, Cureus Journal of Medical Science with 18,4% followed by JMIR Medical Education with 10,4% and in the second case, ChatGPT and Chemistry Education it is the Journal of Chemical Education the first with 63,6% (Figure 3).

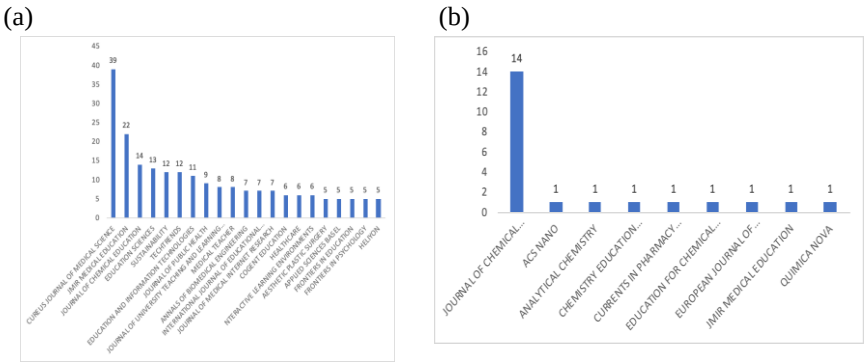

Figure 3. Journals with publications about ChatGPT and education (a) Journals with five or more articles in education in general; (b) Journals with one or more articles in chemistry education

Based on the authors' affiliation, the United States of America (USA) has the highest percentage of publications, 25.5% on this topic, followed by China (8.9%) and India (6,7%). In the case of Chemistry Education, the authors of the publications are mostly Americans (32.6%), as with publications on education in general, followed by those from the People's Republic of China (20.9%) and then Australians (14%) (Figure 4).

a) b)

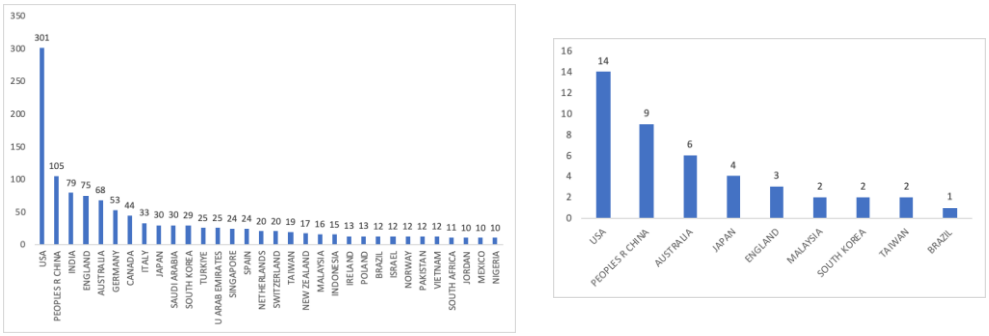

Figure 4. Author's countries with publications (a) about ChatGPT and Education with more than ten articles; (b) about ChatGPT and Chemistry Education with more then one article

4. Discussion

Since 2022, the year in which ChatGPT appeared, this artificial intelligence tool has aroused enormous curiosity in the scientific community, which led to an explosion in the number of articles in the following year. If initially the concerns were related to academic integrity and the way of evaluating students, the big question quickly became trying to find out what impact it had on teaching and learning, and how it could be used in the tasks of this process, whether by the student or the teacher, as well as in research.

The largest number of publications occurred in the area of Medicine/health and, of course, in Education with the area of computing/technology being further away. As education is one of the search keywords, it is natural that the major number of publications were obtained in this area. The same cannot be said with Medicine/Health. The high number of publications in this area is due to the nature of the knowledge and the characteristics of the tool; it's easy to ask questions and get an answer. The use of ChatGPT in area of computing/technology is due to the fact that ChatGPT appears to be very successful to help in programming by providing lines of code.

The two journals with the largest number of publications are Cureus Journal of Medical Science and JMIR Medical Education. The aims and scopes of these journals explain their position on this ranking, which respectively include teaching / learning medicine and health. The third and fourth journals are in the area of chemistry education. Both journals publish articles that are studies that seek to understand how the use of technology can increase knowledge. In addition to another area present is computing/technology, it is strongly linked.

It is notable that developed countries, with the exception of India, publish the most, with the USA and China leading the ranking. Geographically, in the first 10 places in the ranking there

are countries from 4 continents. This data is also directly related to the data with the universities that publish the most.

4.1. Case of Chemistry Education

The articles published on Education and ChatGPT of interest to this work are in their entirely published in the Journal of Chemical Education (JCE). This is a Journal of the American Chemical Society, USA.

Fourteen articles were identified in from 2023 to 2024 (January) in JCE, based on the title and keywords, but after reading the abstract, two articles were excluded as they did not fall within the scope of this work. Therefore, after full papers reading, it was possible to a group them according the authors' approach to the topic "ChatGPT and Chemistry Education": (1) author's opinion regarding the use of the possible advantages/potentialities and disadvantages/limitations of using ChatGPT in education and research in the area of chemistry (Alasadi & Baiz, 2023; Emenike & Emenike, 2023; Tyson, 2023); (2) The use of ChatGPT to carry out lab reports. For the authors ChatGPT gave a readable answer but with little analysis result. ChatGPT generates clear, error-free writing with generally correct information, especially within abstract and introduction sections. The student needs to understand the chemical principles for to formulate the correct question in order to get the appropriate answer, and also need to analyze the output of ChatGPT (Humphry & Fuller, 2023; West et al., 2023). (3) Comparative analysis of ChatGPT responses to exam and assignment questions. In general, the authors' opinion that ChatGPT responds better to questions that use "describe" and "discuss" than to questions that focus on the application of knowledge and interpretation with non-textual information (Clark, 2023; Fergus et al., 2023; Leon & Vidhani, 2023; Watts et al., 2023). Analyzing ChatGPT responses by students could be an exercise in developing critical thinking (Guo & Lee, 2023).

5. Conclusions

In conclusion, ChatGPT is a technological tool that aroused great curiosity in the area of education, which led to the publication of a large number of articles in different areas, namely Medicine/Health and Technology/Computing. American authors are those who have published the most on the topic, followed by Chinese and Indian authors. In Chemistry Education, ChatGPT is the American Journal of Chemical Education that has practically all publications. The authors point out ChatGPT as a tool that still needs to be improved, as the answers obtained are not correct, however it has potential.

References

Alasadi, E. A., & Baiz, C. R. (2023). Generative AI in Education and Research: Opportunities, Concerns, and Solutions. *Journal of Chemical Education*, *100*(8), 2965–2971. https://doi.org/10.1021/acs.jchemed.3c00323

ChatGPT. https://openai.com/chatgpt(Accessed February 2024)

Clark, T. M. (2023). Investigating the Use of an Artificial Intelligence Chatbot with General Chemistry Exam Questions. *Journal of Chemical Education*, *100*(5), 1905–1916. https://doi.org/10.1021/acs.jchemed.3c00027

Emenike, M. E., & Emenike, B. U. (2023). Was This Title Generated by ChatGPT? Considerations for Artificial Intelligence Text-Generation Software Programs for Chemists and Chemistry Educators. *Journal of Chemical Education*, *100*(4), 1413–1418. https://doi.org/10.1021/acs.jchemed.3c00063

Fergus, S., Botha, M., & Ostovar, M. (2023). Evaluating Academic Answers Generated Using ChatGPT. *Journal of Chemical Education*, *100*(4), 1672–1675. https://doi.org/10.1021/acs.jchemed.3c00087

Guo, Y., & Lee, D. (2023). Leveraging ChatGPT for Enhancing Critical Thinking Skills. *Journal of Chemical Education*, *100*(12), 4876–4883. https://doi.org/10.1021/acs.jchemed.3c00505

Humphry, T., & Fuller, A. L. (2023). Potential ChatGPT Use in Undergraduate Chemistry Laboratories. *Journal of Chemical Education*, *100*(4), 1434–1436. https://doi.org/10.1021/acs.jchemed.3c00006

Leon, A. J., & Vidhani, D. (2023). ChatGPT Needs a Chemistry Tutor Too. *Journal of Chemical Education*, *100*(10), 3859–3865. https://doi.org/10.1021/acs.jchemed.3c00288

Tyson, J. (2023). Shortcomings of ChatGPT. *Journal of Chemical Education*, *100*(8), 3098–3101. https://doi.org/10.1021/acs.jchemed.3c00361

Watts, F. M., Dood, A. J., Shultz, G. V., & Rodriguez, J.-M. G. (2023). Comparing Student and Generative Artificial Intelligence Chatbot Responses to Organic Chemistry Writing-to-Learn Assignments. *Journal of Chemical Education*, *100*(10), 3806–3817. https://doi.org/10.1021/acs.jchemed.3c00664

West, J. K., Franz, J. L., Hein, S. M., Leverentz-Culp, H. R., Mauser, J. F., Ruff, E. F., & Zemke, J. M. (2023). An Analysis of AI-Generated Laboratory Reports across the Chemistry Curriculum and Student Perceptions of ChatGPT. *Journal of Chemical Education*, *100*(11), 4351–4359. https://doi.org/10.1021/acs.jchemed.3c00581