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Evaluation of ChatGPT research in STEAM education

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ABSTRACT

Research focus of reviews trends and research on implementing ChatGPT in science, technology, engineering, arts, and math (STEAM) learning. It emphasizes the importance of deep learning and 21st-century skills in education, highlighting the limitations of ChatGPT in accuracy and credibility. The authors analyzed 204 STEAM education documents, revealing that 65% focused on technology education and less than 3% on art and mathematics education. The articles written in technology scope are the most widely circulated. The most productive region is the United States, which has three productive authors. The most productive authors are Ray (India) and Wang (Macao), who have the highest h-index. The United States and United Kingdom are the most productive affiliations. Many types of research on ChatGPT in STEAM education include a survey with several participants of different education levels. Social science is the most popular subject area. The Journal Nature is the primary source for this research. Several research highlighted artificial intelligence, ChatGPT, and human keywords. This study highlights the potential of ChatGPT in STEAM, suggesting further research on student behavior, learning designs, and credibility concerns. It suggests collaboration with Google Scholar or Web of Science data for in-depth analysis.

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1. INTRODUCTION

There are grand challenges facing today's society that call for quick action especially education. Grand challenges in education have been found to foster deep learning and students' 21st century skills. Learning integrated technology (tech-learning) can significantly improve the quality and meaning of learning experiences and learning outcomes [1], [2]. Tech-learning significantly impacts students' academic success and support long-term memory [3]. Interest education for artificial intelligence (AI) has recently advanced in various scope [4]. AI can help increase efficiency and reduce human error and speed up response times in critical situations. AI guides students through system and assess performance through integrated test [5]. AI is used to modify materials, clarify misunderstanding, and facilitate learning. There are many types of AI Chatbot technologies, such as Google Bard, Microsoft Bing, and ChatGPT.

ChatGPT use natural language processing [6]. It has been widely used in academia with models 3 and 3.5 released in 2022 and 2023 [7]. ChatGPT can help students to understand complex subject matter and increase learning effectiveness. ChatGPT is an alternative for teachers in facilitating students in learning activities [4]. However, the implementation of ChatGPT also has shortcomings, one of which is the accuracy and credibility of the information obtained. Overall, the implementation of ChatGPT offers opportunities to face real life challenges.

On another hand, science, technology, engineering, arts, and math (STEAM) learning is able to support 21st century skills learning [8]. STEAM learning creates contextual learning atmosphere that uses several thematic-integrative learning models [9]. In STEAM, these challenges encourage students to tackle diverse challenges and integrate ideas to create a final solution. Many research was elaborated AI with STEAM learning [10]. Tsai *et al*. [11] explores the use of LLMs or ChatGPT in chemical engineering education as their problem-solving tool. However, there are limited resources reported ChatGPT with STEAM learning. It emphasizes the need for science, technology, engineering, and mathematics (STEM) expertise to effectively utilize AI technology especially ChatGPT.

In addition, digital education tools -AI- can help educators quickly share knowledge and material in higher education. AI and STEAM education are two points essential in 21st-century learning. STEAM education has an enormous scope and is also related to ChatGPT, which can be applied in various scopes. ChatGPT can enhance education by creating personalized learning materials, revolutionizing exams, providing real-time feedback, and assisting educators in grading assignments [12]. It can also improve students' academic performance, teachers' lesson plans, language learning, test preparation, and online tutoring by analyzing students' learning preferences. It provides timely support, considering students' academic abilities and preferences [13]. AI also optimizes learning environments through learning analytics. It organizes curriculum sequences, designs instruction, and manages student big data. However, more research is needed to explore ChatGPT's potential in education fully. In addition, ChatGPT can assist engineering-STEAM education. ChatGPT is a tool that can generate code snippets based on user input, optimize code by analyzing language, algorithms, and data structures, and assist in debugging by providing recommendations for efficient coding errors. It also aids in code documentation by analyzing language, structure, and function requirements and in code review by analyzing data on programming language, coding standards, and best practices [14]. These tools can help developers improve code quality and reliability, ensuring efficient and effective development.

A bibliometric analysis is conducted to identify research trends, research gaps, and new findings related to ChatGPT in education [15]. Previous authors use bibliometrics study to identifies research topics, highlights new development, and suggest potential directions for future research [16], [17]. This analysis provides valid quality reviews and comprehensive data visualization [18]. This research reviews the trends and research of implementation ChatGPT in STEAM learning which focuses on each scope. In the last two years, students have used ChatGPT during their learning activities. Examining the advantages and disadvantages of implementing ChatGPT in the classroom is essential for educators looking to design new and more effective learning opportunities [19], [20]. This research can help researchers in future studies. The research analyzes the research activities and their AI-ChatGPT related education content.

i) What were the location, writers, and research techniques of ChatGPT in STEAM education research regarding research characteristics and features?
ii) In the context of STEAM education research, who were the participants and sample sizes of ChatGPT in terms of the interaction between them?
iii) What contributions did the leading STEAM fields make to STEAM education disciplines in terms of application?

2. METHOD

The metadata sourced from Scopus because it has the largest collection of academic literature [21]. There are 204 STEAM education documents. There were 65% of technology education documents and less than 3% documents in art and mathematics education. The authors input the keywords on title, abstract, and keywords as: “TITLE-ABS-KEY (chatgpt)”. Data were collected with the newest data documented in .csv and .ris format. The author selected the subject STEAM and education and then exported data on each STEAM education scope. At the selection stage, 44% of documents had a STEAM scope, followed by 38% of STEAM education documents. The detail selection of data process is shown in Figure 1. Vosviewer used .ris metadata to construct and view a visualization of the network [8], [22]–[24]. Data in .csv format and Microsoft Excel is used to categorize and plot the data.

3. RESULTS AND DISCUSSION

In this section, there are three important points of discussion, namely: i) Research characteristics and features, including discussion of research distribution based on year, region, affiliation, and author; ii) Interaction between participants and ChatGPT includes a discussion of the use of sample size and demographic information and methods used during research; and iii) Applications discusses the sources, subject area and contribution of ChatGPT to STEAM education based on keyword cluster analysis.

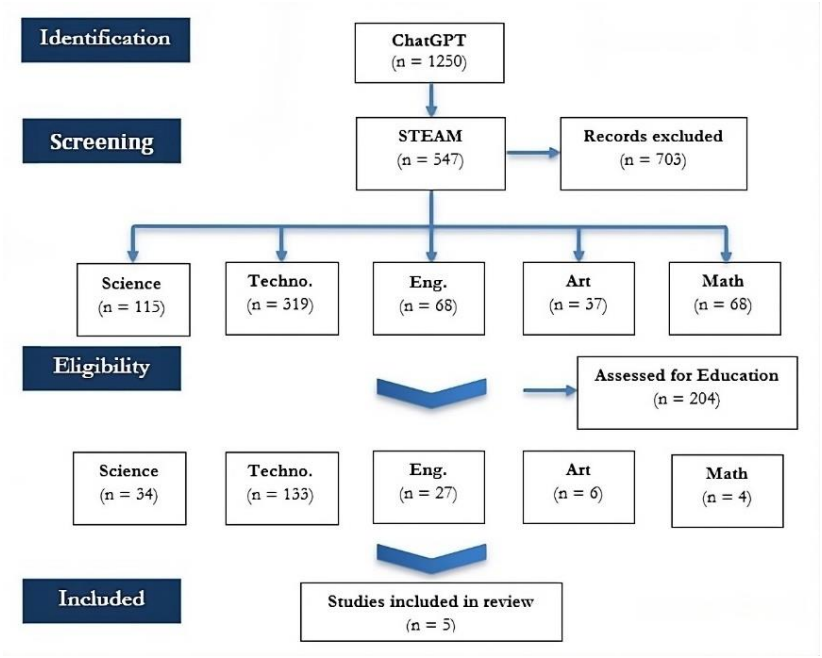


Figure 1. Cognitive process dimension

3.1. The year-wise distribution

The GPT models have been created by OpenAI in 2018 [14]. GPT models related to natural language processing. The first generation of GPT models is GPT-1, which is modest in size. GPT-1 can classification test, analyze sentiment, and do translation [25]. Next, GPT-2 has 1,5 billion parameters and released in 2019. GPT-2 can give better results, generalize new tasks, and produced more extended and more cohesive sequences than GPT-1 [26]. Figure 2 represents Chatbot -AI developments- over the last three years, but ChatGPT has been widely studied by international researchers from 2022 until now. The third generation was GPT-3 was launched in 2020 which produces excellent natural language writing and anticipates the word that will come next in a string of text [4]. GPT-3 is more adaptable for various natural language processing applications than previous models [27]. The last generation is ChatGPT. Compared to GPT-3, ChatGPT provides better contextual comprehension, logical-realistic discussion, response creation, and overall coherence and is intended for conversation-based applications [28]. ChatGPT is a text-based conversational model that improves the quality of interactions by understanding context and producing precise, grammatically correct, and coherent responses [29]. ChatGPT can fix several tasks, like summarizing and creating content. ChatGPT is multilingual and is used in various applications [30].

ChatGPT is an OpenAI product with one million users in five days. ChatGPT has been very popular since its release in November 2022 [31], [32]. Half of ChatGPT research was reported in technology scope with 133 documents. Science scope gets second place with 34 documents. Besides, mathematics and art needed to be explored with international authors because of limited publication in this subject. According to Figure 3, future research can focus on mathematics and art education that can be combined with the implementation of ChatGPT in education.

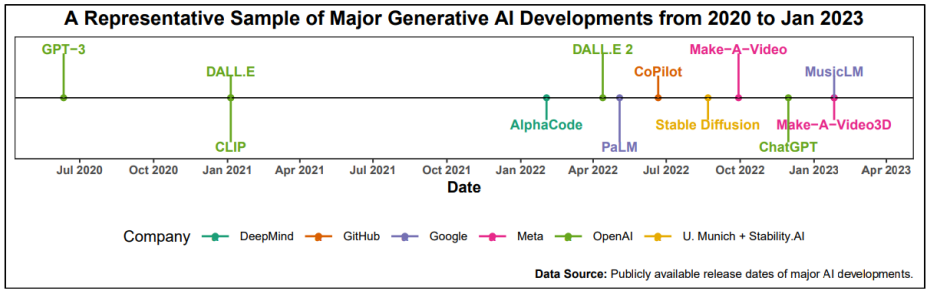


Figure 2. The development of AI during the last three years [16]

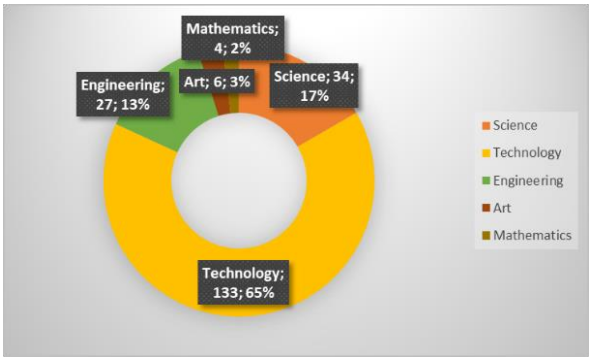


Figure 3. ChatGPT research in STEAM subject

3.2. Document types

According to Figure 4, half of the document type in ChatGPT research were article. Editorial has a small number of document types in each STEAM education scope. Figure 5 shows that international researchers publish more work on technology scope than others across all documents. The editorial does not report on ChatGPT in technology, engineering, and art. Almost all STEAM education documents are published in various sources, except math education documents, which are only published in journals, which is 2% documents, as shown in Figure 5(a). Most STEAM education research is published in journals where technology dominates. There are same percentage of art education research publication in conference proceedings and book, as shown in Figure 5(b) and 5(c). In addition, the comparison of publications in fields of science, engineering, and technology in trade journal reached 1:1:2; there was no research related to science and mathematics, as shown in Figure 5(d). Educational technology documents also dominate various types of sources.

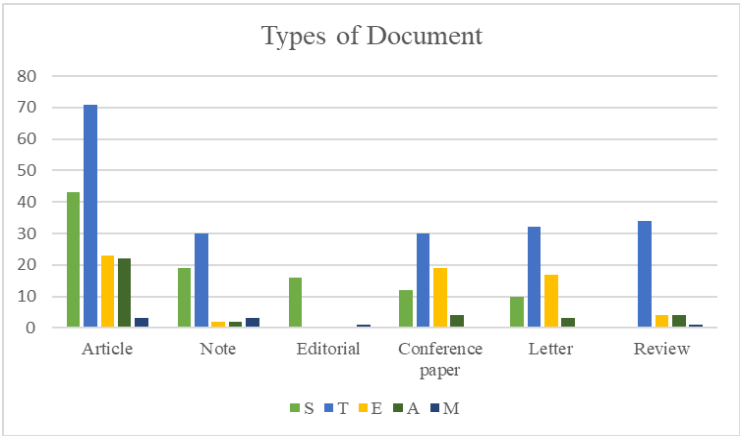
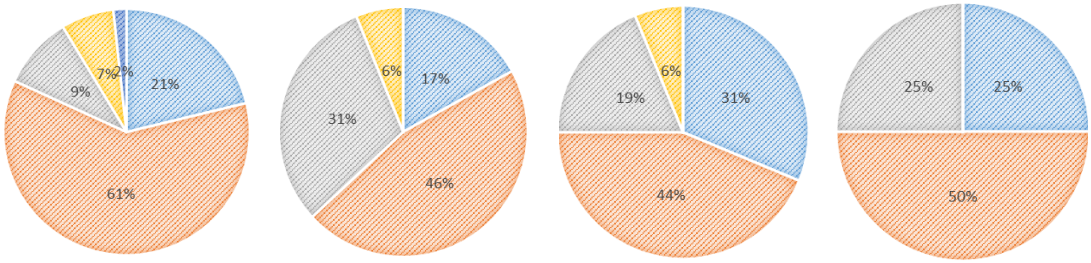


Figure 4. The types of documents



(a) (b) (c) (d)

Figure 5. The types of sources of (a) journal, (b) conference proceedings, (c) book, (d) trade journal (Note: light blue=science, orange=technology, grey=engineering, yellow=art, and dark blue=mathematics)

3.3. The productive author, affiliation, and country of ChatGPT in STEAM education research

The top authors in every STEAM education scope are listed in Table 1. India, China, and United States are all research-intensive countries with many publications. Top three authors from nine country were participated in ChatGPT STEAM education research. Ray from Sikkum University, India has seven publications in science and technology major. China has eleven documents and four productive authors in technology, engineering, and art major such as Agathokleous, Cheng, Gu, He, and Guo. Biswas, Lu, Wu, and Cahan are US-researchers who published their research on technology, engineering, and mathematics major. In addition, Agathokleous from China and Lee from South Korea have the highest percentage of ChatGPT-STEAM education research. Both play a role in science-STEAM education publications. Even though the art scope has few published documents, this scope has Wang with the highest H-index.

China and the US have three productive authors, making the US the country with the most publications, and China gets the second number. However, the difference in their publications is quite significant, up to four times. Figure 6 shows the top 5 countries with the most publications, but only Canada does not have top authors. India and the UK have also been colored light blue, indicating that STEAM education research is still little developed. Almost all non-colored regions, especially Europe, Russia, Asia, South America, and Africa, must explore ChatGPT STEAM education. The United States dominates all fields of STEAM education except mathematics, with the field of technology publishing as many as 112 documents. The field of science STEAM education has yet to be published in India, China, Australia, or other top countries. Publications in technology, engineering, mathematics, and art are also not published in Australia, Canada, and several countries. STEAM education math publications also publish in several countries with only 1 document each.

Table 1. The productive authors in ChatGPT-STEAM education research

Subject	Author	TD	%P	HI	Affiliation	Country
Science	Agathokleous, E.	2	33.33	35	NUIST	China
	Lee, J. Y.	2	33.33	2	Hanyang University	South Korea
	Ray, P.	2	1.67	25	Sikkim University	India
Technology	Pratim	5	4.17	25		
	Karakose, T.	3	6.38	14	Dumlupinar University	Turkey
	Klang, E.	3	1.60	30	Tel-Aviv University	Israel
Engineering	Cheng, K.	3	0.125	8	Zhengzhou University	China
	Lu, K.Y.	3	0.15	9	Duke University	United States
	Wu, H.	3	2.08	29		
Art	Guo, C.	2	13.33	5	Chinese Academy of Sciences	China
	Wang, F. Y.	2	0.34	126	MUST	Macao
	Anggarwal, N.	1	0.24	1	De. BR. Ambedkar National Institute of Technology	India
Mathematics	Al-Ali, R.	1	4.34	4	King Faisal University	Saudi Arabia
	Cahan, P.	1	1.40	31	John Hopkins University	United States
	Delardas, O.	1	14.28	4	Promotion of Engineering and Evaluation Research Society	United Kingdom

Note: TD=total docs; %P=percentage of ChatGPT-STEAM education research; HI=H-Index

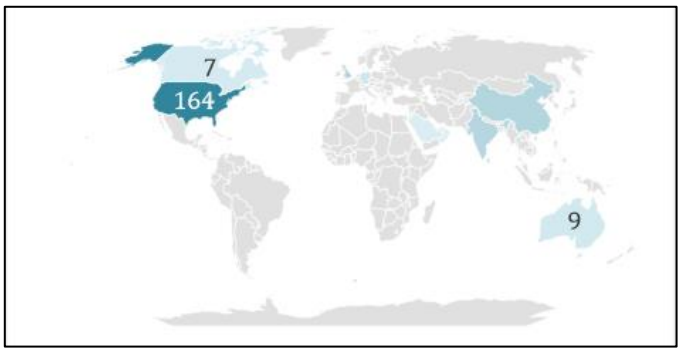


Figure 6. The distribution of Chat-GPT-STEAM education in the world

Table 2 explains that several countries are not included in the top ten affiliates in the ChatGPT STEAM education research. Apart from the University of Birmingham, Duke University, and Johns Hopkins University as top affiliates in ChatGPT research in technology scope, the US and UK have other affiliations: The University of Manchester and the University of Louisville for science scope and Promotion of Emerging

and Evaluation Research Society (UK) for mathematics scope. In science, four affiliates from Germany, the UK, the US, and Canada support ChatGPT STEAM education research; Engineering-STEAM education has 1 US affiliate and two from China. Meanwhile, research on art scope has affiliations from China and Germany; India, the UK, and the US for tech-STEAM education research, and the UK and Germany for math-STEAM education research.

Table 2. Top country and affiliation

Country	S	T	E	A	M	Top affiliation	TP
United States	20	112	22	10	-	Duke University, Johns Hopkins University	3
United Kingdom	12	27	-	4	-	University of Birmingham	4
Australia	9	23	6	3	-		
Canada	7	-	-	-	-	University of Toronto	2
Germany	7	-	4	-	1	Fau Erlangen	2
India	-	27	4	5	-	Sikkim University	5
China	-	26	8	5	-	Tianjin Medical University, Zhengzhou University	3
Hongkong	-	-	-	-	1		
Jordan	-	-	-	-	1		
Oman	-	-	-	-	1		
Saudi Arabia	-	-	-	-	1		

3.4. The research methods and participants in Chat-GPT-STEAM education research

Research regarding the implementation of ChatGPT in every field of STEAM education has similarities. Researchers often develop questionnaires to conduct surveys. Surveys were conducted to find out user responses and impact implementing ChatGPT in learning. Apart from surveys, researchers also combine them with interviews. The interview's main focus was on the participants' technological usage experiences. Participants were asked to provide details or remarks on the subject under discussion [33]. Another method is a literature review in which 53.5% of international literature reviews from 1990-2017 discussed AI [12]. Five methods were used in the research, all of which aim to investigate the quality, credibility, comfort, and ease of use of ChatGPT in education. Table 3 summarizes method and participant information from several studies.

Table 3. Research methods and participants

Category	Description	S	T	E	A	M
Research design/methodology	Survey	[34]	[35]	[36]	[37]	[7]
	Exploratory	[38]		[16]	[39]	
	Case study	[40]	[41]	[42]	[43]	
	Interview	[44]	[45]			[46]
	Literature Review	[47]				
Participants' demographics	University students	[44]	[48]	[36]		
	Students			[49]	[50]	[46]
	Society	[34]		[51]		
Sample size	<100	[44]	[52]	[31]	[53]	[46]
	100-500	[54]		[36]		
	>500			[55]		

There are several similarities in taking participants in research. Most surveys, interviews, and case study research involve participants from various levels of education and society. Most studies using interview methods involve less than 50 participants. Survey research has a larger sample size, more than 50 or even up to 1,200 people. Quotas were employed to attain a representation of critical demographic characteristics [56]. The participants' demographics varied, including teachers, academic staff, and librarians, from elementary to university students. In addition, Relmasira *et al*. [50] use constructivist, transformational learning theories, and constructionist to study the implementing of AI for students in elementary schools.

3.5. The sources publishing and subject area of ChatGPT in STEAM education research

Figure 7 shows the top five subject areas in ChatGPT-STEAM education research. Science-STEAM education covered five subjects predominantly in medicine, Technology and Math-STEAM education research were dominated by social sciences, Engineering in engineering scope, and Art in computer sciences. The three scopes in STEAM education do not include multidisciplinary research. Research in engineering and mathematics only covers the three top subject areas.

Apart from these five subject areas, the ChatGPT in STEAM learning research also discusses BMA in technology scope (24 docs), Mathematics and Physics in Engineering scope (12 docs), and arts and

humanities for art education (4 docs). All fields are related to each other, which allows for more than one subject in each document. The social sciences field in the ChatGPT in STEAM education research is related to education, e-learning, and information technology research. Computer science is also related to human interaction, AI, computer networks and communication, and software. AI can be combined with IoT to create AIoT, with ChatGPT being a promising AI technology. The subject of engineering is related to biomedical engineering; this is what makes the number of publications on the subject of medicine relatively high. The field of computer science and social sciences has many published documents. Table 4 provides information that most top sources have top subject areas.

According to Figures 4 and 5, international researchers publish their articles in journal form. There are 11 top sources consisting of 1 book, four proceeding papers, and six journals in Table 4. The top subject areas of these top sources are social sciences and computer science, both of which are included in the top subject areas, which are explained in Figure 7. The field of science-STEAM education is widely published in nature journals with the Nature Publishing Group in the UK. Many UK researchers published their ChatGPT research in this journal and made the UK the top country after the US. Researchers in technology-STEAM education publish through journals and conferences, including the journal Annals of Biomedical Engineering with publisher Springer in the Netherlands (18 docs). This journal also publishes 17 engineering-STEAM education research documents. The US, as the top country, also contributed to published conference documents in technology and art STEAM education. Canada has the publisher JMIR, which contains articles about technology and mathematics STEAM education.

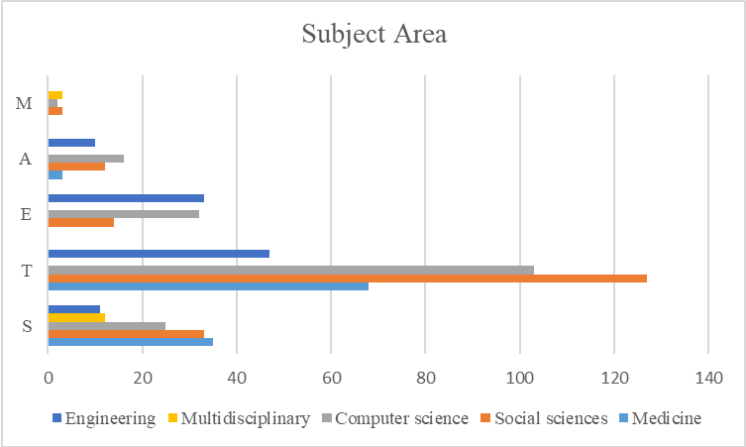


Figure 7. The subject area

Table 4. Top source

Name sources	Types	Top subject area	TP S	T	E	A	M
Nature	Journal	M	12	8			3
Annals of Biomedical Engineering		E	3	18	17	2	
Library Hi Tech News		CS			9		
JMIR Medic Edu		SC		7			1
Lecture Notes in Comp Scie	Book	CS	6				
CEUR Workshop Proceedings	Conference paper	CS		4		2	
Journal of Applied Learning and Teaching	Journal	SC		5			
ITiCSE	Conference paper	SC	4				
ACM Inter Conf. Proceeding Series		CS		2		1	
CHI Proceedings		CS		2			
Edu and information tech.	Journal	SC				2	

Note: CS=Computer science; SC=Social science; M=Multidisciplinary; E=Engineering

3.6. Top cited documents and visualization of co-occurrence keywords of ChatGPT in STEAM

Table 5 contains information on top citations of article about ChatGPT in each field in STEAM education. Even though research on ChatGPT in education is very new and is a hot topic being discussed by researchers, many articles have received more than 100 citations. Some of these document publications are survey research, interviews, or literature studies. All documents will also be published in the 1st to 2nd quarter of 2023.

Table 6 provides information about ten keywords often appearing in ChatGPT research in STEAM education. Four top keywords often appear, namely AI, ChatGPT, Chatbot, and human, and they are often used in STEAM education technology research. Some keywords are also used in the technology field. The keywords machine learning and humans are also often used in STEAM learning science research.

Table 5. Top highest cited ChatGPT in education

PY	TC	Recommendation	Ref.
2023	225	Further research should focus on identifying necessary skills, examining biases, determining optimal AI-human combinations, assessing text accuracy, and addressing ethical and legal issues.	[57]
2023	202	ChatGPT has potential for small group education particularly for problem-based learning. Its accurate dialogic responses support problem-solving and reflective practice. Researchers can use the most recent version of ChatGPT to obtain an accurate depiction.	[58]
2023	200	The rapid growth of literature on ChatGPT applications necessitates further studies and reviews. The review's single author screening and interpretation may limit interpretability.	[29]
2023	191	Large language models in education can enhance learning but must be evaluated for limitations, biases, and ethical requirements. Human monitoring and critical thinking are crucial, and further research is needed.	[59]
2023	122	Higher education must focus on academic integrity, digital literacy, writing skills, and critical thinking. This approach can enhance employability, generate new ideas, and solve real-world problems. This approach will help students, teachers, and institutions build trust and ensure a student-centric approach to AI tools. Students must balance their 21st-century skills before using AI language tools like ChatGPT. Then, they should practice using AI language tools to solve real-world problems.	[60]

Table 6. Top 10 keywords

Keywords	Total docs					Occurrences					Link strength				
	S	T	E	A	M	S	T	E	A	M	S	T	E	A	M
AI	66	164	23	12	5	19	71	10	3	3	41	276	19	45	5
ChatGPT	53	182	39	14	5	21	89	17		4	44	287	24		6
Human	31	63	30	12			27					184			
Machine learning	20				4	.									
Language model			22	5		0									
Humans	16					12					41				
Biomedical engineering			15												
Chatbots		61	13				13					68			
Natural language processing					3		11			3		67			5
Math-Computing					3										

Numerous studies claim that ChatGPT has beneficial and harmful uses in the academic. The project by Cardenas *et al*. [61] offers AI learning for STEAM challenges, so students learn coding and machine learning using robot or microcontrollers to build their creative solutions and prototypes. Machine learning is a branch of AI that enables computers to analyze data and increase efficiency and accuracy as more data is entered [62], [63]. The integration of machine learning in STEAM education affects the teaching and depth of STEAM concept [64]. While ChatGPT is beneficial in learning applications, it also raises issues with oversimplification, ethical usage, students' assessment, and students required to learn scientific terminology for STEAM education. Many students face difficulties with specific competencies. The introduction of ChatGPT and similar tools may impede the thorough assimilation of methods and outcomes, impairing the learning process [7].

There are three points in ChatGPT, such as natural language processing, Chatbot, and machine learning [65]. It makes virtual interaction easy, so students get feedback and explanations [66]. However, students respond to accurate responses and feel less thoughtful [36]. A balanced approach is necessary for successful integration, enhancing human supervision and engagement. Educators have to explore ChatGPT and teach their students how to use it. Figure 8 visualizes how several keywords are connected. Links between keywords in technology and engineering research have the same pattern and are more numerous than other scopes. The same pattern occurs in the scope of art and mathematics, which shows that more research is needed in this scope.

Based on Figure 8(a), research on implementing ChatGPT in science education focuses on solutions, effectiveness, and responses. Suggest teaching AI ethics through case study, interactive seminars, self-guided learning and FGD, considering the implications of AI in medical education [40], [47]. Sánchez-Ruiz *et al*. [7] explores how ChatGPT can affect students' critical thinking, problem-solving, and collaboration.

The findings' Liang *et al*. [38] showed that ChatGPT can solve science problems by explaining for solutions and resolving some science computation issues. However, high failure rates are caused by ChatGPT's difficulty converting figures into words and table-based questions. It only provides satisfactory quiz responses and gets some questions wrong [67]. It cannot conduct practical experiments or take the role

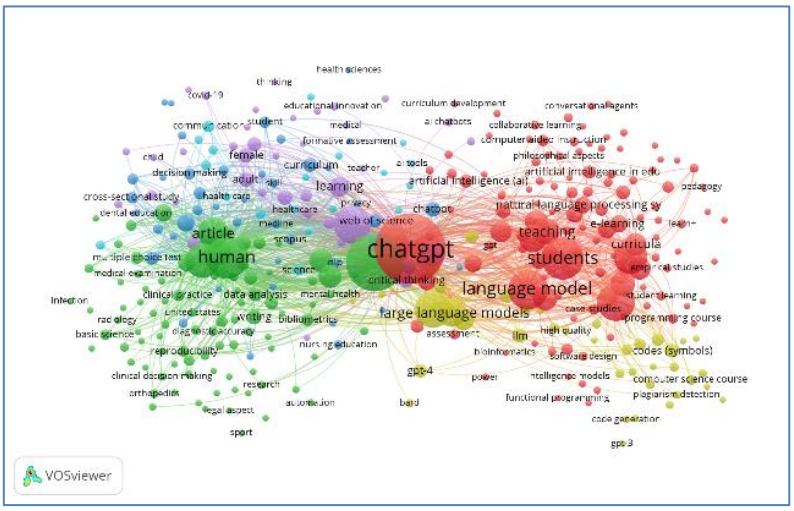
of students, but it can answer numerical problems and give detailed explanations. When combined with reflective exercises, it could improve writing and experimentation understanding.

According to Figure 8(b) and 8(c), research in technology and engineering is mainly of the RnD and case study type, focusing on digital technology practice, students' response, and practice use code. By offering individualized feedback, ChatGPT's capacity to comprehend and produce human language can improve software engineering education [68]. So, ChatGPT has the potential to help programmers in generating code [69]. But to avoid unsupervised use that might have a detrimental effect on learning, it is critical to modify curricula to account for shifting engineer profiles and offer direction for generative AI integration. Implementing ChatGPT gives new challenges for engineering education, so we must develop essential skills for future engineers [7]. ChatGPT has the potential to be an invaluable resource for students who want to learn how to solve code difficulties differently and get past their programming obstacles [70]. Teachers can create coding tasks that reduce the possibility of cheating while retaining their validity as evaluation tools by being aware of their limits.

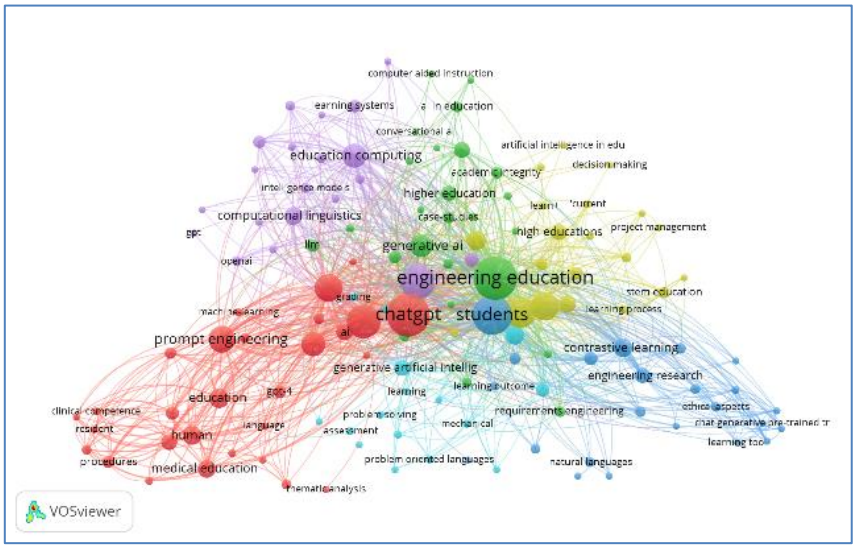
Figure 8(d) shows that implementing ChatGPT in arts focuses on creativity, computer games, digital devices, games and behavioral tools, cultural heritage, theater, and elementary schools. AI ChatGPT can be beneficial to screen media programs, expanding access and diversity for underrepresented students and addressing the traditional issues for students studying media production. Integrating ChatGPT into students' art projects enhances employment opportunities, promotes a creative mindset, enhances accessibility and inclusivity for media arts courses, and emphasizes aesthetic judgment, critical understanding, and theoretical understanding [43].

Implementing Minecraft in theatre education enriches students' cultural heritage knowledge, encourages active participation, and facilitates experiential learning [37]. These games allow students to express themselves, unleash imagination, and understand history. Game based learning is a strategy that can improve their abilities, optimize learning, support behavior change, and socialize [71]. Incorporating digital visual media in educational programs is essential for achieving and promoting essential knowledge rather than superficial information. Gen-AI's impact on screen media and creative arts education is significant, as it enhances content generation, digital literacy, accessibility, diversity, aesthetic taste, and critical visual literacy. Integrating Gen-AI into screen production 'ideation' sessions can improve students' creative intentions.

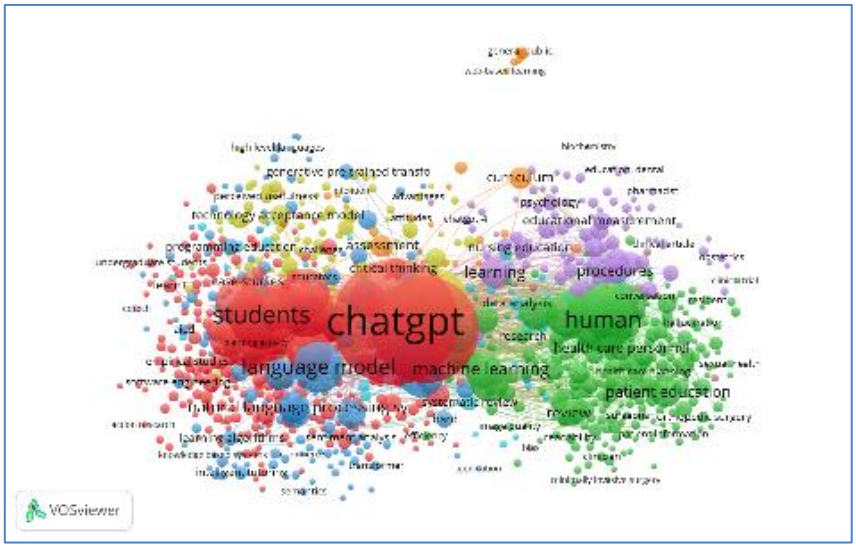
Many ChatGPT research on mathematics subjects use GPT series 3 and 4. Figure 8(e) shows that Chat GPT in mathematics education have connection keyword with assessment. Chat GPT 4 needs help with multiple-choice and infographic questions. ChatGPT is good in arithmetic and algebraic computations but struggles with longer queries. The complexity of the equations, the input data, and the instructions all affect ChatGPT's accuracy and efficacy, but it should get better at tackling challenging math problems [46], [72]. It responds to unanswered questions, offers clear instructions, and provides accurate, trustworthy directions despite its unreliability for calculations. Implementing ChatGPT during math-computer science education can enhance students' critical thinking, communication, and problem-solving [73], [74]. Despite their upbeat benefits, ChatGPT has several limitations for its performance in radiology, medicine, and nuclear medicine [75]. The effectiveness depends on students' knowledge, so ChatGPT is not the sole learning resource.



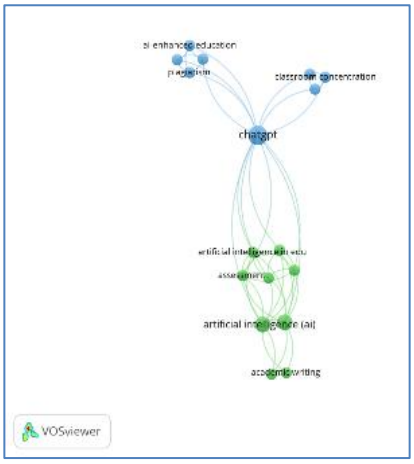
(a)

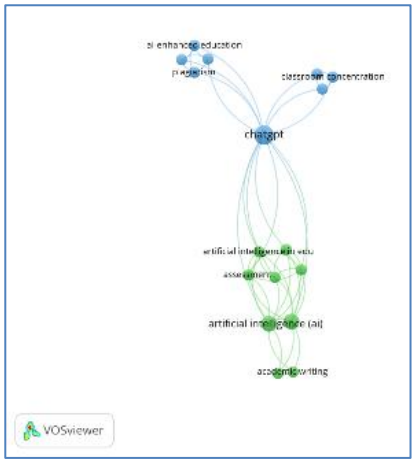


(b)



(c)





(d) (e)

Figure 8. Comparing keywords visualization of ChatGPT in (a) science, (b) technology, (c) engineering, (d) art, and (e) mathematics education in the world

4. CONCLUSION

This research provides information about research trend of ChatGPT in STEAM education. Most documents were published in 2022 with technology subject was dominated. ChatGPT research primarily consists of articles, with international researchers publishing more technology-focused work. Most STEAM education documents are published in technology-dominated journals. India, China, and the US being research-intensive countries. The US has the most publications, but few research in China. Europe, Russia, Europe, Russia, Asia, South America, and Africa have the most publications. The US dominates all fields except mathematics. Research of ChatGPT implementation in STEAM education using questionnaires, surveys, interviews, and five methods. Participants range from teachers to university students. ChatGPT-STEAM education research focuses on five main subjects: science-STEAM education, technology and math-STEAM education, engineering, and art. Top five subjects include medicine, technology and math, engineering, and art. Research covers BMA, mathematics, physics, arts, humanities, social sciences, computer science, and biomedical engineering. The implications for researchers, librarians, digital developers, policymakers, and educators in providing them with an overview of the latest research opportunities of ChatGPT in STEAM education. Further research can be developed based on the scope of art and mathematics education, especially research on student behavior. Future research could discuss learning designs and methods that reduce concerns regarding the credibility of ChatGPT. Future researchers can collaborate with Google Scholar or the Web of Science data for in-depth analysis.

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