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Examining the Trend of Research on Active Engagement in Science Education: Bibliometric Analysis

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**This article report using bibliometric analysis.*

ABSTRACT
In the field of educational psychology, active engagement is one of the instructional approach research topics. Research indicates that various advantages occur when students are actively engaged in their learning, involving increased motivation and higher-order thinking skills. The tremendous growth in encouraging students' active engagement in science education has gained prominence and plays a vital role in determining science specialisations and future careers. Based on the benefits of active engagement in science education, numerous studies have been conducted on this issue. As such, this paper will examine and report on Scopus-indexed articles on active engagement. As of April 24th, 2021, 1174 documents have been retrieved and evaluated. This article summarises the research productivity, most active source title, distribution of publications by countries, most active institutions, most productive authors, and citation analyses using established bibliometric indicators. The results show an increased growth rate of literature on active engagement in science education from 2016 to 2020. A total of 168 authors from 90 different countries and 167 institutions have collaborated on numerous studies on active engagement in science education, which have been published in various journals.

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Introduction

Engagement could be considered the holy grail of education. Engagement in these terms has been associated with favourable outcomes for learning inside and outside of school (Asniza et al., 2021; Barlow et al., 2020; Pöysä et al., 2019; Struyf et al., 2019; Sukor et al., 2021). Moreover, according to studies, consistent engagement can lead to long-term involvement in schooling.

Students should actively engage in science education by engaging in Science, Technology, Engineering and Math (STEM) pedagogical approaches like experiential learning, project-based learning, learning by doing and inquiry-based learning (Corrigan & Smith, 2020; Pöysä et al., 2019;

Sinatra et al., 2015). Active engagement in science education indicates that students contribute energy to their in-class learning processes, thereby providing a meaningful process for them in relation to science, technology, engineering, and mathematics (STEM) learning activities (Chi & Wylie, 2014; De Loof et al., 2021; Kim et al., 2020). Students' active engagement in learning entails psychological and behavioral engagement across constructivist learning methods (Almeda & Baker, 2020; Sari et al., 2020; Skinner et al., 2017). For example, initiatives were taken for study, higher-order thinking skills, and involvement in educationally efficient practices. Critical thinking skills do not develop on their own; rather, students must actively engage in educational activities for these skills to improve (Aktamiş et al., 2016; Bickford et al., 2020; Irwanto et al., 2019; Suwarna & Rhodiatussholihah, 2020; N. T. A. Wahid et al., 2018). Active engagement expresses the magnitude to which students participate actively in learning activities that are expected to result in high-quality learning (Almeda & Baker, 2020; Chi & Wylie, 2014; Sinatra et al., 2015). Students must be highly engaged and make a concerted effort to improve higher-order cognitive processes through active engagement in science lessons (Baharin et al., 2018; Bickford et al., 2020; Suprapto et al., 2020).

On the other hand, Kim et al. (2020) have explicitly examined the association between academic technology used by university students and their ability to think in higher-order ways through their active engagement and effort in learning. The findings with indicate that using mobile technology for academic purposes directly affects students' higher-order thinking abilities as well as their commitment and active engagement in classes. This is consistent with earlier research showing that mobile technology significantly impacts students' learning outcomes, particularly their higher-order thinking skills when actively engaged in class (Putranta et al., 2021; Shatri, 2020).

Also, Cents-Boonstra et al. (2022) used a microanalytic approach to examine trends in teachers' use of the particular motivating instructional practice in relation to indexes of students' positive engagement. The lessons of 52 teachers were evaluated and event-based coded. According to the findings, directly motivating students and giving positive responses and support throughout exercises were related to perceived positive student engagement. Tessier et al. (2010) have indicated that motivation and active engagement are both associated with the provision of psychological need support. When teachers effectively incorporate psychological need support into their teaching style, students' self-determined motivation and active engagement are boosted (Bara & Xhomara, 2020; Samsudin et al., 2020).

To ensure effective learning in school, students should be actively engaged and show interest in their classes. They must be highly motivated and actively engaged in class to accomplish this. Students are expected to demonstrate intrinsic motivation and genuine active engagement in class throughout the teaching-learning process. To accomplish this, it is necessary to first assess students' motivation levels and then plan activities that will increase their active class participation (Mujasam et al., 2018). As a result, teachers must monitor their students' motivation levels and implement motivation strategies to certify their genuine active engagement in class. Student active engagement is a process that promotes learning (Pap et al., 2021; Turner & Patrick, 2004) and academic achievement (Marks, 2000; Saeed & Mohamedali, 2022). Active engagement is a critical factor in determining success. Students who participate actively in academic activities will be more successful (Harboura et al., 2015; Zengaro & Zengaro, 2022). Actively engaged students dedicate themselves to the subject and perform with passion and care throughout the process of learning, as they place a high value on it. Although when confronted with obstacles while completing an assignment, a student perseveres and discovers personal value and significance in her work (Schlechty, 2002; Shin & Bolkan, 2021). Students' concentration on assignments and subjects indicates that teachers have met their objectives and that students are actively participating in the learning process.

Despite the rise in active engagement studies, there have been several attempts to notify the literature, notably those that used the bibliometric approach. Segura-Robles et al. (2020), for example, mention classic explanations of bibliometrics, indexes of co-authorship, and collaboration networks, using Web of Science (WoS) documents indexed between 2009 and 2019. Another study conducted by (Aparicio et al., 2021) proposed the standard bibliometric results for the data collected from 1998 until

2018. The report used information from Web of Science (WoS)-indexed journals that provide abstracts, citation counts, author lists, references, affiliations and countries, as well as the journal impact factor.
This paper conducts a bibliometric analysis of Active Engagement in Science Education, with a focus on three main research questions (RQs):
RQ1: How has research on Active Engagement in Science Education developed and been disseminated?
RQ2: What key topic areas have been addressed in Active Engagement in Science Education research?
RQ3: Who are the major participants in Active Engagement in Science Education research, and how have they collaborated.

Why Bibliometric Analysis

The use of the bibliometric analysis to determine the trend of studies is becoming more popular (Ahmi & Mohammad Nasr, 2019). As stated by Pritchard (1969), bibliometrics is defined as "the application of mathematical and statistical methods to books and other forms of communication". Additionally, the bibliometric study is a quantitative method that employs statistics to quantify text and information, and analyze published documents (Daim et al., 2006; Hall, 2011). Furthermore, it can be used in assessing the quantity and quality of the published materials to observe the trends or patterns in a particular field of study (Sweileh et al., 2017). Bibliometric analysis, according to Ho (2007), can reveal descriptive styles of completed articles published by domain, field, country, time frame, or any combination of the preceding.

Additionally, Rusly et al. (2019) stated that a methodical approach to bibliometric analysis might yield descriptive publications' patterns, including the list of authors, keywords' frequency and line of citations. Meanwhile, according to Ahmi & Mohamad Nasr (2019), among the most frequently examined factors are the following: publisher, publication type, author, institution, list of country and h-index. These indicators represent a subset of the descriptive analyses conducted on the set of data provided by the selected databases. In addition, several research findings have also looked at the impact of publications based on citations, including citations per publication (CPP), the number of citations, impact per publication (IPP), co-citations and impact factor (IF). Given the recent availability and breadth of data for academic publications, various methods for analyzing these bibliometric data are being developed. The current trend in the bibliometric study is to visualize bibliometric networks. For example, VOSviewer is free software for creating and visualizing networks. Additionally, VOSviewer encompasses text analysis capabilities that enable the creation and visualization of co-occurrences networks of critical phrases derived from a dataset of scientific literature (www.vosviewer.com).

Methods

In answering the research questions mentioned, our study has considered the following aspects of the literature on Active Engagement in Science Education. The first aspect is to choose a database. Certain databases, for example, the Web of Science (WoS), Scopus, Education Resources Information Centres (ERIC), Science Direct and Emerald are popular for database selection. However, database inclusion in this study is a top consideration to reveal the evolution and intellectual framework of previous research. Gavel and Iselid (2008) used overlap calculation to compare the two main citation databases, WoS and Scopus, and discovered that Scopus has roughly 84 per cent reportage, incorporating indexed titles from WoS. Feng et al. (2017), on the other hand, agreed that the Scopus database has wider coverage than the WoS database. Furthermore, according to Cobo et al. (2011), Scopus is an efficient indexed database that can export metadata and publication data for various research fields. As a result of the preceding claims, Scopus is selected for this study.

The next aspect is deciding on a time frame. Considering the concept of research field maturity, as emphasised by Kraus et al. (2020), this analysis restricted the screening process to articles published from 2016 until 2020. This timeline was selected since the number of publications research (1174 articles) was adequate to conduct a thorough review. Therefore, based on this, the timeline between 2016 and 2020 was selected as one of the inclusion criteria.

Scopus provides precise citation search results and comprehensive coverage of resources for areas of study other than medicine and the physical sciences (Hallinger & Kovačević, 2019). The keywords used to search relevant articles related to this study are "Active Engagement" and "Science Education" contained in the research title, abstract and keyword. We did not focus solely on the titles of the articles because some laboratory studies omitted the active engagement or education keyword from their study titles, even though the articles themselves reflect a particular topic that is relevant to the research field and the purpose of the research. In addition, the scope of the review was limited in terms of document and source types, with only articles and journals included.

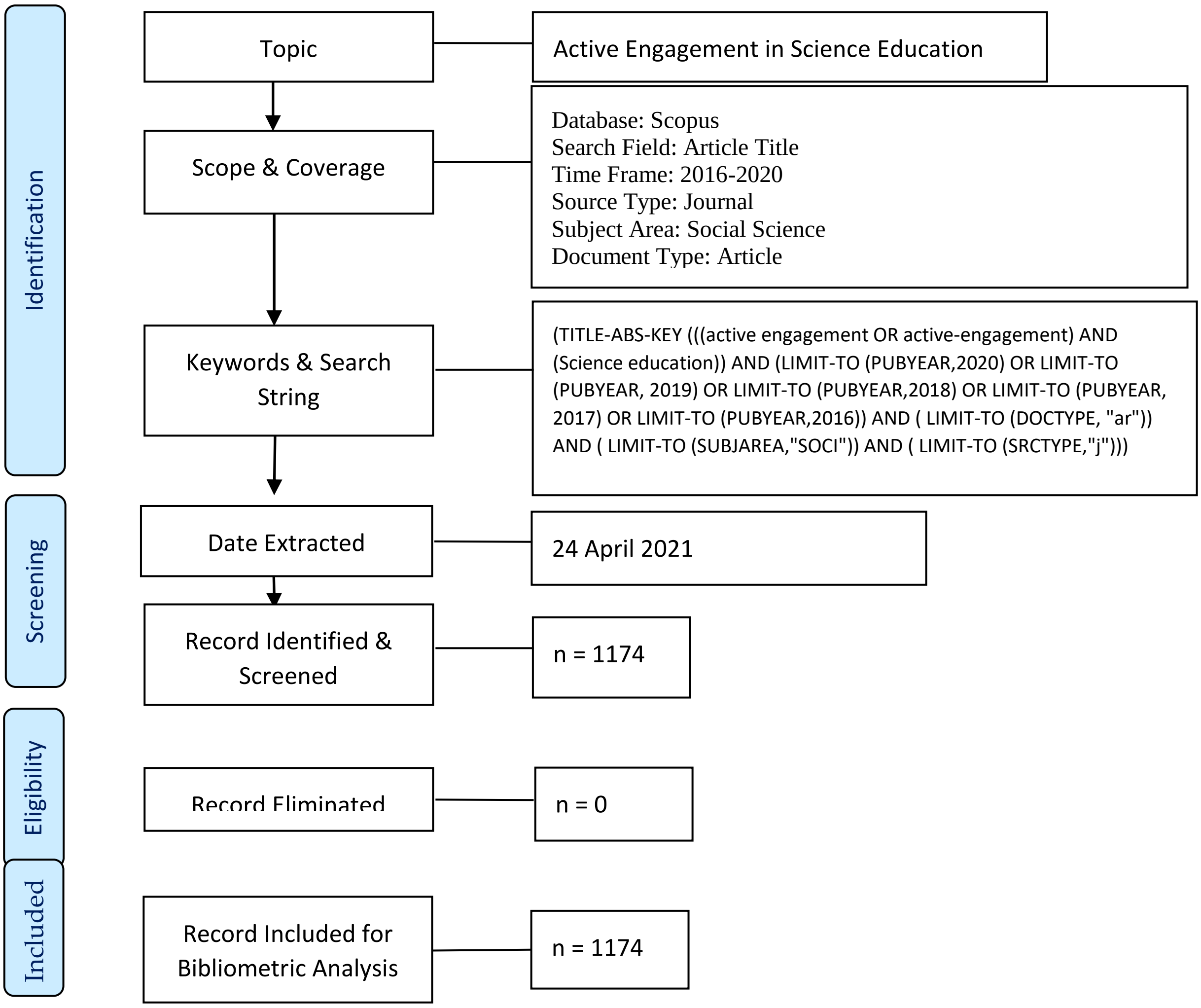
For the evolution and distribution of Active Engagement in Science Education, we analyzed the languages of documents and the research trends in publications by year. In the key topic areas of Active Engagement in Science Education research, we resolved top keywords and co-occurrence analysis. Despite major participants in Active Engagement in Science Education research, we figured out the top countries that contribute to publications, the most influential institutions, the most active journal, the citation analysis and the authorship analysis. The objective of this research was to achieve more understanding of Active Engagement in Science Education research trends, notably concerning its wide reach and collaborative partnerships. Furthermore, it was essential to screen the most recent data to assist researchers in declaring recommendations for future research in the development of Active Engagement in Science Education.

The review was guided by the modified PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidance for conducting systematic reviews of studies (Moher et al., 2009; Zakaria et al., 2021). First, the search string "Active Engagement" AND "Science Education" was accessed using the Scopus search engine. Then, the scope and coverage in this study were excluded based on the search field, time frame, source type, subject area and document type. This search yielded 1174 documents (see Fig.1). After searching the abstracts of all of the documents in the list, more exclusions have been made based on topical relevance. The final database of 1174 documents on Active Engagement in Science Education remained after the document screening was completed.

In answering our research questions, we analyzed the results in various ways to get the input. Some findings were achieved directly from Scopus using the search result analysis function. Additional results were manually entered or transferred as part of the data sets to a new Excel file in the CSV and RIS formats. The file containing all of the results was analyzed for data, including percentages and the cumulative percentage. Additionally, we calculated the citation metrics and some of the other occurrences using Harzing's Publish and Perish software. VOSviewer was also used to visualise the bibliometric networks since it is a freely accessible tool for constructing and visualising the networks (Ahmi & Mohd Nasir, 2019). Hopefully, this paper can enrich the valuable insights on the trends shown in publications on Active Engagement in Science Education.

Figure 1

Flow Diagram of The Searching Strategy



Results and Findings

Using Scopus data, we analyzed the bibliometric attributes such as research productivity, most active source title, distribution of publications by countries, most active universities, most productive authors, and citation analyses. The selection of documents has been filtered to the year of publications (2016-2020), subject area (social science), document type (article) and source type (journal). Almost all of the results are addressed in frequency and percentage formats, while the co-occurrence of the author keywords was mapped using VOS viewer. The data analysis was divided into sections according to the research questions.

RQ1: How has Active Engagement in Science Education research developed and been disseminated?

The first RQ of this study aims to investigate how has active engagement in Science Education research developed and been disseminated by interpreting (a) publications by languages, and (b) productivity in research.

Publications by Languages

Table 1 showed that English was the most common language, which accounted for 99.57% of 1169 publications on Active Engagement in Science Education research. Spanish became the second language in publication but only reported for 0.25%. The other documents were published in two other languages, namely Italian and Turkish. However, these languages accounted for 0.09%, respectively. Generally, the papers published in English would have the advantage of being encountered in scientific community journals as English is a legally recognised lingua franca of all scientific fields (Bornmann et al., 2012).

Table 1

Type of Languages

Language	Total Publications (TP)*	Percentage (%)
English	1169	99.57%
Spanish	3	0.25%
Italian	1	0.09%
Turkish	1	0.09%
Total	1174	100.00

Productivity in Research

This second analysis analyzed productivity in research in terms of the number of documents published each year. Analyzing the articles based on the publication year allows the researcher to track the pattern and prominence of the research subject over time (Ahmi & Mohammad, 2019). As shown in Table 2, the number of publications increased year by year, with the highest number of publications on active engagement was in 2020, and we believe this trend will continue. The number of cited publications rose year after year, with 2019 having the highest number of cited publications on active engagement (204). Nevertheless, Figure 2 indicates the number of cited publications on active engagement showed a decreased trend between 2016 and 2020. The total number of citations also shows a decreased pattern from 2016 to 2020. The table provides an overview of the publication's year of active engagement from 2016 until 2020. Active engagement seems to be a widely discussed topic among academics, based on the number of publications.

Table 2

Publication Year

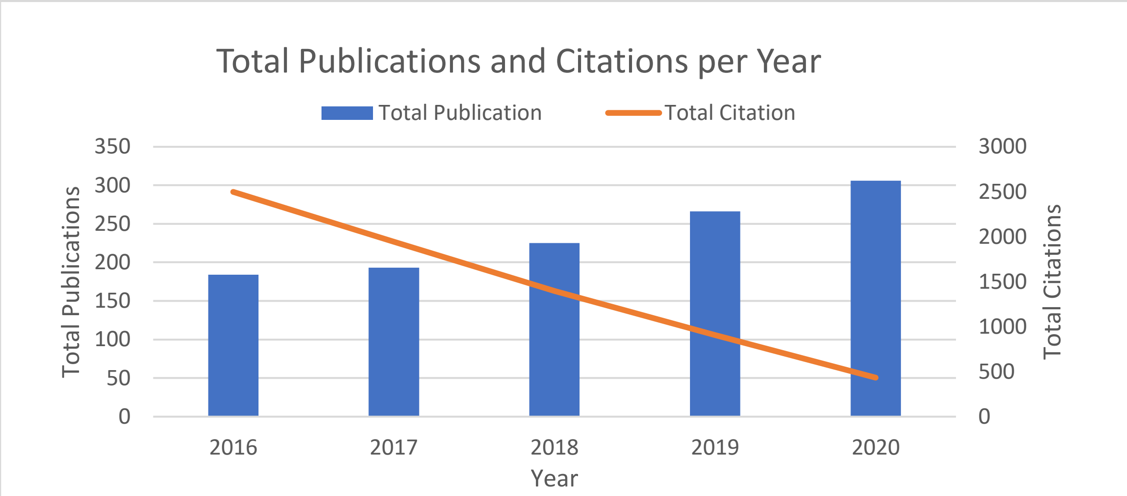
Year	TP	Percentage (%)	Cumulative Percentage (%)
2016	184	15.67	15.67
2017	193	16.44	32.11
2018	225	19.17	52.28
2019	266	22.66	73.94
2020	306	26.06	100.00
Total	1174	100.00	

Year	TP	NCP	TC	C/P	C/CP	*h*	*g*
2016	184	170	2498	13.58	14.69	24	40
2017	193	176	1942	10.06	9.50	24	31
2018	225	192	1395	6.20	7.27	16	23
2019	266	204	904	3.40	4.43	12	16
2020	306	158	432	1.41	3.40	7	11
Total	1174						

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

Figure 2

Total Publications and Citations per Year



RQ 2: What Key Topic Areas Have Been Addressed in Active Engagement In Science Education Research?

The second RQ of this study aims to resolve top keywords and co-occurrence analysis. In response to RQ2, we used top keyword and co-occurrence analysis to examine the citation networks of 1174 articles. Keyword co-occurrence analysis is a powerful content analysis technique for determining the degree of association among keywords in the literature (Shmagun et al., 2020).

To address RQ2, this study identifies the keyword that is most frequently used among scholars on Active Engagement in Science Education research. The keywords from the 1174 Active Engagement in Science Education studies were summarized and presented in Table 3. "Science Education" keyword representing 67.38% revealed as the most intermittently used keyword in the Active Engagement in Science Education literature. The second most repeatedly used keyword is "engagement" (66.87%). This finding is logical since engagement is part of science education. Other popular keywords coming out over 100 times were "education", "higher education" and "student engagement".

Table 3

Top 20 Keywords

Author Keywords	Total Publications (TP)	Percentage (%)
Science Education	791	67.38%
Engagement	785	66.87%
Education	336	28.62%
Higher Education	125	10.65%
Student Engagement	116	9.88%
Learning	94	8.01%
STEM Education	85	7.24%
Technology	80	6.81%
Student	80	6.81%
Scientific Literacy	78	6.64%
Curriculum	77	6.56%
Teaching	75	6.39%
Student	75	6.39%
Active Learning	73	6.22%
Social Science	64	5.45%
STEM	55	4.68%

Curricula	54	4.60%
Motivation	49	4.17%
Science	48	4.09%
Science Learning	45	3.83%

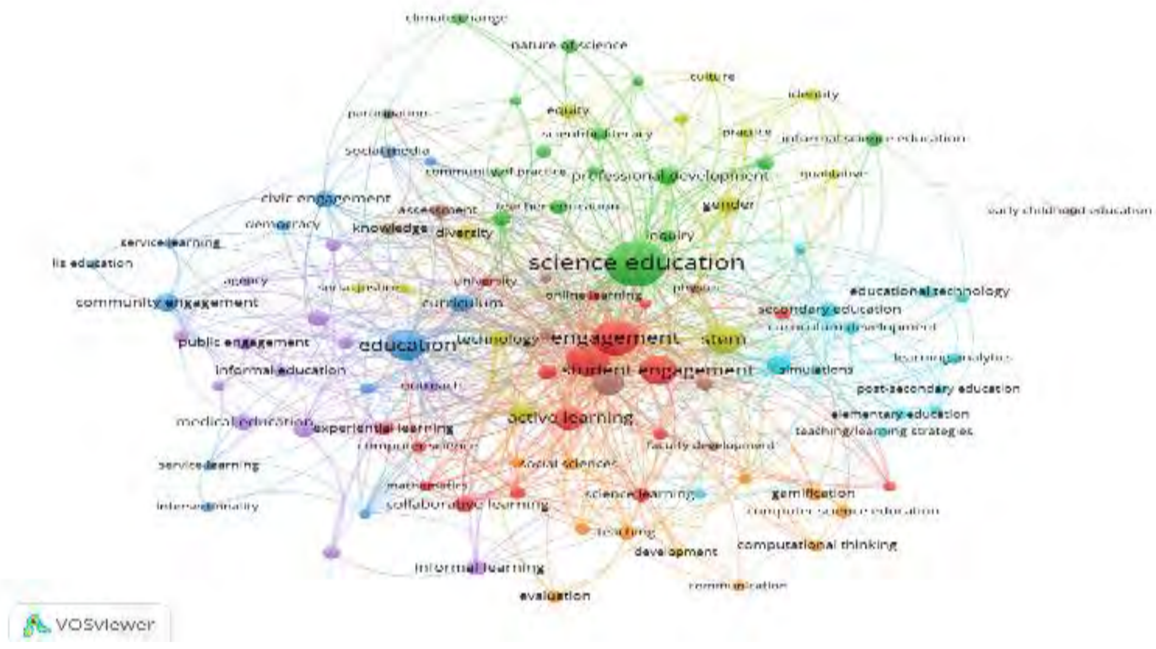
Additionally, the author's keywords have been mapped using VOSviewer. Baker et al. (2020) indicate that keyword co-occurrence occurs when two appear in the same article, implying a connection between the two concepts. The circle size, font size, colour and connecting line thickness were used to indicate the relationships between the keywords (Sweileh et al., 2017). Keyword co-occurrence appears when two keywords appear simultaneously in an article, implying a relationship between the two concepts (Baker et al., 2020). Figure 3 shows a network visualization of the author keywords, each with at least six occurrences.

Therefore, from the 3395 keywords in total, 105 words met the criteria. The total strength of co-occurrence connections with other keywords was determined by calculating for each of the 105 keywords (Van Eck & Waltman, 2008, 2017; Waltman et al., 2010). Those keywords were divided into nine clusters, and the frequency of keywords is depicted by the size of the nodes. Meanwhile, the different colour of the node represents the different cluster to which it belongs (Zhang et al., 2020).

The first cluster, highlighted in red, is associated with engagement, active learning, science learning, student engagement, higher education, mathematics, experiential learning and online learning. The second cluster, denoted by the green colour, includes the keywords of science education, inquiry, nature of science, pedagogy, self-efficacy and informal science education. The third cluster, highlighted in blue, is associated with education, curriculum, civic engagement, community engagement and action research. The "science education", which was the biggest node, was nearest to the "engagement" node, and the close distance of both keywords means a strong connection between each other (Nurul Mardhiah Azura Md Nadzar et al., 2017; Van Eck & Waltman, 2017). Besides, keyword analysis provides meaningful insight into a specific issue's popularity or level of importance in a given research domain. In another respect, analysis of authors, their affiliation and h-index could indicate the authors' prominence of the article authorship (Ahmi & Mohamad Nasr, 2019).

Figure 3

Author Keywords Network Visualisation Map With At Least Six Occurrences



RQ 3: Who are the major participants of Active Engagement in Science Education research, and how have they collaborated?

The purpose of this study was to investigate the characteristics of scientific collaborations on Active Engagement in Science Education research by interpreting (a) top countries contributing to publications, (b) the most influential affiliations, (c) the most active journal, (d) citations analysis, (e) the most productive authors analysis and (f) the authorship analysis.

Top Countries Contribute to The Publication

This article assesses the number of country-based publications on the author's affiliation institution. Table 4 listed the highest ten active countries that played a role in active engagement in science education between 2016 and 2020. The United States produces the most publications. (540), representing 51.53% of the total publications on active engagement in science education, compared to the United Kingdom (123) and Australia (121). The other distribution of authors' national affiliations represented less than 100 publications, namely Canada, South Africa, Spain, Germany, Ireland, New Zealand and the Netherlands. Apparently, Active Engagement in Science Education research plays a prominent role in various geographic ranges. The geographical distribution of publications in the leading countries is depicted in Figure 4.

Table 4

Top 10 Countries Contribution of Publication

Country	TP	Percentage (%)	NCP	TC	C/P	C/CP	*h*	*g*
United States	540	51.53	430	3829	7.09	8.90	26	42
United Kingdom	123	11.74	93	706	3.47	7.59	14	19
Australia	121	11.55	91	750	6.20	8.24	14	21
Canada	78	7.44	62	365	4.68	5.89	12	15
South Africa	42	4.01	24	104	2.48	4.33	7	8
Spain	37	3.53	28	221	5.97	7.89	9	13
Germany	30	2.86	24	115	3.83	4.79	5	9
Ireland	28	2.67	17	69	2.46	4.06	4	7
New Zealand	26	2.48	20	104	4.00	5.20	5	9
Netherlands	23	2.19	20	93	4.04	4.65	4	8

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

Figure 5 depicts a network visualization map of citations by country. According to the authors' affiliations, there were nine clusters based on the co-occurrence of countries. Included are all countries that are involved in at least 23 publications. The number of publications affiliated with a country is displayed by the size of its node. The first cluster consists of Finland, Austria, Germany, the Netherlands, Portugal and Switzerland. On the other hand, the second cluster consists of five countries, the United Kingdom, the United Arab Emirates, Hong Kong, China and Pakistan. Cluster 3 encompassed the leading country, the United States, and the other two countries were India and Singapore. The next fourth cluster consists of four countries, Australia, Canada, Indonesia and New Zealand.

Figure 4

Geographical Distribution of Publication

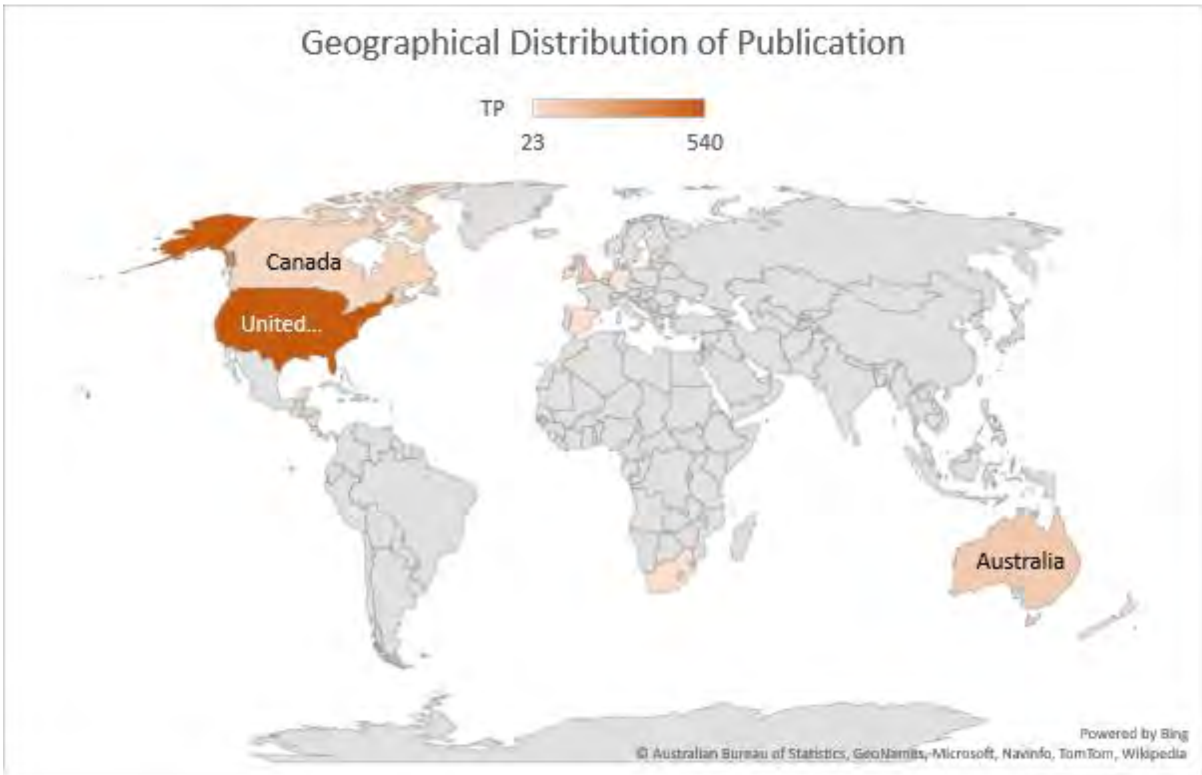
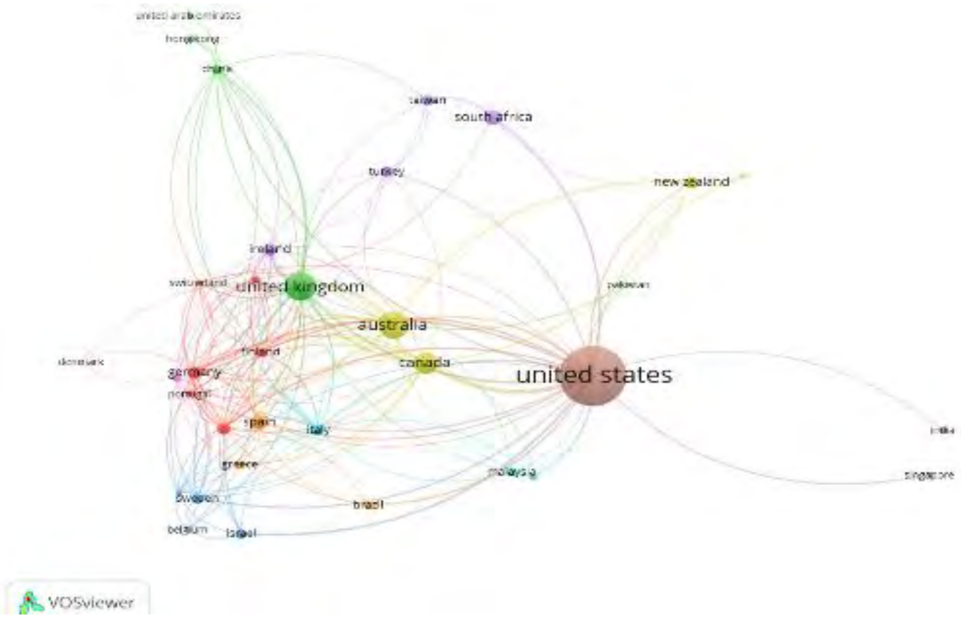


Figure 5

Network Visualization Map of The Citation by Country



Note: Smallest quantity of documents of an author = 5; Minimum number of citations of an author = 5.

The Greatest Influential Institutions

The greatest influential institutions with a minimum of eleven publications on Active Engagement in Science Education are listed in Table 5. Out of the 1,174 documents, Michigan State University (20 publications) contributed most to Active Engagement in Science Education publications. The University of Washington in the United States, Purdue University and NC State University came in second, third and fourth, with 18, 15, and 14 total publications, respectively. Four institutions were shared with the same number of 13 publications, Pennsylvania State University, Monash University, University of Sydney and the University of Wisconsin-Madison. The others contributed 11 and below the number of publications.

Table 5

Most Influential Institutions With At Least Eleven Publications

Affiliation	Country	TP	NCP	TC	C/P	C/CP	*h*	*g*
Michigan State University	United States	20	16	425	21.25	26.56	9	20
University of Washington	United States	18	17	181	10.06	10.65	7	13
Purdue University	United States	15	14	139	9.27	9.93	7	11
NC State University	United States	14	12	73	5.21	6.08	5	8
Pennsylvania State University	United States	13	11	59	4.54	5.36	5	7
Monash University	Australia	13	10	84	6.46	8.40	5	9
University of Sydney	Australia	13	8	65	5.00	8.13	4	8
University of Wisconsin-Madison	United States	13	9	227	17.46	25.22	6	13
University of Auckland	New Zealand	11	10	66	6.00	6.60	4	7
The University of British Columbia	Canada	11	9	73	6.64	8.11	5	8

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

The Most Active Journal

This study also provides the most active journal with at least 18 journal publications on active engagement, as shown in Table 6. Springer became a leading publisher that continues to contribute to active engagement publications, with 34 publications in Research in Science Education from 2016 until 2020. The second most active journal with 553 total citations was cited from the Journal of Research in Science Teaching. Meanwhile, Computers and Education is leading in CiteScore (CS) even though the journal was not listed as the top highest publications. Scopus has introduced a CiteScore as a new scientometric indicator (citation impact metric) for tracking journals' performance in terms of citation analysis after the database of Elsevier had numerous metrics for evaluating the quality of science, such as Source Normalized Impact per Paper (SNIP) and Scimago Journal Rank (SJR) indicators (Zijlstra & Mccullough, 2016). Significantly, CS can provide a more natural perception of citations than the Impact Factor (Khosravi & Menon, 2019).

Table 6

Most Active Journal

Journal Title	TP	TC	Publisher	Cite Score	SJR 2019	SNIP 2019
Research in Science Education	34	109	Springer	3.2	0.893	2.089
Journal Of Research in Science Teaching	27	553	Wiley Periodicals, Inc.	7.2	3.012	3.231
Computers And Education	26	506	Elsevier	12.7	3.047	4.280
Cultural Studies of Science Education	25	88	Springer Nature	1.8	0.573	0.950
International Journal of Science Education	23	139	Taylor & Francis	2.8	1.058	1.626
CBE Life Sciences Education	20	363	American Society for Cell Biology	4.9	1.173	2.067
Journal Of Science Education and Technology	20	134	Springer Nature	5.2	1.170	2.315
BMC Medical Education	19	137	Multidisciplinary Digital Publishing Institute (MDPI)	0.8	0.242	0.733
Science Education	19	202	Wiley-Blackwell	4.8	2.012	2.405
International Journal of Science Education Part B Communication and Public Engagement	18	110	Taylor & Francis	2.6	0.863	1.398

Notes: TP=total number of publications; TC=total citations.

The Citation Analysis

Citation analysis is one of the systematic methods for evaluating the quality and impact of research publications (Aristodemou & Tietze, 2018; Ding & Cronin, 2011; Haddow & Genoni, 2010; Karamustafaoğlu, 2009). Table 7 outlines the citation metrics for the selected documents as of April 24th, 2021. In five years of active engagement in science education publications (2016–2020), there have been 7171 citations. This citation metric was generated using Harzing's Publish and Perish software, which used a RIS-formatted file from the Scopus database to present the raw citation metrics.

Table 7

Citations Metrics

Metrics	Data
Publication years	2016-2020
Citation years	5
Papers	1174
Citations	7171

Years	5
Cites_Year	1434.2
Cites_Paper	6.11
Cites_Author	2871.37
Papers_Author	535.97
Authors_Paper	3.17
h_index	31
g_index	48

The Authorship Analysis

Table 8 displays the top 20 most cited articles in the field of Active Engagement in Science Education. The article with the most citations, titled "Can citizen science improve public understanding of science?" was published in Public Understanding of Science in 2016. This article gained 185 citations in total, with 37 citations per year. Bonney et al. (2016) were named the most productive author with the highest number of citations on Active Engagement in Science Education articles.

Table 8

Top 20 Highly Cited Articles on Active Engagement in Science Education

Num.	Authors	Article Title	Year	Cites	Cites per Year
1	Bonney et al. (2016)	"Can citizen science enhance public understanding of science?"	2016	185	37
2	Berland et al. (2016)	"Epistemologies in practice: Making scientific practices meaningful for students"	2016	152	30.4
3	Lindgren et al. (2016)	"Enhancing learning and engagement through embodied interaction within a mixed reality simulation"	2016	151	30.2
4	Rodenbusch et al. (2016)	"Early engagement in course-based research increases graduation rates and completion of science, engineering, and mathematics degrees"	2016	109	21.8
5	Hew et al. (2016)	"Engaging Asian students through game mechanics: Findings from two experiment studies"	2016	96	19.2
6	Barton, Tan, & Greenberg (2017)	"The maker space movement: Sites of possibilities for equitable opportunities to engage underrepresented youth in STEM"	2017	79	19.75
7	Quin (2017)	"Longitudinal and Contextual Associations Between Teacherâ€ "Student Relationships and Student Engagement: A Systematic Review"	2017	75	18.75
8	Makransky (2018)	"A structural equation modelling investigation of the emotional value of immersive virtual reality in education"	2018	70	23.33
9	Jaber & Hammer (2016)	"Learning to Feel Like a Scientist"	2016	56	11.2
10	Sogari, Menozzi & Mora (2017)	"Exploring young foodies knowledge and attitude regarding entomophagy: A qualitative study in Italy"	2017	53	13.25
11	Reimschisel et al. (2017)	"A systematic review of the published literature on team-based learning in health professions education"	2017	52	13

12	Alexander (2018)	"Developing dialogic teaching: genesis, process, trial"	2018	48	16
13	Cózar-Gutiérrez & Sáez-López (2016)	"Game-based learning and gamification in initial teacher training in the social sciences: an experiment with Minecraft Edu"	2016	46	9.2
14	Cavanagh et al. (2016)	"Student buy-in to active learning in a college science course'	2016	45	9
15	Tsiotakis & Jimoyiannis (2016)	"Critical factors towards analysing teachers' presence in online learning communities"	2016	43	8.6
16	Sha et al. (2016)	"Families support their children's success in science learning by influencing interest and self-efficacy"	2016	40	8
17	Kang et al. (2016)	"Designing, launching, and implementing high-quality learning opportunities for students that advance scientific thinking"	2016	39	7.8
18	Takayama (2016)	"Deploying the post-colonial predicaments of researching on/with Asia in education: a standpoint from a rich peripheral country"	2016	39	7.8
19	Kostaris et al. (2017)	"Investigating the potential of the flipped classroom model in K-12 ICT teaching and learning: An action research study"	2017	38	9.5
20	Nichols et al. (2017)	"Early career teachers' emotion and emerging teacher identities"	2017	37	9.25

The Most Productive Authors

Subsequently, this study highlights the most productive authors of documents on Active Engagement in Science Education. Table 9 outlined the most active authors, each of whom had at least three publications. According to the table, Bazzul J., Jones, M.G., I., Andre T., Beymer, P.N., Rosenberg J.M. and Zimmerman, H.T. are some of the most active authors in this research area, each having published a minimum four papers on active engagement.

Additionally, Table 9 lists the most productive authors who have made a significant contribution to the body of knowledge regarding Active Engagement in Science Education. The authors had the most publications on Active Engagement in Science Education research with five publications, namely Bazzul J. affiliated with the University of Regina in Canada and Jones, M.G. from NC State University in the United States. In the meantime, five authors ranked as second-most productive authors (4 publications), namely Andre T. (Iowa State University), Beymer, P.N. (Michigan State University), Rosenberg J.M. (Michigan State University) and Schmidt J.A. (Michigan State University) and Zimmerman, H.T. (Penn State University). These five authors come from the United States. Otherwise, the other authors listed contributed three total publications. Dramatically, the highest average citations per publication (28.33 times) presented among the productive authors was Cavanagh, A.J. from Yale University, the United States, with an h-index of 3 and full publications of 3. Meanwhile, the h-index is measured by the number of times a researcher's papers have been cited (Hirsch, 2005, 2010). Hirsch's proposal sparked widespread global interest because it represented a single whole number that accounted for both the quantity and impact of the researchers' portfolio of work (Abramo et al., 2013).

Table 9

Most Productive Authors With At Least Three Publications

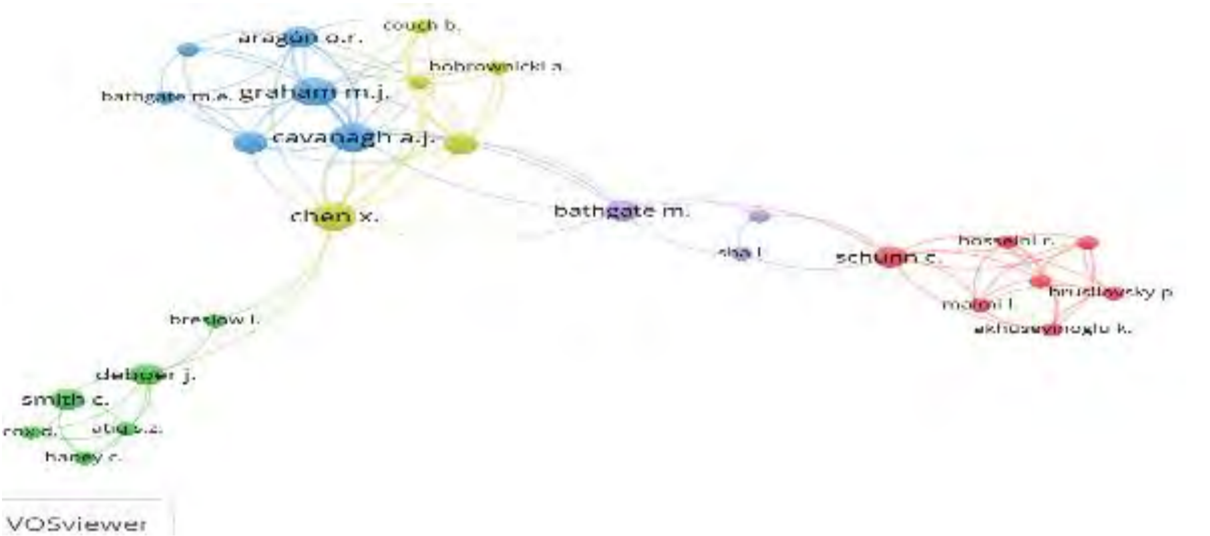
Author's Name	Affiliation	Country	TP	NCP	TC	C/P	C/CP	*h*	*g*
Bazzul J.	University of Regina	Canada	5	12	24	4.80	22.5	2	4
Jones, M.G.	NC State University	United States	5	22	24	8.67	9.45	8	13
Andre T.	Iowa State University	United States	4	22	22	5.5	5.5	2	4
Beymer, P.N.	Michigan State University	United States	4	43	43	10.75	10.75	3	4
Rosenberg J.M	Michigan State University	United States	4	43	43	10.75	10.75	3	4
Schmidt J.A.	Michigan State University	United States	4	43	43	10.75	10.75	3	4
Zimmerman, H.T.	Penn State University	United States	4	23	23	5.75	5.75	4	4
Bjønness, B.	Norwegian University of Life Sciences	Norway	3	5	20	1.67	5.00	1	2
Cavanagh, A.J.	Yale University	United States	3	85	85	28.33	28.33	3	3
Childers, G.M.	University of North Georgia	United States	3	22	22	5.33	5.33	3	1

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

Co-authorship maps are applied when two or more authors collaborate to write a paper, and this collaboration reveals the structure of scientific networks (Yan & Ding, 2012; Zupic & Čater, 2015). Figure 6 was presented the co-authorship network map with a minimum of one document per author and at least two citations per author. As a result, 2312 authors out of 3543 met the thresholds and remained in the analysis. The co-authorship map of authors includes five clusters in different colours. The patterns vary according to the colour, size of the font, size of the circle, and line thickness. The connecting lines patterns imply the relationship's strength among authors (R. Wahid et al., 2020). Among the 2312 visible co-authors, Cavanagh, A.J., the largest node, was the most active author with the greatest degree of collaboration and presented the most average citations per publication.

Figure 6

Network Visualization Map Of The Co-Authorship



Notes: Analysis unit= Authors; Method of counting: Full counting; Minimum number of documents of an author = 1; Minimum number of citations of an author = 2

Discussion and Conclusions

This study aims to conduct a comprehensive bibliometric analysis of the research on Active Engagement in Science Education from 2016 to 2020. This bibliometric analysis can determine research productivity (Moed et al., 2002) and the number of publications in a particular research field. Gu (2014) has stated that the data extracted from the bibliometric analysis can be used to assess the performance of a particular research field. For research organizations, it is advantageous to regulate some financing policies and to compare the input and output of scientific research. Furthermore, the outcomes of the bibliometric analysis could be used to clarify the factors that relate to the contribution of studies in a specific field of study and to direct scholars toward conducting well-researched studies (Akhavan et al., 2016). Accordingly, this research gathers data from the Scopus database on publications related to active engagement. Using the defined search query, this analysis revealed 1174 documents from the indicated database. The study on Active Engagement in Science Education (based on the documents retrieved from the Scopus database) stated 184 (15.67%) of total publications and increased each year until 2020. Springer is among the top publishers contributing to active engagement publications, with 34 publications and 109 total citations from 2016 until 2020.

In response to the first RQ, according to the publication trend in Active Engagement in Science Education, English was found as the primary language. The results indicate that the publications of the journal on this topic have continuously grown and been widely published. The second RQ response was on key topic areas which had been discussed in this analysis. The most frequently used keyword among scholars on Active Engagement in Science Education research was the identified 'Science Education' word, which contributed 67.38%. Meanwhile, in order to answer RQ3 of this study, the analysis recorded the major participants in Active Engagement in Science Education Research and explained how they have collaborated. The United States reported the highest number of contributing authors. The institutions most often affiliated with Active Engagement in Science Education authors Michigan State University, the United States, with 20 total publications.

The Research in Science Education was the most cited source in these earlier five years. VOSviewer software used in this study was able to map the citation and co-authorship network in exploring the characteristics of scientific collaborations on Active Engagement in Science Education research. Citation metrics were calculated using Harzing's Publish or Perish software for 7171 citations reported in five years (2016–2020) for 1174 articles, with an average of 1434 citations per year and six citations per paper. Bonney et al. (2016) were named the most productive author with the highest number of citations on Active Engagement in Science Education articles. Their article was titled "Can citizen science enhance public understanding of science?". Finally, descriptive analysis had outlined Bazzul J, affiliated with the University of Regina in Canada, and Jones, M.G. from NC State University, United States as the greatest productive author in terms of the highest total publication. Nevertheless, the result of co-authorship analysis, Cavanagh, A.J. from Yale University, United States, presented as the most active author with the top degree of authors' collaboration.

Regardless of the unique characteristics of the bibliometric analysis, the study has certain limitations that must be referred to convey a clear vision to the readers. First and foremost, this research is limited to the Scopus database as the primary source of documents. Even though Scopus is one of the most comprehensive databases for scholarly works (Ahmi & Mohamad, 2019; Sweileh et al., 2017), it is good to see another interesting outcome when combined with other databases. Future research may include additional databases such as Web of Science, Google Scholar and Dimensions. Second, due to the broad scope of the Active Engagement concept, we only looked at a sample of the relevant literature with limited search queries; otherwise, the period covered was fixed. Third, the keyword co-occurrence and co-authorship network mapping has not been triangulated with other methods. The results were derived solely from the specified keyword such as "active engagement" or "active-engagement" and "science education", and are based on the article title, abstract and keyword. The main reason for this is that most research focusing on a specific topic will only include the documents' title, abstract and keywords.

As a result, extensive filtering and cleaning must be performed before the analysis. Citation analysis weaknesses also provide inherent unknown reasons for citing certain documents and self-citations. Thus, the following suggestion for future studies may be recommended: (1) Employ additional analysis and counting methods such as bibliographic coupling and fractional counting to triangulate the findings. (2) Replicate the study using any other database like Web of Science and Science Direct or the combination of database to show the higher representation of publications. (3) Explore more studies and contribute to narrowing the education gap that may arise due to the development of Active Engagement in Science Education. This will facilitate the achievement of educational objectives globally among Active Engagement in Science Education educators. Furthermore, using a bibliometric strategy and scientific approach to prior literature trends, this study extends and supplements prior findings on active engagement in science education literature.

Competing Financial Interests

There are no competing financial interests declared by the authors.

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