Research Article

Analysis and Visualization Critical Thinking and Creative Thinking Trends of Research in Science Education Using R Studio

Aay Susilawati[1], Diana Rochintaniawati[1]*, Iwan Kustiawan[2], Lilik Hasanah[3], Riandi Riandi[1], Algiranto Algiranto[3], Martha Ioupatty[4], Supriyadi Supriyadi[4]

[1]Universitas Pendidikan Indonesia, Department of Science Education, Bandung 40154, Indonesia
[2]Universitas Pendidikan Indonesia, Department of Electrical Engineering and TVETRC, Bandung 40154, Indonesia
[3]Universitas Pendidikan Indonesia, Department of Physics Education, Bandung 40154, Indonesia
[4]Universitas Musamus, Department of Physics Education, Merauke 99611, Indonesia

ORCID
Aay Susilawati: https://orcid.org/0000-0002-9520-8896
Iwan Kustiawan: https://orcid.org/0000-0001-7623-4071
ilik Hasanah: https://orcid.org/0000-0002-7281-2556
Riandi Riandi: https://orcid.org/0000-0003-4187-7338
Algiranto Algiranto: https://orcid.org/0000-0002-2627-4742
Martha Ioupatty: https://orcid.org/0000-0002-4893-5142
Supriyadi Supriyadi: https://orcid.org/0000-0002-5944-3055

Corresponding Author: Diana Rochintaniawati; email: diana_rochintaniawati@upi.edu

Abstract.
This study aimed to give a thorough overview of how to analyze and visualize creative and critical thinking trends in science education research using the bibliometrics technique. This study is based on 319 papers that were gathered and indexed by Scopus between the years 2002 and 2022 that dealt with critical and creative thinking in scientific education. For bibliometric analysis, we employed R Studio. There is an upsurge in studies on critical and creative thinking tendencies, and some nations have recently investigated critical and creative thinking in science education. Additionally, there is a growing tendency in education that emphasizes the connection between critical and creative thinking in the subject of study covered in this study. Considering the findings of this bibliometric analysis, it thus offers a summary and opportunities for additional research.

Keywords: critical thinking, creative thinking, science education, R Studio

1. INTRODUCTION

Science plays a significant role in students' getting to know and make sense of the environment they live in [1]. Science can be divided into sub-branches such as physics, chemistry and biology. This branch of science is significant for students to acquire scientific process skills, gain systematic working habits, find solutions to problems

encountered in daily life, analytical, critical, reflective and creative thinking, and especially gain the so-called 21st century skills [2]. In addition, it is another essential feature to provide easy integration of technology and to have alternatives for adapting course content to technology. In the 21st century, knowledge is learned in a pile. Now, only information learned in schools is not enough for students. Therefore, continuous research, analysis, learning and teaching situations are essential parts of development [3]. In this context, education types should be revised, and education should adopt various uses of technology. In our country, education types are divided into two as formal education and non-formal education. Formal education is education planned and programmed in schools. Non-formal education is the type of education carried out to meet the educational needs of individuals who cannot continue their formal education for any reason [4]. However, education is not always carried out in schools. Natural disasters, global crises, wars, international conflicts and epidemics can prevent education from being fulfilled.

This paper provides a comprehensive overview of the present current state and trends of critical and creative thinking in science education and research. It reports a bibliometric analysis of critical and creative publications in science education published between 2002 to 2020, with pattern on collaboration, major publications, major themes and research trends. Cover the trend.in particular, the bibliometric analysis focused on the following research questions: i) what is the present state of critical and creative thinking in science education research, in terms of major research areas, key publication and collaboration patterns?, ii) what are the thematic patterns in critical and creative thinking on science education reseach, as regards the use of keywords in the publications?, iii) what are the trends and directions of development in critical and creative thinking in science research?

2. RESEARCH METHOD

This research is based on systematic quantitative research. To evaluate the literature on the critical and creative thinking in science education field, we employ bibliometric analysis to assess search results in Scopus on the Friday, September 2th, 2022 at 10.15. Researchers ran an online search using the keywords {Critical Thinking and creative thinking in science education} and in the topic area. The period of publications was 2012-2022. Keyword analysis and the title of the article are used to analyze groups and themes for research utilizing Scopus sources in fifth categories. The database contains 319 articles relevant to the critical and creative thinking in science education, including

35 conference papers, 13 article, 4 conference review and 2 review. In this study, sample articles retrieved in *CSV format from Scopus are processed using R Studio software to aid visualization and identify trends [5, 6]. This strategy was influenced by [7, 8].

Thus, a quantitative analysis was conducted, applying performance analysis and science mapping using the RStudio software, which is one of the most used tools by researchers, data analysts, and analytical practitioners to conduct statistical analysis. R integrates several packages and is updated almost daily, making it very helpful for conducting meta-analyses such as bibliometric ones. To perform this study, the Bibliometrix package developed was adopted. Bibliometrix has been gaining increasing attention from scholars in a wide range of disciplines as it enables them to perform descriptive analysis starting with bibliographic databases.

3. RESULTS AND DISCUSSION

The minimum number of occurrences of terms used in the analyzed research results from Scopus. After being analyzed there are five categories, they are by year, countries, author, type, and subject area. The results by year. Researches about critical and creative thinking in science education first appeared in 2002 with only one article until 2004, and then increase in 2005 but down 2006, after that in 2017 have increase very high significantly. If we look at the Figure 1. Research about critical and creative thinking in science education is likely that the number of researches will continue to increase because the critical and creative thinking is a topic that is being discussed [9].
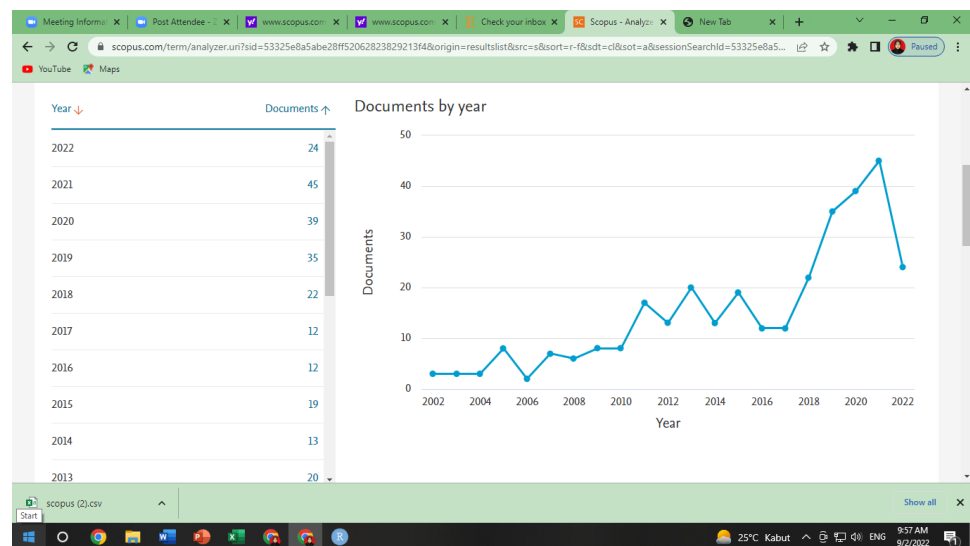

Figure 1: Papers regarding critical and creative thinking on science education published in two decade.

Counting papers by countries for keyword critical and creative thinking in education there many country have research, but from more countries there are ten country have high publication, there are USA, Indonesia, Malaysia, UK, Spain, Turkey, Taiwan, Canada, Australia, and Russian. Refer to Figure 2, USA is the country that publishing the most paper discussing the critical and creative thinking in education. They have 98 papers, and then the second country that have 26 papers form Indonesia, and then Malaysia has 20 papers. But if we look from many citation, we can see from Figure 3. about N Citation paper from countries. There ten countries have many citation, there are USA, UK, Turkey, Australia, Spain, New Zealand, Korea, South Africa, China and Indonesia. Refer to Figure 3. USA is the country that publishing the most citation the critical and creative thinking in education. They have 592 citation, and then the second country that have 145 citation form UK, and then Turkey has 128 citation. From this result, we can see the quality paper and we can compare more citation from countries although small count paper, and from have more papers haven't more quality if he small citation [4]. We can see about citation, spread picture, and collaboration country from R Studio application. In the Figure 4. We can see more countries have publication about critical and creative thinking in science education, we can see the dark blue is more publication and citation but the sky-blue color is have publication but small citation. Figure 5. We can see USA have most papers discussed about critical and creative thinking in science education, that networking with the other countries. Even so, from UK, Malaysia, China, Spain, Portugal, Pakistan, Korea and Canada have multiple collaboration with other country, but paper about critical and creative thinking in science education in Indonesia no have networking research with the other countries. this proves that research on the critical and creative thinking in Indonesia education must continue to be developed and conduct research collaboration with various countries.

The collaboration network shows the major collaborative patterns among researchers in different countries/regions. This have two categories, MCP (Multiple collaboration patterns) from this we can see, that have collaboration with other country but SCP (Single collaboration patterns) is collaboration from country itself. But from many country have high increase research about critical and creative thinking, like Fig. 6 we can see all country have increase for line, that's mean research about critical and creative thinking is trends topics for research and development in science and education.

Document have discussed about critical and creative thinking in science education have some author that can we use for references. Figure 7 we can see about author with more document about critical thinking and creative thinking in science education,
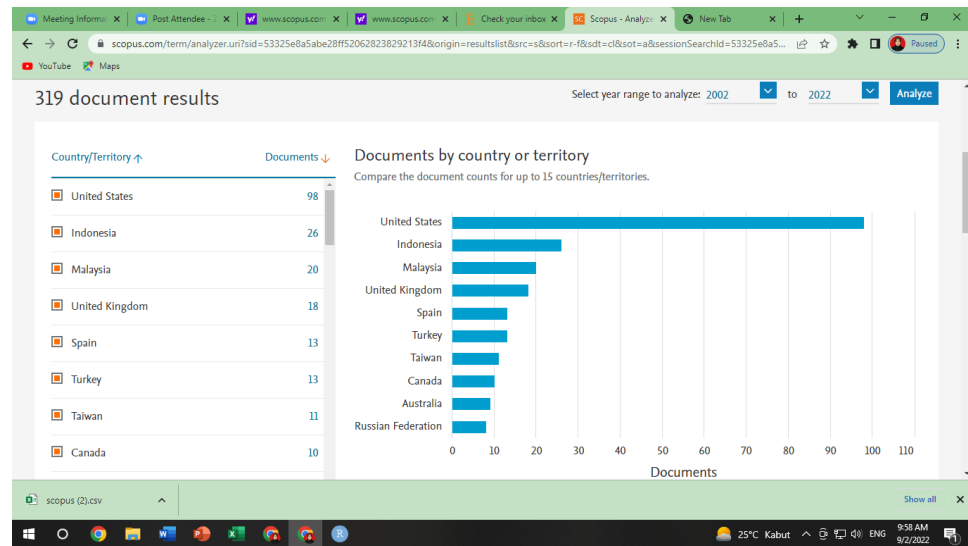
Figure 2: Analize documents counts about critical dan creative thinking in science education for up to 15 countries.
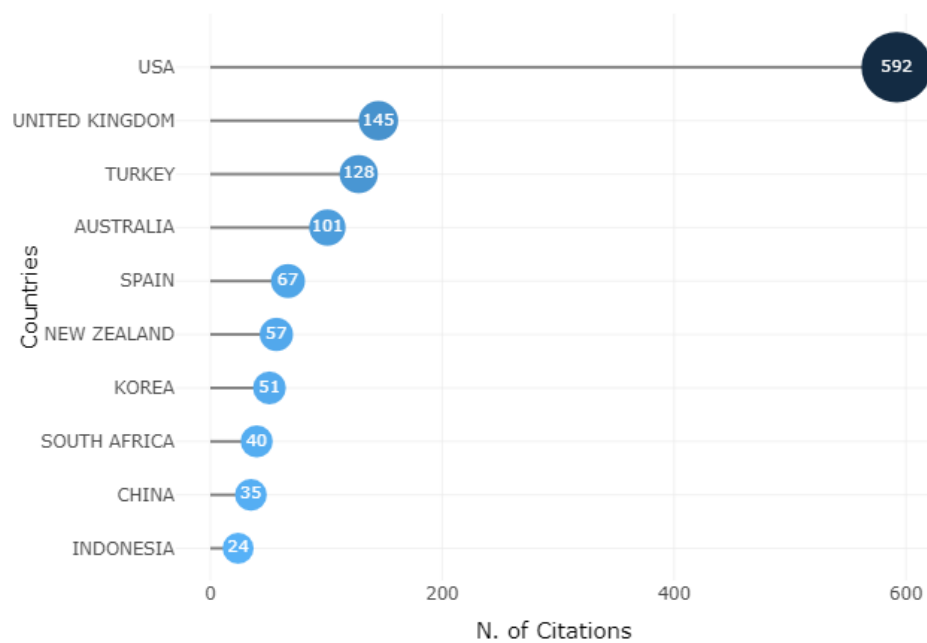

Figure 3: Visualization country and N citations using R studio application.

they are Megri AC, Hamous S, Pinto, etc. Megri have 5 documents, and then Hamous 4 documents, and the others.

This diagram circle from Fig. 8 shows that the highest presentation of publications is in article type and then conferences paper type, and the others. This shows that this research is interesting to be published in reputable article and conferences paper and has a great opportunity to be researched and published by this type of conferences paper.
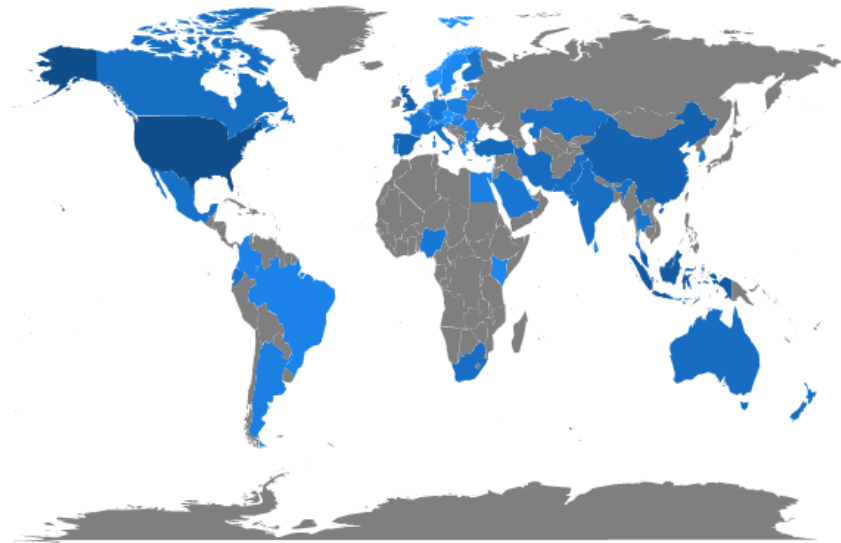
Figure 4: Visualization country publication and citations using R studio application.
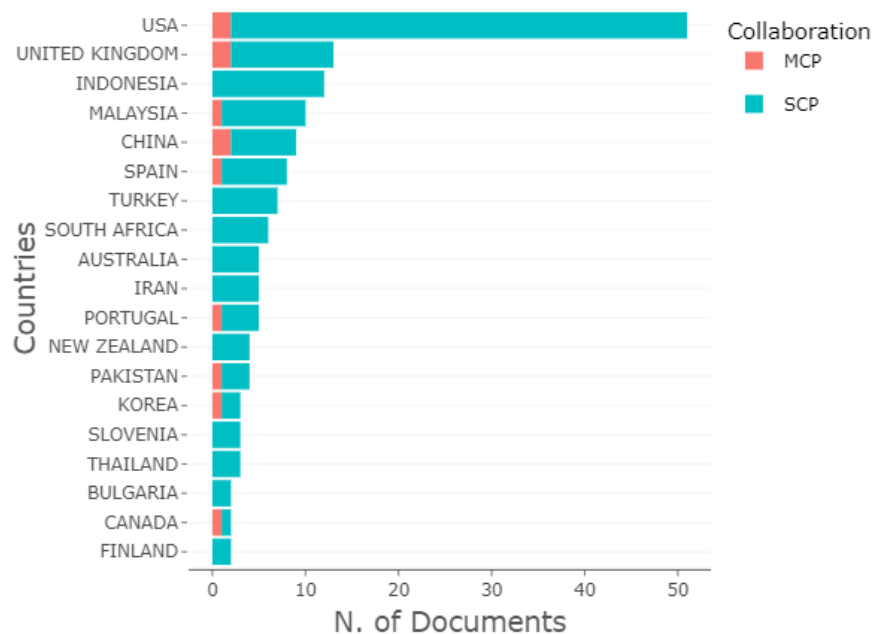

Figure 5: Visualization country collaboration using R studio application.

This section presents the analysis results of keyword in the publication, which help to elucidate the major research themes and research trends in critical and creative thinking in science education, keywords are considered as "content descriptors at macroscopic levels" [10], and the topics in a field can be described by the keywords of relevant publications. [11]. Figure 9. and Figure 10. shows keywords in the publications from R
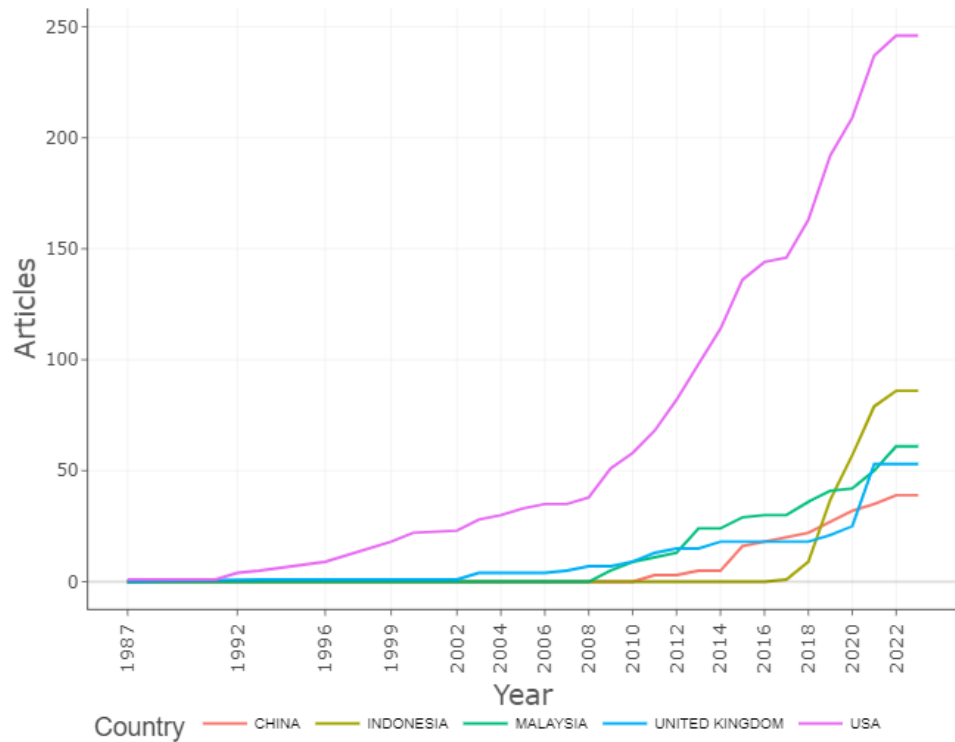
Figure 6: Visualization country increase research about critical and creative thinking using R studio application.
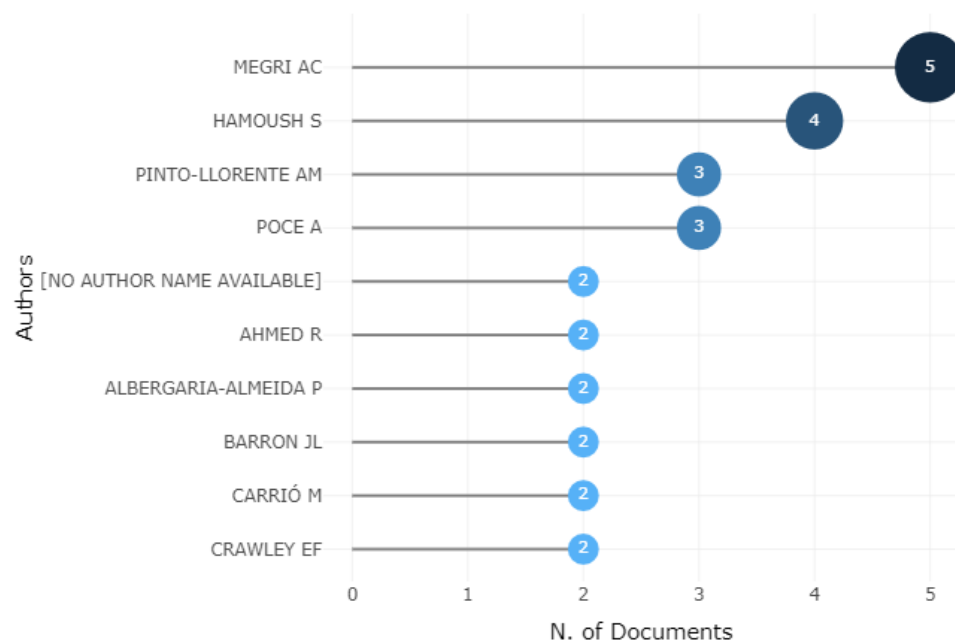

Figure 7: Visualization author discussed about critical and creative thinking using R studio application.

Studio, there are more items that connections with critical and creative thinking which
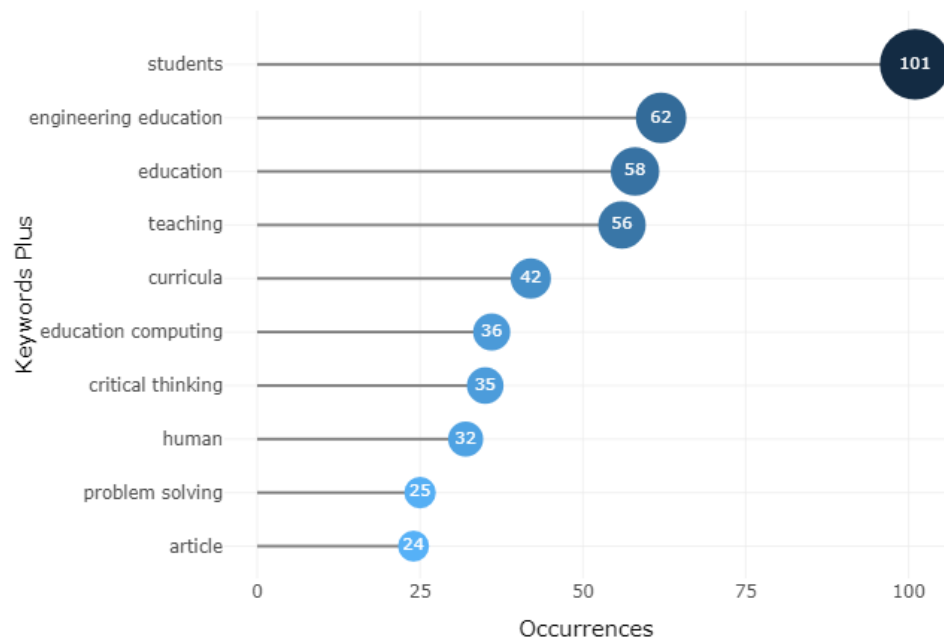
Figure 8: Visualization about documents by type from scopus analysis.

is divided into more colors, but students is items mostly they are (110) 11%, its means the critical and creative thinking more use and try to student, where in the 21st century it is hoped that students' skills can be improved on critical and creative thinking skills. The second item is engineering education have (62) 7%, this is means that with engineering education more help for increase critical and creative thinking in education especially in science education. And than for education have (58) 7%, its mean that in education if we focus for critical and creative thinking so education have build and develop, and more items other.

Figure 9: Visualization items in critical and creative thinking research with R studio.

Figure 10: Visualization keywords plus in critical and creative thinking research with R studio.

More items that we can discussion with critical and creative thinking in science education, but from more items, if we can see trends keywords or item that discuss in this year or five years, we can see from Figure 11 that's from 2017 to 2021 there items that consisten and trend to discuss they are artifial intelligence, learning systems, STEM (science technology, engineering and mathematics), 3D printers, education computing, critical thinking skills, surveys, students, engineering education and the other. But from all items, STEM, learning systems and artificial intelligence are trends topics in this year, so this opportunity for our research about it and develop with from this items, likes artificial intelligence its part from internet of things so we can research about STEM with internet of thing for help increase critical and creative thinking in science education.

The results obtained based on the keywords in the trends topic of different research these in the field of the critical and creative in science education that make the STEM education with artificial intelligence (internet of things). which are critical and creative thinking in STEM for computational thinking, design skill in STEM, using simulation in critical and creative thinking for STEM, using the project for developing critical and creative thinking in STEM, using STEM concepts in internet of things. This provides a great opportunity to conduct research on science education that applies internet of things-based STEM learning for engineering process for increasing the critical and creative thinking in science education.
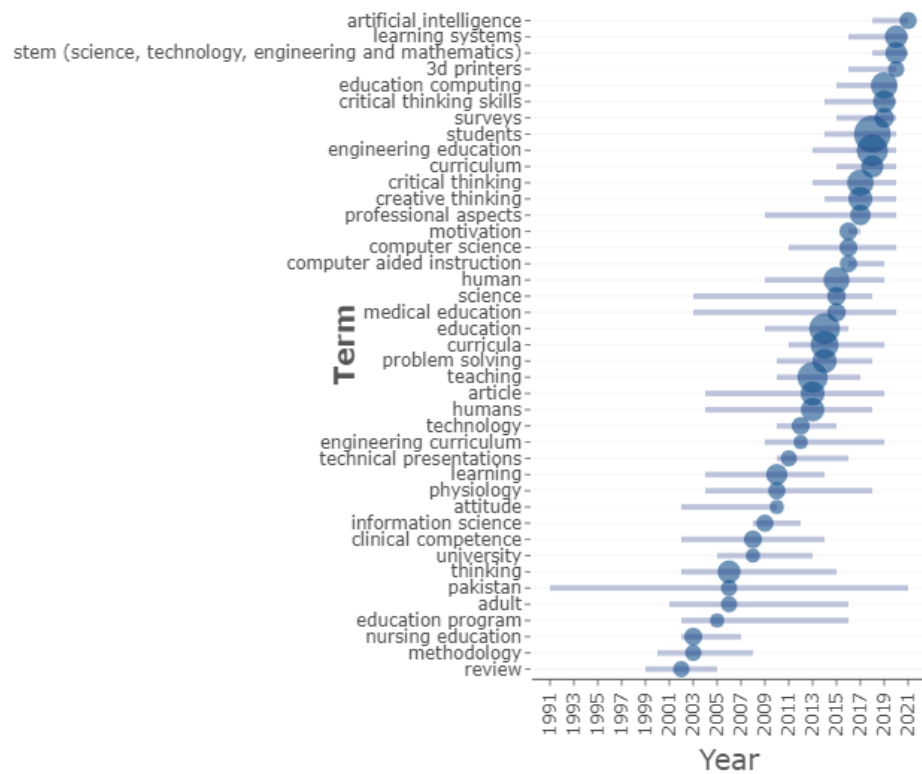
Figure 11: Visualization terms items in critical and creative thinking research by year with R studio.

4. CONCLUSION

Based on results and discussion, we may conclude that the development of research on the trends in the critical and creative thinking in science education area from 2002 to 2022 fluctuates. Most publications on this theme are 2021 with only 45 articles. As for document types, 319 article documents have been published. Seen from the types or types documents that are widely studied are in the form of articles followed by articles and conference paper. This study obtained data form various research themes and their relationships with each other. This article visualizes various literature through bibliometric analysis to identify the main themes in each study or scope. According to the results obtained from this study, R Studio had visualization and Scopus analysis. If we see the data from scopus and R Studio are many new authors who are interested researching critical and creative in the field of science education and many publication about subject area of social science from a near year, that's means many opportunity that can be discussed critical and creative thinking in social science.

References

[1] Jacob SM, Sam HK. "Measuring critical thinking in problem solving through online discussion forums in first year university mathematics.," In: Proceedings of the Internationals MultiConference of Engineers and Computer Scientists (IMECS), Hong Kong (2008).

[2] Afriansyah EA, Herman T, Turmudi T, Dahlan JA. Mendesain soal berbasis masalah untuk kemampuan berpikir kritis matematis calon guru. Mosharafa: Jurnal Pendidikan Matematika. 2020;9(2):239–50.

[3] Kartowagiran B, Kusuma M, Santoso PH, Bahri S. "Developing a test based on the 21st century skills.," In: 5th International Conference on Current Issues in Education (ICCIE 2021). pp. 121–126. Atlantis Press (2022).

[4] Yilmaz A. The effect of technology integration in education on prospective teachers' critical and creative thinking, multidimensional 21st century skills and academic achievements. Participatory Educational Research. 2021;8(2):163–99.

[5] Petrovich M, Shah M, Foster A. "Augmented reality experiences in informal education.," 2018 IEEE International …. p. 2018. https://doi.org/10.1109/TALE.2018.8615396.

[6] van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2010 Aug;84(2):523–38.

[7] N. Novia, A. Permanasari, and R. Riandi, "Research on educational games in STEM area 2010-2020: A bibliometric analysis of literature.," Journal of Physics: Conference Series. vol. 1806, no. 1, p. 2021. https://doi.org/10.1088/1742-6596/1806/1/012209.

[8] Dai Z, Zhang Q, Zhu X, Zhao L. A Comparative study of chinese and foreign research on the internet of things in education: bibliometric analysis and visualization. IEEE Access. 2021;9:130127–40.

[9] X. Chen, D. Zou, H. Xie, and F.L. Wang, "Past, present, and future of smart learning: A topic-based bibliometric analysis.," International Journal of Educational Technology in Higher Education. vol. 18, no. 1, p. 2021. https://doi.org/10.1186/s41239-020-00239-6.

[10] Chen C, Song IY, Yuan X, Zhang J. The thematic and citation landscape of data and knowledge engineering (1985-2007). Data Knowl Eng. 2008;67(2):234–59.

[11] Chen CM, Tsai YN. "Interactive augmented reality system for enhancing library instruction in elementary schools.," Computers & Education. p. 2012. https://doi.org/10.1016/j.compedu.2012.03.001.