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Mapping Visualization Analysis of Computer Science Research data in 2017-2021 on the Google Scholar database with VOSviewer

Dwi Fitria Al Husaeni, Asep Bayu Dani Nandiyanto
Universitas Pendidikan Indonesia, Indonesia
E-mail: dwifitriaalhusaeni@upi.edu

ABSTRACTS

The purpose of this research is to examine the development and interrelationships between terms in computer science research using mapping analysis with VOSviewer. The research data was collected from the Google Scholar database for the period 2017-2021 using the Publish or Perish 7 application. Data collection was based on the keyword "Computer Science". The data search results found 992 articles that were considered relevant. The results showed that computer science research experienced high popularity in 2018 with a total of 232 articles. Computer science research experienced a decline in research in 2019-2021. Based on the mapping analysis that has been done using the VOSviewer application, computer science terms are connected to 4 main terms in each cluster, namely student, computer science education, education, and skills. Computer science research is mostly associated with the term student, namely the strength of link 221. This research can be used as a reference in determining the research theme or research discussion topic in the field of computer science.

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1. INTRODUCTION

Computer science is generally defined as the study of computers, hardware, and software (Armoni & Gal-Ezer, 2014). Computer science is rooted in electronics, mathematics, and linguistics (Alhazov, 2010). Computer Science covers a wide range of computer-related topics, from abstract analysis of algorithms to more specific topics such as programming languages, software, and hardware. Computer science focuses more on computer programming and software engineering. Computer science is a branch of science that deals with computers and computing. Computer Science covers theory, component testing, and design and includes questions related to the theoretical understanding of computer devices, programs, and systems, experimental development and testing of computational concepts, design methodologies, algorithms, and tools to achieve them, analytical methods to demonstrate that implementation conforms to requirements.

The development of the times is getting faster due to drastic technological changes. Therefore, computer science personnel are needed in the workplace because all human needs can be facilitated because of technology (Tussyadiah, 2020). Therefore, research on computer science also needs to know its development so that it can continue to develop as the times. Analysis of mapping visualization can be used to determine the development of computer science research. Currently, there are many studies on mapping analysis, including new science mapping analysis software tool (Cobo et al., 2012), science mapping analysis using R-tool (Aria & Cuccurullo, 2017), equity mapping analysis (Wolch et al., 2005; Jurado de Los Santos et al., 2020; Talen, 1998; Mennis & Jordan, 2005), mapping analysis about magnetic properties and energy (Xiang et al., 2013), and mapping analysis of the pipeline for pooled RNA-seq (Hill et al., 2013).

However, there is no research on mapping analysis that discusses research in the field of computer science based on text data and bibliographic data using VOSviewer. Therefore, this research examines the analysis of mapping data for computer science publications using VOSviewer by visualizing the mapping into three types, namely network visualization, overlay visualization, and density visualization. Thus, through this research, it can be seen that the terms of computer science research are connected to facilitate the search for other fields of discussion that have high novelty in the field of computer science.

2. METHODOLOGY

This study uses a mapping analysis method on a data set of articles published in journals from 2017 to 2021 indexed by Google Scholar. Data retrieval from the Google Scholar database is open source. To get the data from the research, we use the reference manager application Publish or Perish 7. All data were obtained on 12 January 2022. The Publish or Perish software review the literature on a predefined topic is "Computer Science". Detailed information for installing and using software (Google Scholar and Publish or Perish 7) and a step-by-step process for obtaining data were described in our previous study (Al Husaeni & Nandiyanto, 2022).

There are several stages carried out in this research:

(i) Determination of study topics,
(ii) Collection of publication data is taken from the Google Scholar database using the Publish or Perish 7 application.
(iii) Processing of text data and bibliometric data on articles that have been obtained using Microsoft Excel application, which is converted into three file formats, namely research information systems (.ris), comma-separated value format (*.csv) and excel workbook (*.xlsx)

(iv) Visualization of publication data mapping using the VOSviewer application version 1.6.16, and
(v) Analysis of mapping analysis results.

Visualization of mapping text data and article bibliometric data is made in 3 types, namely network visualization, density visualization, and overlay visualization based on the relationship between existing items. Data mapping is carried out in 2 steps, namely mapping based on text data and mapping based on bibliographic data. Data mapping based on text data found 5972 terms. The terms that have been found are re-sorted with several provisions including the minimum number of occurrences of a term is 10. Therefore, the number of terms used in the mapping analysis is 159 terms. Data mapping based on text data is used to see the relationship between existing terms and is used in research in the field of computer science. The second data mapping on the same data was carried out based on bibliographic data. This mapping was carried out to find connections and also to see authors who contributed quite high to research in the field of computer science as recorded by Google Scholar. The rules used in making this data mapping include the maximum number of authors per document is 25 authors, the minimum number of documents of an author is 3 times. Thus, it was found that 87 authors from 2073 authors met the criteria and entered the data mapping process.

3. RESULT AND DISCUSSION

3.1. Publication Data Search Results

The search results for published data on computer science found 992 articles in the Google Scholar database for 2017-2021. Table 1 presents one of the article data used in the VOSviewer mapping analysis. All article data that has been obtained are then sorted based on their citation values so that the 20 best articles with the highest citations are found as presented in Table 1. From the data in Table 1, it is found that the highest citations were dominated by articles published in 2017, which were 20 articles with an average number of citations of 114.4 times. The average citation in 2017 for 20 articles with the highest citations was 22.88 times per year.

Table 1. Computer science publication data

No	Authors	Title	Year	Cites	Cites Per Year	Cites Per Author	Refs
1	Weintrop, D., & Wilensky, U	Comparing block-based and text-based programming in high school computer science classrooms	2017	204	40.80	102	Weintrop & Wilensky (2017)

No	Authors	Title	Year	Cites	Cites Per Year	Cites Per Author	Refs
2	Webb, M., Davis, N., Bell, T., Katz, Y. J., Reynolds, N., Chambers, D. P., & Sysło, M. M.	Computer science in K-12 school curricula of the 2lst century: Why, what, and when?	2017	182	36.40	30	Webb et al. (2017)
3	Borrego, C., Fernández, C., Blanes, I., & Robles, S.	Room escapes at class: Escape games activities to facilitate the motivation and learning in computer science	2017	182	36.40	46	Borrego et al. (2017)
4	Sax, L. J., Lehman, K. J., Jacobs, J. A., Kanny, M. A., Lim, G., Monje-Paulson, L., & Zimmerman, H. B.	Anatomy of an enduring gender gap: The evolution of women's participation in computer science	2017	177	35.40	35	Sax et al. (2017)
5	Wang, D., Liang, Y., Xu, D., Feng, X., & Guan, R.	A content-based recommender system for computer science publications	2018	173	43.25	35	Wang et al. (2018)
6	Vakil, S.	Ethics, identity, and political vision: Toward a justice-centered approach to	2018	114	28.50	114	Vakil (2018)

No	Authors	Title	Year	Cites	Cites Per Year	Cites Per Author	Refs
		equity in computer science education					
7	Passey, D.	Computer science (CS) in the compulsory education curriculum: Implications for future research	2017	95	19.00	95	Passey (2017)
8	Giannakos, M. N., Pappas, I. O., Jaccheri, L., & Sampson, D. G.	Understanding student retention in computer science education: The role of environment, gains, barriers, and usefulness	2017	87	17.40	22	Giannakos et al. (2017)
9	Garcia, R., Falkner, K., & Vivian, R.	Systematic literature review: Self-Regulated Learning strategies using e-learning tools for Computer Science	2018	80	20.00	27	Garcia et al. (2018)
10	Leyton-Brown, K., Milgrom, P., & Segal, I. (2017).	Economics and computer science of a radio spectrum reallocation	2017	66	13.20	22	Leyton-Brown et al. (2017)

No	Authors	Title	Year	Cites	Cites Per Year	Cites Per Author	Refs
11	Fields, D. A., Kafai, Y., Nakajima, T., Goode, J., & Margolis, J. (2018).	Putting Making into High School Computer Science Classrooms: Promoting Equity in Teaching and Learning with Electronic Textiles in Exploring Computer Science	2018	65	16.25	13	Fields et al. (2018)
12	Qian, Y., Hambrusch, S., Yadav, A., & Gretter, S.	Who needs what: Recommendations for designing effective online professional development for computer science teachers	2018	61	15.25	15	Qian et al. (2018)
13	Weintrop, D.	Block-based programming in computer science education	2019	56	18.67	56	Weintrop (2019)
14	Bonham, K. S., & Stefan, M. I.	Women are underrepresented in computational biology: An analysis of the scholarly literature in biology,	2017	55	11.00	28	Bonham & Stefan (2017)

No	Authors	Title	Year	Cites	Cites Per Year	Cites Per Author	Refs
		computer science, and computational biology					
15	Burnette, J. L., Hoyt, C. L., Russell, V. M., Lawson, B., Dweck, C. S., & Finkel, E.	A growth mindset intervention improves interest but not academic performance in the field of computer science	2020	53	26.50	13	Burnette et al. (2020)
16	Ehrlinger, J., Plant, E. A., Hartwig, M. K., Vossen, J. J., Columb, C. J., & Brewer, L. E.	Do gender differences in perceived prototypical computer scientists and engineers contribute to gender gaps in computer science and engineering?	2018	51	12.75	10	Ehrlinger et al. (2018)
17	Bers, M. U.	Coding as another language: a pedagogical approach for teaching computer science in early childhood	2019	50	16.67	50	Bers (2019)
18	Malik, S. I., & Al-Emran, M.	Social Factors Influence on Career Choices for Female Computer	2018	49	12.25	25	Malik & Al-Emran (2018)

No	Authors	Title	Year	Cites	Cites Per Year	Cites Per Author	Refs
		Science Students.					
19	Nissim, K., Bembenek, A., Wood, A., Bun, M., Gaboardi, M., Gasser, U., O'Brien, D.R., Steinke, T. & Vadhan, S.	Bridging the gap between computer science and legal approaches to privacy	2017	48	9.60	8	Nissim et al. (2017)
20	Hur, J. W., Andrzejewski, C. E., & Marghitu, D.	Girls and computer science: experiences, perceptions, and career aspirations	2017	48	9.60	16	Hur et al. (2017)

3.2. Research Developments in Computer Science Research

The development of research on computer science over the last 5 years, namely from 2017-2021 which has been published in Google Scholar indexed publications amounted to 992 articles. The number of each publication in sequence from 2017 to 2021 is 198, 232, 208, 206, and 148 articles. Table 2 also shows that the most researched and published articles on computer science in 2018 amounted to 232 articles and the least research occurred in 2021, namely 148 articles. The average publication for the last 5 years is 198.4 articles. The development of research on computer science is shown more clearly in Fig. 1.

Table 2. Development of computer science research.

Year	Number of Publication Per Year
2017	198.0
2018	232.0
2019	208.0
2020	206.0
2021	148.0
Total	**992.0**
Averange	**198.4**

Fig. 1 shows that in 2017 research on computer science there were 198 articles and there was an increase in publications in 2018 to 232 articles. However, it decreased in 2019 to 208 articles. Research on computer science continues to decline from 2018, namely 2020, there were 206 articles and 148 articles in 2021. Overall, it can be seen that the increase occurred only in 2018 only. In the following year, it continued to decline.

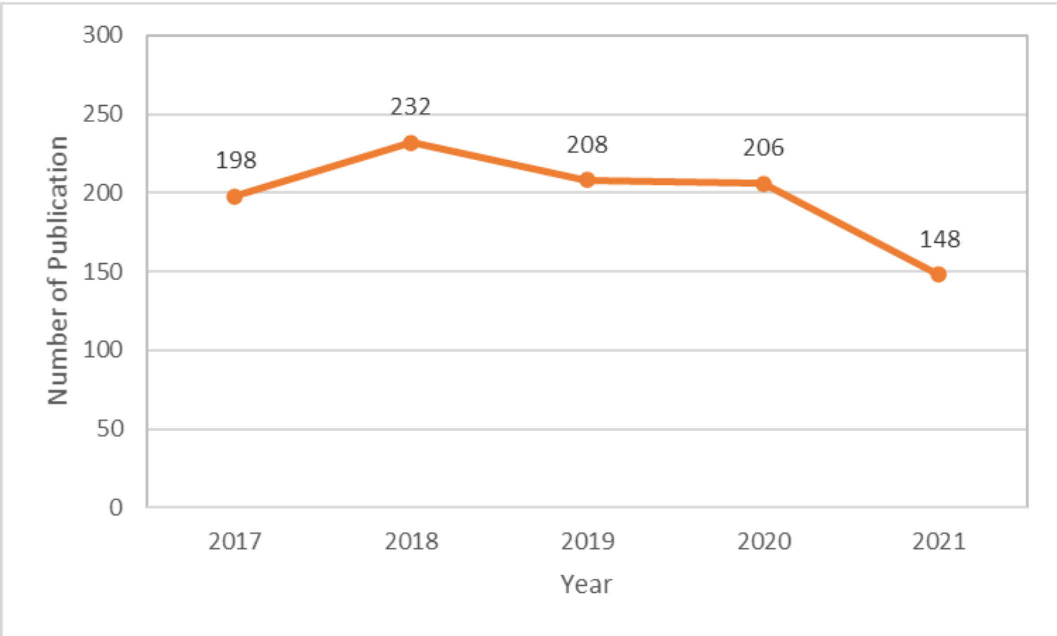

Fig. 1. Level of development in computer science research.

3.3. Mapping Analysis based on Text Data of Computer Science using VOSviewer

In mapping the analysis based on text data using the VOSviewer application. Found 5792 terms relevant to computational thinking research. However, in this study, we give the minimum number of occurrences of the term to be 10 times. Therefore, the results obtained are 136 items used in the process of mapping data analysis. Research related to computer science based on network visualization is divided into 5 clusters and there are 5028 links.

Cluster 1 has 37 items, marked in red and presented in Fig. 2. The items in cluster 1 are access, assessment, challenge, classroom, computational thinking, computer science curriculum, computer science education, computer science educator, computer science program, computer science teacher, content, curricula, curriculum, development, effort, equity, evaluation, faculty, framework, implementation, implication, information technology, knowledge, learner, learning, opportunity, perception, practice, program, project, school survey, teacher, teaching, technique, tool, and understanding.

Cluster 2 has 36 items and is marked in green, shown in Fig. 3. The items in cluster 2 are algorithm, application, approach, area, artificial intelligence, aspect, computer, computer science, computer science department, computer science perspective, computer science research, computer scientist, computing, data, data science, discipline, fact, field, focus, mathematics, model, paper, perspective, physics, problem, process, research, researcher, science, social science, system, technology, term, theoretical computer science, theory, and topic.

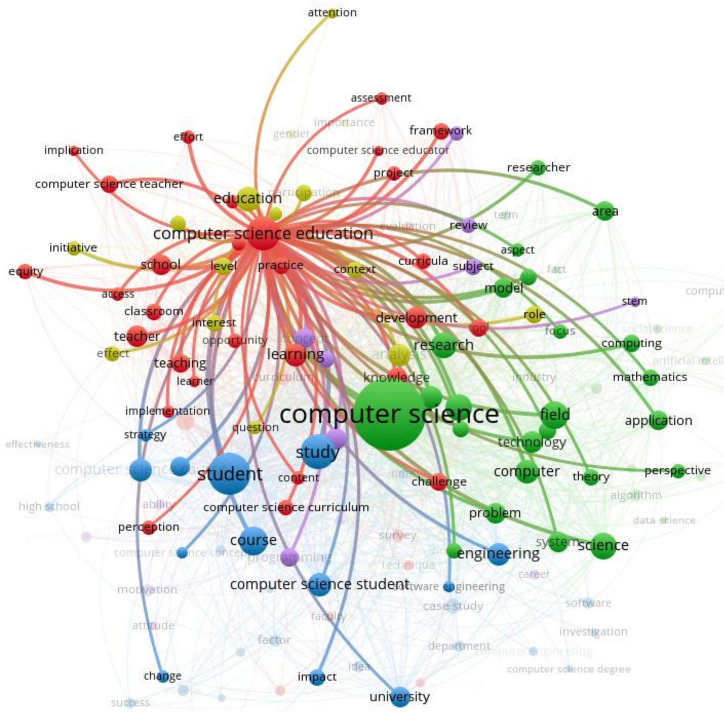

Fig. 2. Network visualization of the main term in cluster 1.

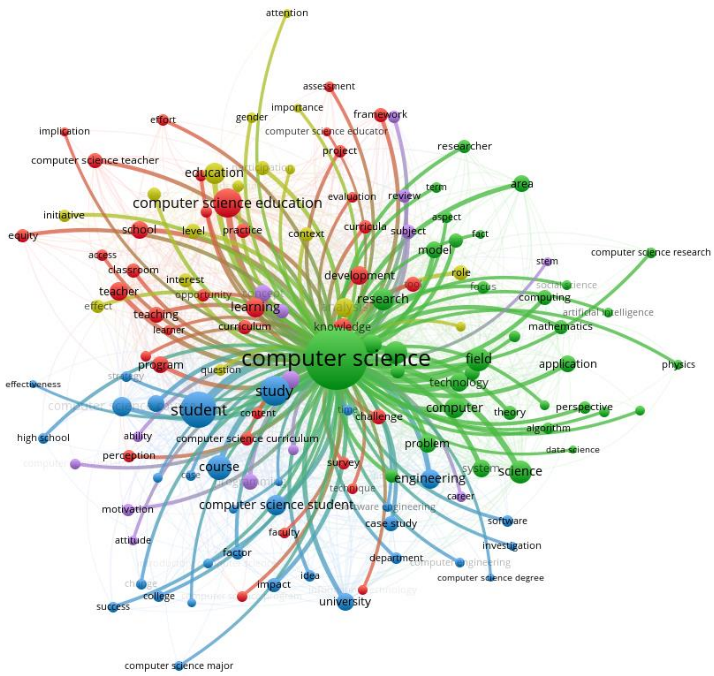

Fig. 3. Network visualization of the main term in cluster 2.

Cluster 3 has 32 items and is marked in blue, shown in Fig. 4. The items in cluster 3 are case, case study, change, college, computer engineering, computer science concept, computer science course, computer science degree, a computer science major, computer science student, course, department, effectiveness, engineering experience, factor, high school, higher education, idea, impact, introductory computer science, introductory computer science course, investigation, software, software engineering, strategy, student, study, success, systematic literature review, time, and university.

Cluster 4 has 17 items marked in yellow, shown in Fig. 5. The items in cluster 4 are analysis, attention, context, demand, education, effect, gender, group, importance, industry, initiative, level, participation, question, relationship, and role.

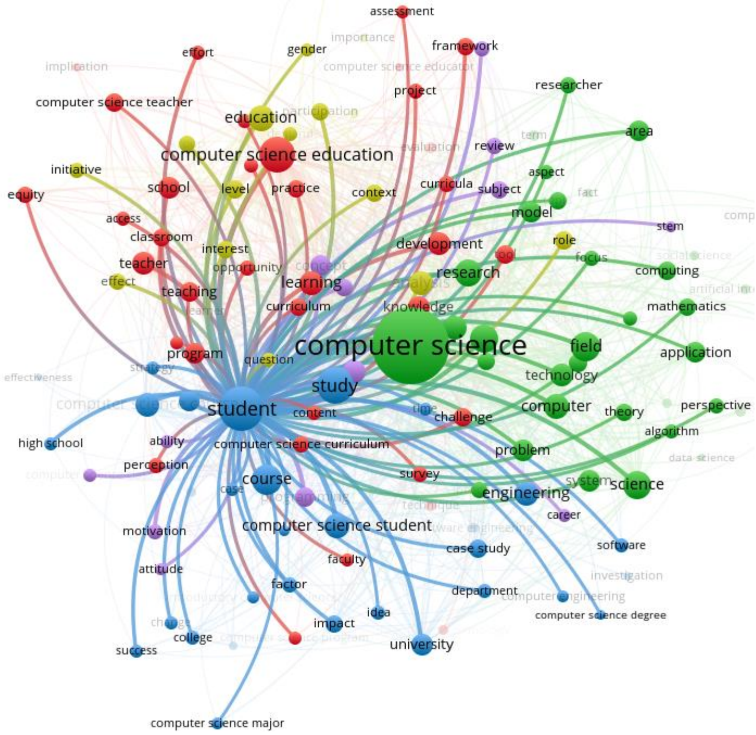

Fig. 4. Network visualization of the main term in cluster 3.

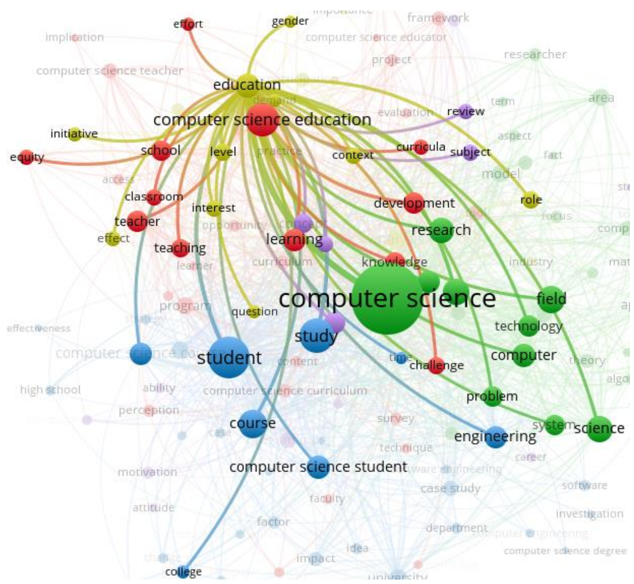

Fig. 5. Network visualization of the main term in cluster 4.

Cluster 5 has 14 items and is marked in purple (Fig. 6). The items in cluster 5 are ability, activity, attitude, career, computer science class, concept, goal, information, motivation, programming, review, skill, stem, and subject.

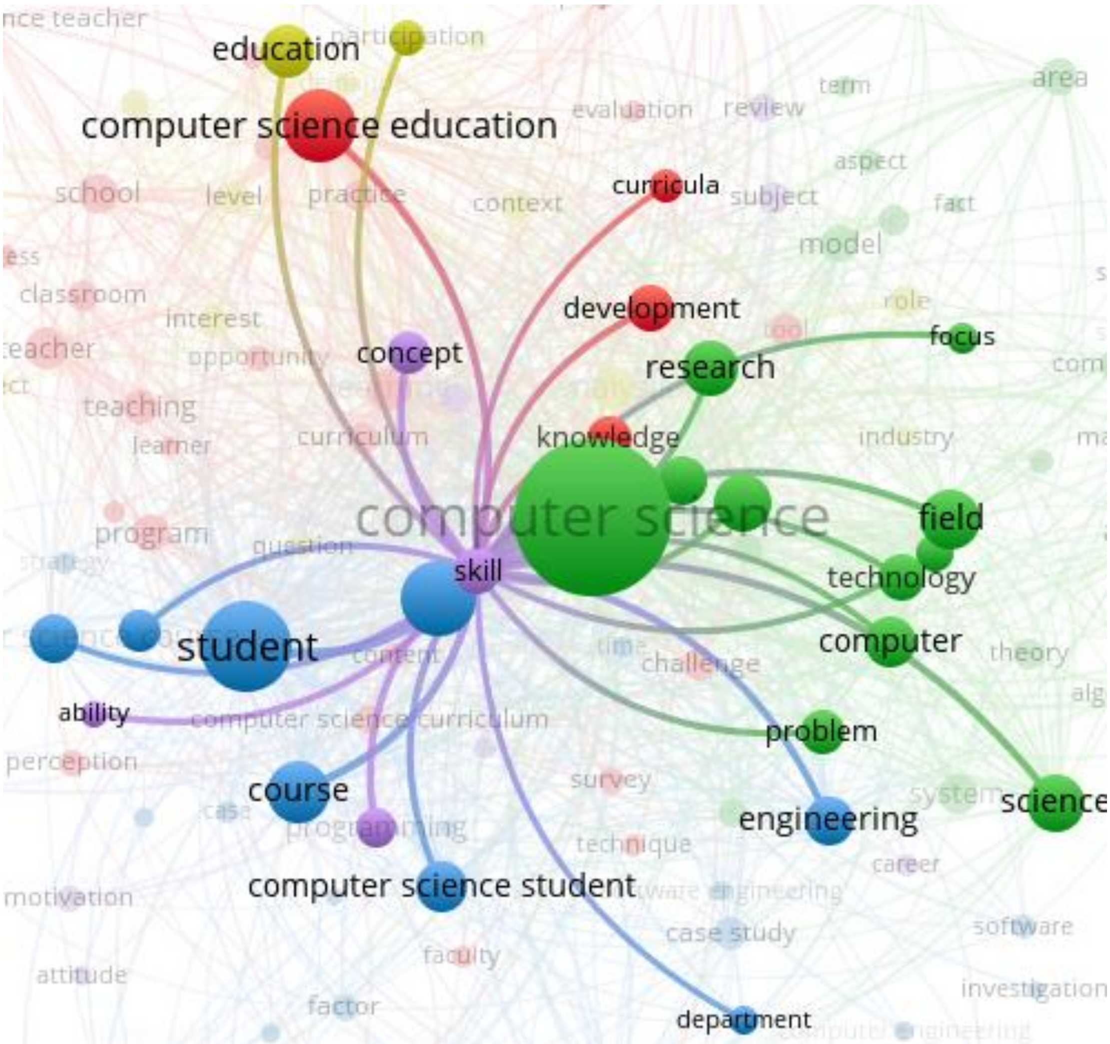

Fig. 6. Network visualization of the main term in cluster 5.

In mapping analysis using VOSviewer, cluster describes the relationship between one term and another (Nandiyanto et al., 2021; Al Husaeni & Nandiyanto, 2022; Nandiyanto & Al Husaeni, 2021). The existing terms are labeled and also different colors. The color indicates the term cluster is located. The size of each label indicates the frequency with which the term appears or is used in computer science research. If the size of the circle label is bigger, the more often the term is used, and vice versa, the smaller it is, the less often it is used (Nandiyanto et al., 2021; Al Husaeni & Nandiyanto, 2022; Nandiyanto & Al Husaeni, 2021).

Fig. 7 illustrates the network visualization in mapping analysis with VOSviewer. Network visualization shows the relationship from one term to another and shows the occurrences of that term. Based on Fig. 7, it can be seen that the term computer science has the largest label size. This shows that the term computer science has a high frequency of occurrences and the connection with other terms is also high.

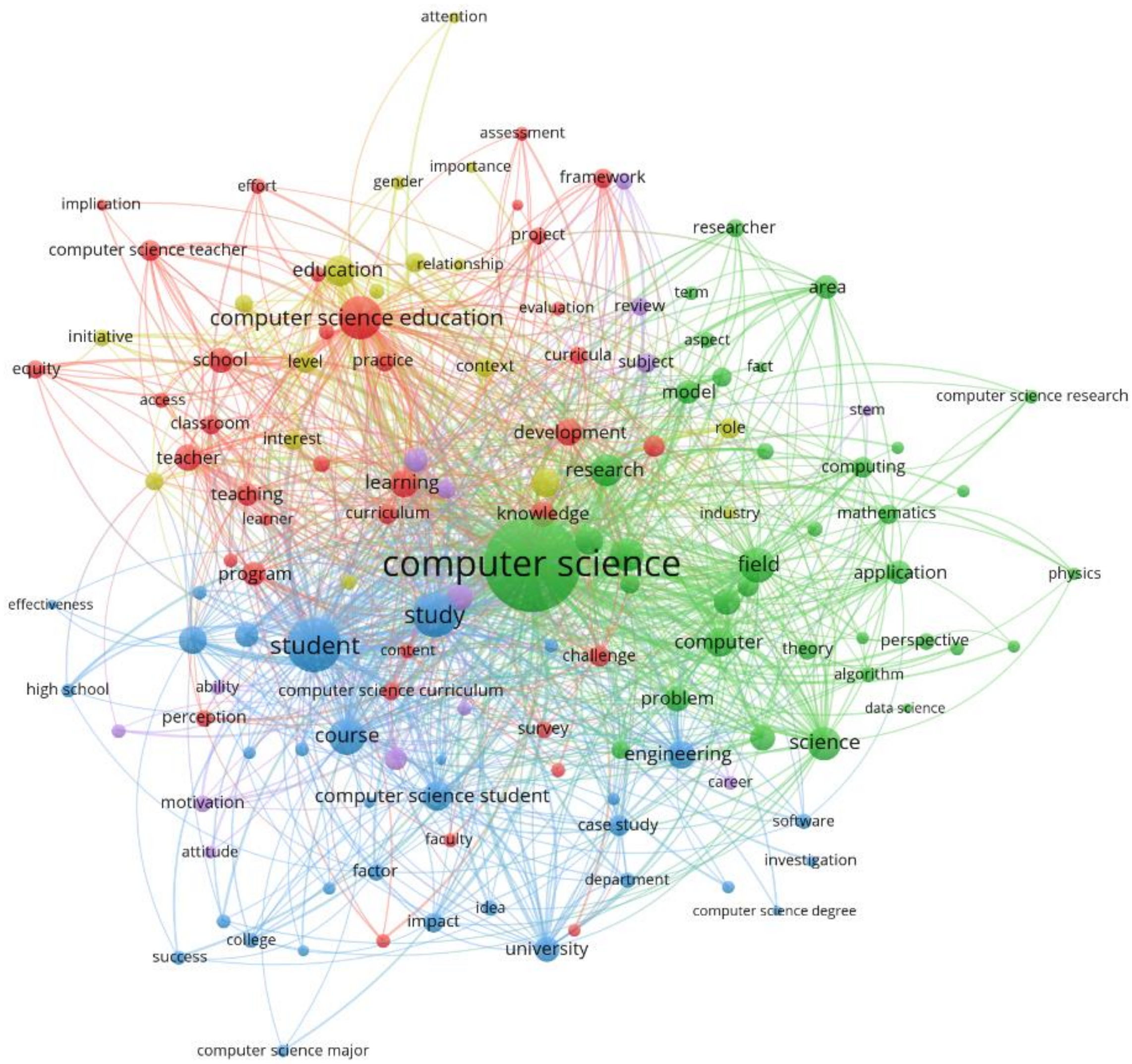

Fig. 7. Network visualization of computer science research.

In this study, we found 4 main terms that have a fairly high degree of connectedness with computer science terms, namely computer science education term with link strength of 116 (Fig. 8a), student term with link strength of 221 (Fig. 8b), education term with link strength of 78 (Fig. 8c), and skill term with link strength 58 (Fig. 8d). The link strength range of terms that are related to research in the field of computer science can be seen in Fig. 9. Fig. 9 shows that research with the theme of computer science has the highest correlation with the student term. This shows that many researchers are researching computer science and it is related to the student condition or term student.

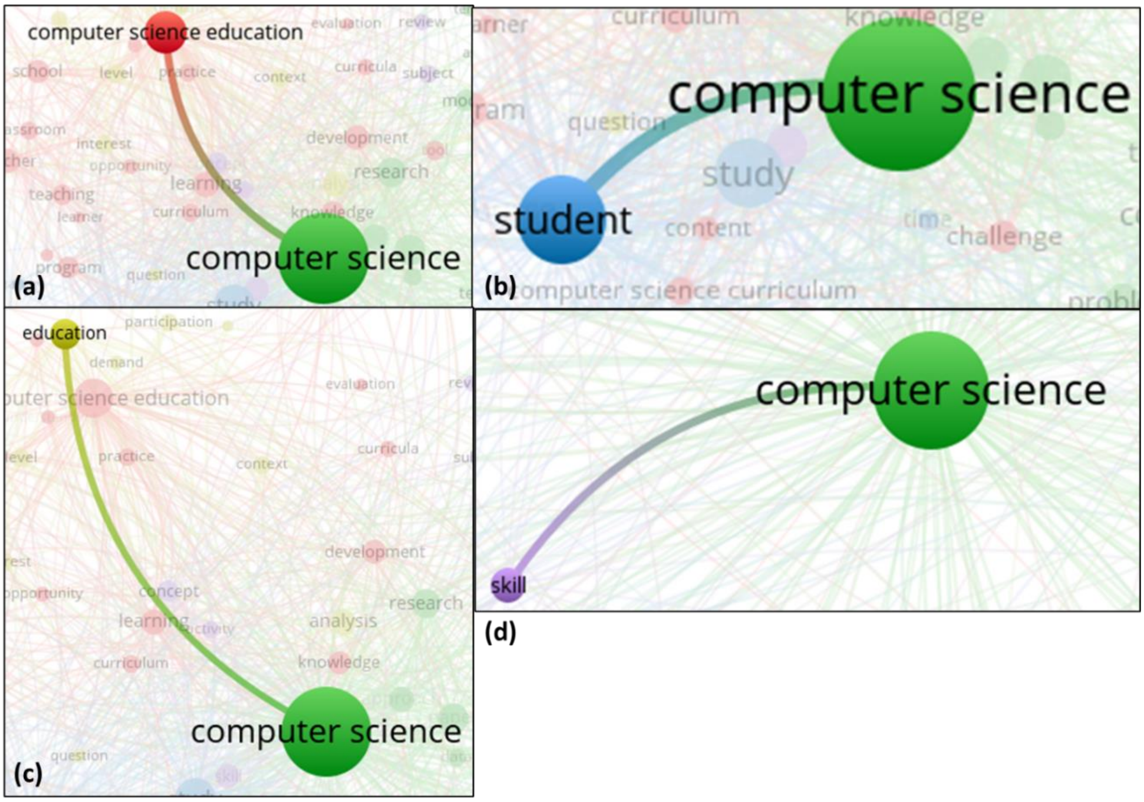

Fig. 8. Network the relationship between computer science research and other terms (a) computer science to computer science education; (b) computer science to students; (c) computer science to education; and (d) computer science to skills.

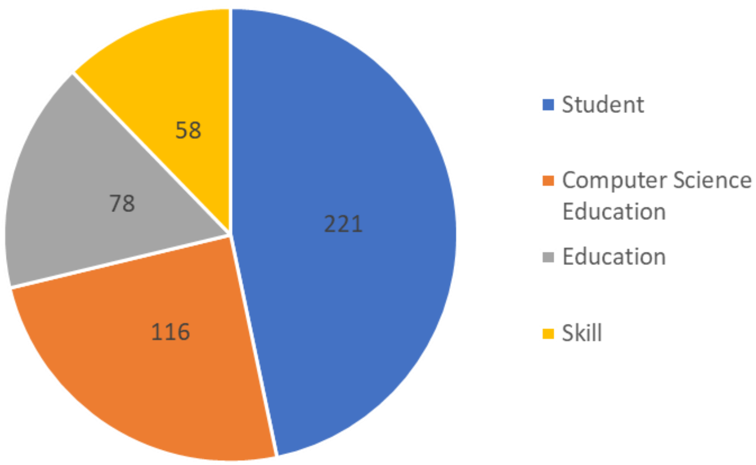

Fig. 9. The link strength range of terms that are related to research in the field of computer science.

Fig. 10 illustrates the overlay visualization of research in the field of computer science from 2017 to 2021. The overlay visualization shows the novelty of research on related terms (Nandiyanto et al., 2021; Al Husaeni & Nandiyanto, 2022; Nandiyanto & Al Husaeni, 2021). Many types of research on computer science have been carried out in the 2018-2019 timeframe as shown in Fig. 11. The term computer science has the largest research time in 2018.8-2019.0. Therefore, when computer science research is in 2020-2021 there are still many opportunities to get new research. Mapping analysis on overlay visualization data using VOSviewer can be used as a reference for new research with the theme of computer science (Nandiyanto et al., 2021; Al Husaeni & Nandiyanto, 2022; Nandiyanto & Al Husaeni, 2021).

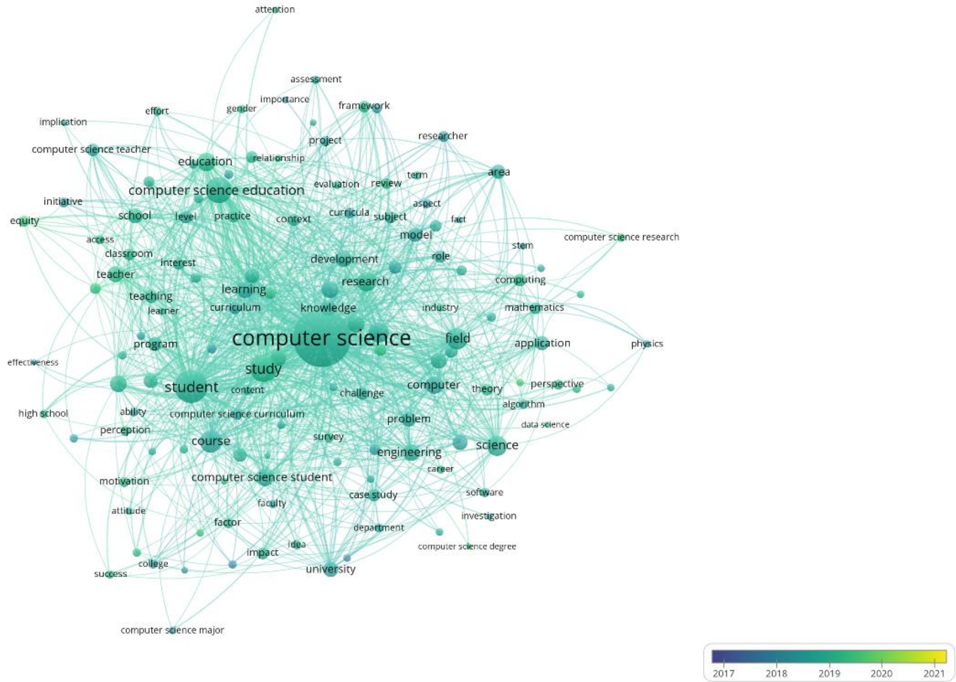

Fig. 10. Overlay visualization of computer science research on 2017-2021.

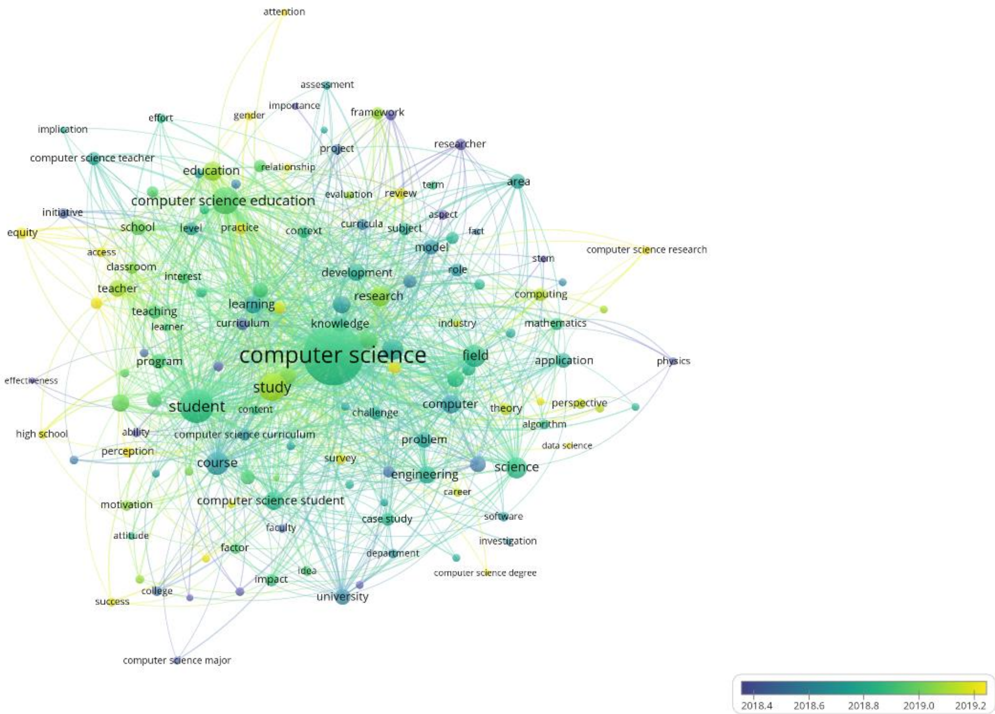

Fig. 11. Overlay visualization of computer science research on 2018-2019.

3.4. Mapping Analysis based on Bibliographic Data of Computer Science using VOSviewer

Mapping analysis based on bibliographic data was conducted to see which authors contributed the most to the field of computer science research published and indexed by Google Scholar. Fig. 12 shows the network visualization author with the most contributions to the collected data. The data shows that Goode, j has the most contribution to research in the field of computer science in 2017-2021 which is published and indexed by Google Scholar, which contributes 12 published article documents.

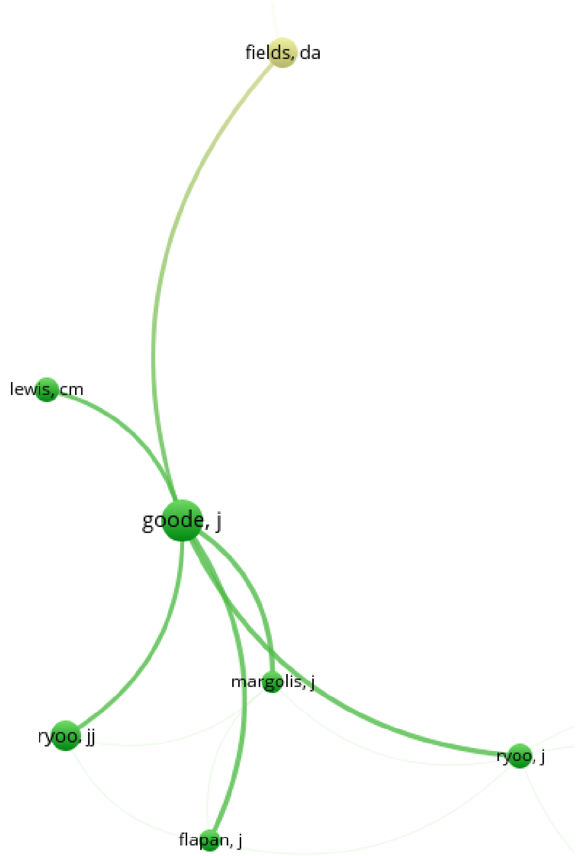

Fig. 12. Network visualization of the author in computer science research.

From the results of this research, we can look for several topics of research in computer science education and their relationship to several other fields of discussion. We can also determine research themes that are more recent and in accordance with research trends in the year concerned, by looking at the track record of previous research.

4. CONCLUSION

The Publish or Perish 7 application was used to collect data from the Google Scholar database for the period 2017-2021. The keyword "Computer Science" was used to collect data. The data search yielded 992 articles that were thought to be relevant. With a total of 232 papers, the results showed that computer science research was quite popular in 2018. In the years 2019-2021, there was a decrease in computer science research. Computer science terms are linked to four key terms in each cluster, according to the mapping analysis performed with the VOSviewer application: student, computer science education, education, and skills. The term "student" is commonly connected with computer science research, specifically the strength of link 221.

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