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Bibliometric Computational Mapping Analysis Using Vosviewer: A Review on Pedagogy for Early Childhood and Computer Science

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Bibliometric; Computational mapping analysis; Computer science; Early childhood; Pedagogy, VOSviewer.

Abstract

This study aims to examine the trend of pedagogy research for early childhood and computer science using the bibliometric mapping analysis method with VOSviewer. Data collected from this research are articles that have been published and indexed by Google Scholar. Keywords such as "pedagogy", "early childhood", and "computer science" are used in performing data collection through the Publish or Perish (PoP) software application. 996 articles were obtained, ranging from 2012 to 2021 (10 year-time). The result of this research shows that the theme of pedagogy for early childhood and computer science fluctuated from 2012 to 2015. Meanwhile, it experienced a drastic decline in the past 6 years (2016-2021). From these results, there are three main research themes obtained, namely pedagogy (290 links, total link strength of 2444, and 377 occurrences), early childhood (228 links, total link strength of 752, and 102 occurrences), and computer science (254 links, total link strength of 1403, and 213 occurrences). Topics that tend to be frequently researched are pedagogy, science, technology, teacher, education, child, play, use, early childhood education, skills, school, and computer science. Hence, there are numerous research topics that should be explored, developed, and conducted. Therefore, the study of pedagogy for early childhood and computer science is possible to be developed in parallel with other research topics.

Kata Kunci: *Bibliometrik; Analisis pemetaan komputasional; Ilmu komputer; Anak usia dini; Pedagogi, VOSviewer;*

Abstrak

Penelitian ini bertujuan untuk melihat tren penelitian pedagogi untuk anak usia dini dan ilmu komputer menggunakan metode analisis pemetaan bibliometrik dengan VOSviewer. Data yang dikumpulkan dari penelitian ini adalah artikel yang telah dipublikasikan dan diindeks oleh Google Scholar. Kata kunci seperti "pedagogi", "anak usia dini", dan "ilmu komputer" digunakan dalam melakukan pengumpulan data melalui aplikasi (software) Publish or Perish (PoP). Diperoleh 996 artikel, mulai dari tahun 2012 hingga 2021 (rentang waktu 10 tahun). Hasil dari penelitian ini menunjukkan bahwa tema pedagogi untuk anak usia dini dan ilmu komputer mengalami fluktuasi dari tahun 2012 hingga 2015. Sementara itu, mengalami penurunan drastis dalam 6 tahun terakhir (2016-2021). Dari hasil tersebut, terdapat tiga tema penelitian utama yang diperoleh, yaitu pedagogi (290 links, total kekuatan links 2444, dan 377 kemunculan), anak usia dini (228 links, total kekuatan links 752, dan 102 kemunculan), dan ilmu komputer (254 tauta links, total kekuatan links 1403, dan 213 kemunculan). Topik yang cenderung sering diteliti adalah pedagogi, sains, teknologi, guru, pendidikan, anak, bermain, penggunaan, pendidikan anak usia dini, keterampilan, sekolah, dan ilmu komputer. Oleh karena itu, ada banyak topik penelitian yang harus dieksplorasi, dikembangkan, dan dilakukan. Oleh karena itu, studi pedagogi untuk anak usia dini dan ilmu komputer memungkinkan untuk dikembangkan secara paralel dengan topik penelitian lainnya.

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1. Introduction

Disruption causes changes in how human beings live, without the exception in the aspect of education. The current concept of education is not interpreted as a conventional intellectual process carried out in schools. However, education itself must be able to adapt with the integration of technology in the learning process. Optimizing technology helps teachers and students in improving learning quality. Research shows that technology can be utilized by teachers in preparing learning contents through various references so that the materials can be absorbed in ease by the students (Huda, 2020). Technology does not have any intention in replacing teachers, but it has the aim to assist teachers in guiding students to understand concepts contextually in an optimal manner.

Paradigm of education should be opened and could be taken as an advantage through the role of technology as a realization of developing potential educated people according to their era. Such process must not neglect the value of education as a process of humanization (Sya'baniah & Kuswanto, 2021). Humanization can be viewed as an approach in learning by positioning students as learning subjects who have the potential to develop (Barantsova & Rutkovskyi, 2022). Hence, teachers play a significant role in the learning process of students by providing various stimuli for them in acquiring knowledge, attitudes, skills, and be able to adapt with technological advances.

With the ever-changing age of technology, the urgent need for education especially in early childhood education to have technology integrated into the curriculum. Computer science education even at the elementary level can unlock several avenues that can enhance computational thinking and problem-solving skills that are some of the most critical abilities required of the 21st century (Chevalier et al., 2020; Waterman et al., 2020). The implementation of computer science in early childhood poses several issues, including curriculum constraints, the preparedness of teachers, and appropriate pedagogical measures for child development. As a result, this study will examine effective learning methods for computer science in early childhood.

In the context of early childhood education, the introduction of technology needs to be integrated in the learning process in line with previous statements. It aims for teachers and students to optimize technology as a tool to stimulate knowledge of the students in understanding a concept of a particular learning material. The empirical conditions show that some early childhood schools (PAUD) have implemented digital-based learning contents. For instance, the use of several computer applications to stimulate children's cognitive aspects using augmented reality (AR), virtual reality (VR), and much more. Computer-based learning is a type of learning that has the orientation towards the state-of-the-art digital media in increasing the learning motivation of the children (Warsita, 2008). It can also be defined as a type of learning that optimizes technology, such as computers, as a media in delivering learning materials (Setiyadi, 2016). Viewed in the pedagogical perspective as educators, it can be inferred that it is necessary to understand the concept of education that is recently developed by integrating technology in designing teaching and learning experiences with the purpose of developing students' potential and competencies.

Through this research, an analytical technique to determine the development of research in the field of computer science for early childhood education pedagogy, namely bibliometric analysis, is conducted. It is a form of meta-analysis of research data that can assist researchers in observing, analyzing, and studying bibliographic content and citation analysis from articles published in journals and other scientific works.

There have been many studies on bibliometric analysis, including bibliometric analysis in research on chemistry (Modak et al., 2020; Grandjean et al., 2011), special needs education (Al Husaeni et al., 2023a), Vocational school (Al Husaeni & Nandianto, 2023b), publication of Augmented Reality in education (Nugraha et al., 2023), Scientific publications (Mulyawati & Ramadhan, 2021), and others. While there are a number of studies that examine early childhood education (ECE) and the introduction of computer science concepts separately, there are not many studies that specifically integrate ECE pedagogy with computer science instruction. The main gap in this research is the lack of proven pedagogical approaches to teaching basic computer science concepts to young children, as well as an understanding of how to adapt technology curricula to suit the cognitive and social developmental needs of children in the early stages of life. This research offers a new approach by developing a pedagogical model that combines the principles of early childhood education with basic computer science materials.

The novelty of this research is to look at the trend of early childhood pedagogical development by combining game-based learning techniques, practical exploration, and interactive technology to teach basic computer science concepts. Specifically, the purpose of the bibliometric analysis in this study is to see the Computational Mapping Using Vosviewer software application by collecting publication data of articles related to the topic from 2012-2021 (in the last 10 years).

2. Methods

Data used in this study are articles obtained from the Google Scholar database through the Publish or Perish software application. Google Scholar has become one of the well-known publicly accessible sources when it comes to looking for literature and or reference. After obtaining the data, the articles are analysed using the mentioned technique. The stage of the bibliometric analysis includes searching of reference, filtering, bibliometric attribute checking, and bibliometric analysis. The details of each step according to (Azizahet al., 2021) are as the followings: a) data collection regarding the publications using Publish or Perish; b) processing of bibliometric data from filtering the publications using Microsoft Excel; c) computational mapping analysis towards the bibliometric data using VOSViewer; and 3) analysing the results obtained from the mapping.

Keywords such as "pedagogy", "early childhood", and "computer science" are used in filtering the available publications. In maintaining the novelty of this research towards knowledge, the articles collected are from 2012 to 2021 (recent 10 year-time). The collected articles with the defined criteria are exported into two file formats, namely (.ris) and (.csv). VOSViewer is then used to visualize and evaluate trends using bibliometric maps.

To ensure the transparency of the research, the data collection process in this study is described in more detail, including the search strategy used, the criteria for selecting articles, and the method of assessing the quality of the sources analyzed. The search strategy was conducted through reputable academic databases with customized keywords to obtain relevant literature (Bramer et al., 2018). In addition, this study used VOSviewer software for bibliometric analysis, which was chosen for its ability to intuitively visualize the relationships between research topics. The justification for choosing VOSviewer is based on its superiority in processing citation, co-occurrence, and co-authorship data over other software, although there are some limitations that also need to be considered. Furthermore, the analysis techniques used in this study include network visualization, density visualization, and overlay visualization (McAllister et al., 2022; Nugraha et al., 2023). Network visualization was used to identify interrelationships between concepts in the research field, density visualization to highlight the most developed research areas, and overlay visualization to observe research trends over time.

3. Result and Discussion

Publication data search results

As much as 996 articles according to the study topics have been determined in the study. The data obtained is in the form of meta data from articles consisting of the author's name, title, year, journal name, publisher, number of citations, article links, and related URLs. The following can be seen through Table 1 which shows some examples of data published using the VOSviewer application based on this research. The data samples taken were the 10 best articles based on the highest number of citations from 2012-2021. The number of citations from all articles obtained in this study is 89944, cites/year is 8994.40, cites/paper is 90.21, author/paper is 2.45, h-index is 144, and g-index is 233.

Tabel 1. Pedagogy for early childhood and computer science publication data.

No	Authors	Title	Cites
1	Dicheva et al., (2015)	Gamification in education: A systematic mapping study	2031
2	Daniel (2012)	Making sense of MOOCs: Musings in a maze of myth, paradox and possibility	1995
3	Koehler et al., (2013)	What is technological pedagogical content knowledge (TPACK)?	1197
4	Weintrop et al., (2016)	Defining computational thinking for mathematics and science classrooms	1144
5	Chatti et al., (2012)	A reference model for learning analytics	907
6	Chai et al., (2013)	A review of technological pedagogical content knowledge	862

7	Rodriguez (2012)	MOOCs and the AI-Stanford Like Courses: Two Successful and Distinct Course Formats for Massive Open Online Courses.	859
8	Papamitsiou et al., (2014)	Learning analytics and educational data mining in practice: A systematic literature review of empirical evidence	814
9	Rattan et al., (2012)	"It's ok—Not everyone can be good at math": Instructors with an entity theory comfort (and demotivate) students	792
10	Alharbi et al., (2014)	Using the technology acceptance model in understanding academics' behavioural intention to use learning management systems	747

Research development in the field of pedagogy for early childhood and computer science

Table 2 shows the development of research on pedagogy for early childhood and computer science published indexed journal of Google Scholar. The data shows that the trend of research developments on pedagogy for early childhood and computer science undergo an increase for 3 years (2012-2015), meanwhile a decline in 2016-2021. Table 2 presents the development of research on pedagogy for early childhood and computer science from 2012 to 2021.

Table 2. Development of pedagogy for early childhood and computer science

Year of Publication	Number of Publication
2012	102
2013	128
2014	120
2015	146
2016	135
2017	112
2018	91
2019	71
2020	68
2021	23
Total	996

The data above represents the development of research related to the theme of pedagogy for early childhood and computer science for the last 10 years (2012-2021). The development of research with this theme fluctuated from 2012 to 2015, after experiencing a very drastic decline in the last 6 years, namely from 135 articles (2016), 112 articles (2017), 91 articles (2018), 71 articles (2019), 68 articles (2020), to 23 articles (2021). From these data, it can be interpreted that research with the theme of pedagogy for early childhood and computer science tends to be unstable and has decreased. The development of the research can be seen clearly in Figure 1.

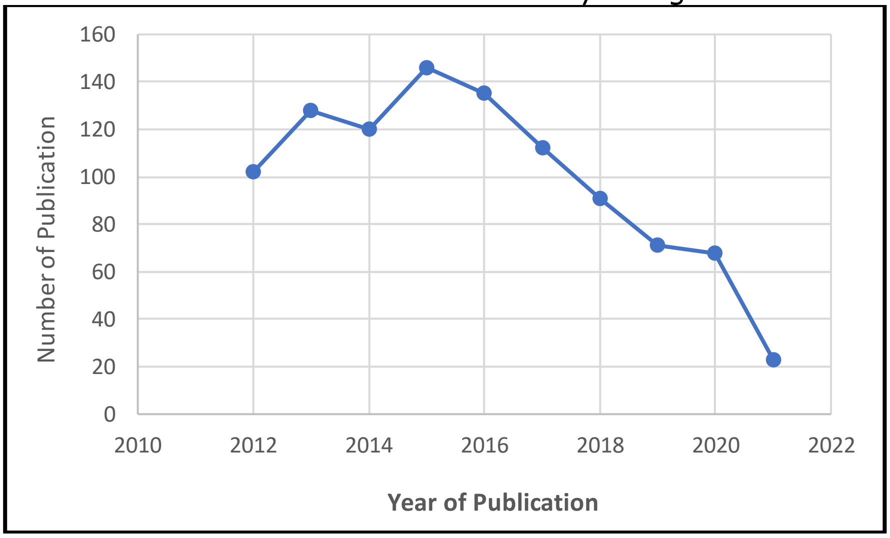

Fig. 1. Level of development in pedagogy for early childhood and computer science

Visualization pedagogy for early childhood and computer science topic area using VOSviewer

Mapping visualization of related articles is performed using the VOSviewer software application. As much as 304 items are obtained through the mapping. Each item found related to pedagogy for early childhood and computer science. There are 11985 links with a total link strength of 24931. The mapping shows 6 different clusters that describe the classification of the total items, namely.

a. Cluster 1 has 60 items marked in red. The 60 items are 21st century, area, attitude, barrier, belief, case, competence, content, content knowledge, control, country, difference, early childhood setting, experience, faculty, framework, future, future teacher, ICT, ICT integration, influence, initial teacher education, knowledge, level, mathematics, pck, pedagogical belief, pedagogical content, pedagogical content knowledge, pedagogical knowledge, pedagogical practice, pedagogical strategy, perception, power, preparation, preservice teacher, problem, process, professional development, program, regard, report, robotic, science learning, science teacher, science teaching, self, self-efficacy, STEM, study, support, teacher, teacher education, technological pedagogical content knowledge, technology, technology integration, tpack, training, variable, year.
b. Cluster 2 has 59 items marked in green. The 59 items are ability, analysis, analitytic, art, application, artificial intelligence, attention, basis, case study, component, computer, computer science, computer science education, development, discipline, effect,

effectiveness, english, focus, hand, heart, higher education institution, history, implementation, importance, intelligent tutoring system, introductory programming, investigation, issue, language, learner, literature, mobile device, music, natural science, new pedagogy, outcome, pedagogical agent, pedagogical approach, pedagogical aspect, pedagogical framework, pedagogical theory, performance, physics, principle, programming, psychology, researcher, review, robot, school, science education, set, skill, social medium, social science, system, theory, tool.

c. Cluster 3 has 52 items marked in blue. The 52 items are care, centre, charge, child, child development, childhood, childhood education, children, classroom, collaboration, community, concern, early childhood, early childhood curriculum, early childhood education, early childhood educator, early childhood pedagogy, early childhood teacher education, early year, early years classroom, effective pedagogy, evidence, family, group, home, identity, implication, instruction, interaction, literacy learning, medium, nature, part, pedagogical implication, pedagogy, perspective, place, play, practice, preschool, question, relationship, response, role, schooling, sense, time, view, voice, way, works, young child.
d. Cluster 4 has 49 items marked in yellow. the 49 items are activity, addition, benefit, challenge, comparison, computer science course, computer science student, concept, course, covid, curriculum, department, e-learning, early childhood centre, early childhood teacher, element, engagement, environment, factor, goal, higher education, information, institution, internet, kind, kindergarten, model, mooc, pandemic, parent, participant, participation, pedagogical activity, pedagogical model, pedagogical perspective, pedagogical process, possibility, primary school, quality, relation, strategy, student, student learning, success, teaching, term, university, variety, word.
e. Cluster 5 has 43 items marked in purple. The 43 items are age, approach, aspect, augmented reality, context, data, decade, earlier year, early age, education, educational technology, educator, engineering, engineering education, evaluation, example, field, game, gap, gender, idea, instance, interest, lens, management, math, need, opportunity, paradigm, pedagogical benefit, pedagogical leadership, pedagogical method, pedagogical potential, professionalism, project, research, resource, serious game, subject, systematic review, type, use, woman.
f. Cluster 6 has 41 items marked in turquoise. The 41 items are achievement, area, assessment, computational thinking, computer scientist, conceptual understanding, digital technology, domain, early childhood classroom, early years education, early years pedagogy, early years setting, effort, examination, exploration, fact, impact, inquiry, insight, integration, journal, learning, learning environment, life, literacy, mobile technology, number, order, paper, pattern, pedagogical design, pedagogical tool, preservice teacher, reality, science instruction, section, stem education, survey, tablet, tablet computer, understanding.

The 6 clusters represent relationships between pedagogy for early childhood and computer science. Cluster 1 shows the most frequent items with the complexity regarding pedagogy and other studies. The least links between pedagogy for early childhood and computer science is from cluster 6 with 41 items. The relationship between one term and another is shows in each existing cluster. Labels are given to each term with colored circles. The size of the circles is determined by the frequency of the term (Bilad, 2022). The size also shows a positive correlation with the occurrence of the term in the title and abstract (Maier et al., 2020). It also applies for the size of the term itself (Al Husaeni & Nandiyanto, 2022). Pedagogy for early childhood and computer science is related to various fields of studies and research. There are 3 different visualization mappings obtained from the analysis using VOSViewer, namely network visualization (see Fig. 2), density visualization (see Fig. 3), and overlay visualization (see Fig. 4).

Network visualization shows the relationship between terms about but not limited to pedagogy for early childhood and computer science. There are various colors that represent identity of each cluster. The terms shown in the figure are most likely present in the research about pedagogy for early childhood and computer science. Terms that have not connected through a line with other terms mean that research about that terms have not been conducted.

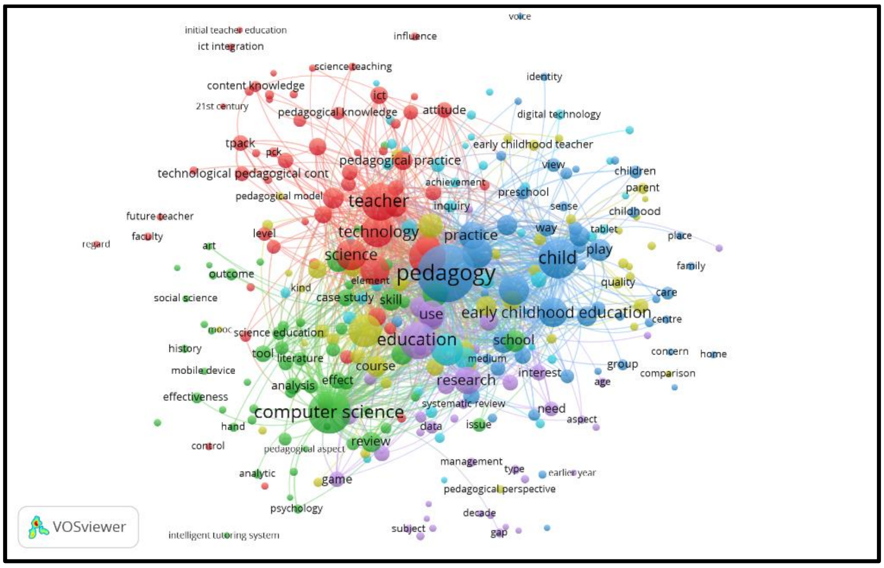

Fig. 2. Network visualization of pedagogy for early childhood and computer science keyword

Similar to the previous visualization, density visualization instead utilizes the color spectrum. The brighter it gets, the more frequent a particular term is being researched. On the contrary, the darker it gets, the less frequent that term is being researched. The figure below shows that the research about pedagogy, science, technology, teacher, education, child, play, use, early childhood education, case study, skill, school and computer science are frequently becoming a research topic. Meanwhile, the opposite applies to early childhood teacher, digital technology, ICT integration, and future teacher. Therefore, the theme of pedagogy for early childhood and computer science is possible to be developed with other research topics.

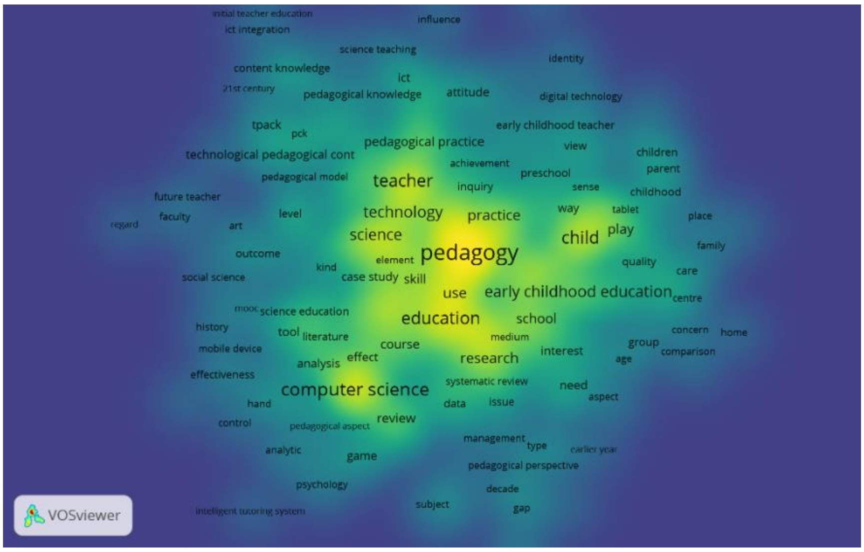

Fig. 3. Density visualization of pedagogy for early childhood and computer science keyword

The last visualization, namely overlay visualization, utilizes both connections between circles and colors. This visualization also uses circles in showing connections between terms. The difference is that the color determines the age of the published article, not the frequency. The following color spectrum represent the year range of the published articles: a) navy blue (2015); b) green (2016); and c) yellow (2017) as shown in the figure.

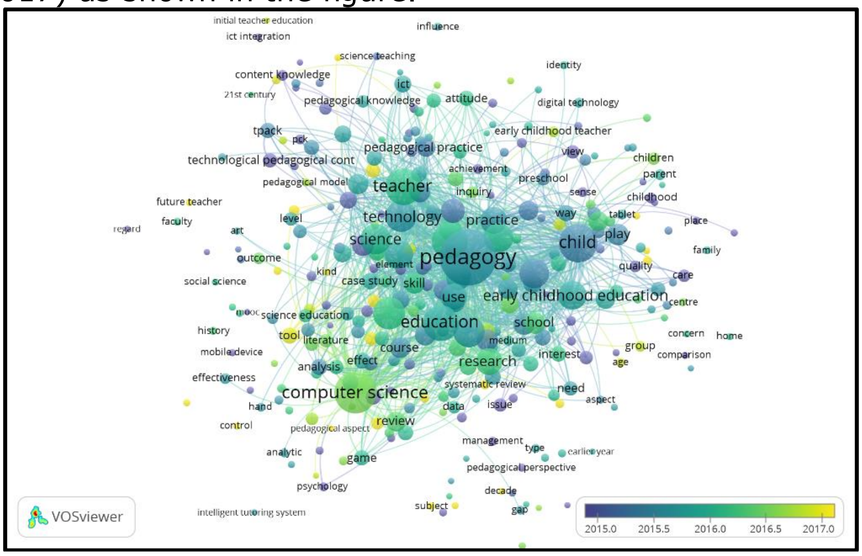

Fig. 4. Overlay visualization of pedagogy for early childhood and computer science keyword

From the clusters as shown in the network visualization, the focus research on pedagogy for early childhood and computer science is classified into 3 classifications which are pedagogy, early childhood, and computer science. The pedagogy theme is included in Cluster 3 with 290 total links, total link strength of 2444, and 377 occurrences (see Fig. 5). The early childhood theme is also included in Cluster 3 with 228 total links, total link strength of 752, and 102 occurences. The last theme which is the computer science theme is included in Cluster 2 with 254 total links, total link strength of 1403, and 213 occurences (see Fig. 6). Fig. 5 shows a network of pedagogy with other terms, namely child, technology, play, early childhood education, view, children, digital technology, identity, early childhood teacher, practice, preschool, sense, quality, group, age, aspect, need, school, issue, research, use, education, data, review, game, psychology, analysis, computer science, effect, course, hand, tool, case study, science, outcome, art, science, level, teacher, pedagogical, content, science teacher, ICT, attitude, report, and professionalism. Figure 6 shows the network of relationships between early childhood terms and existing terms, including attitude, early childhood classroom, parent, play, child, play, aspect, issue, school, research, education, review, computer science, science education, level, teacher, training, technology, case study, use, and science. While Fig. 7 shows a network of computer science relationships connected with the terms of education, ICT, technology, teacher, science, case, outcome, case study, pedagogy, child, school, course, effect, research, data, gap, review, game, psychology, analytics, effectiveness, tool, use, science education, and stem education.

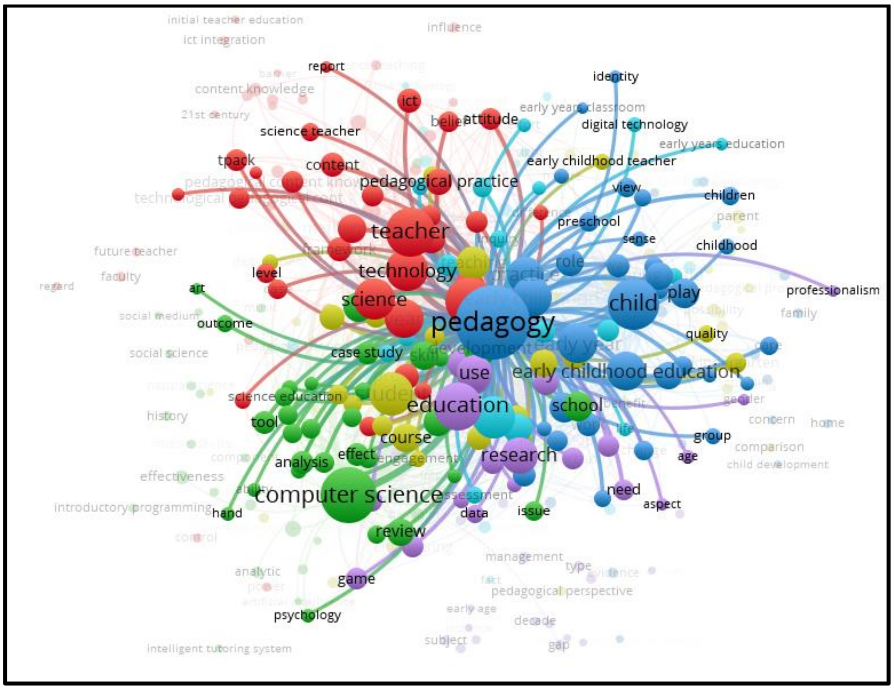

Fig. 5. Network visualization of pedagogy term

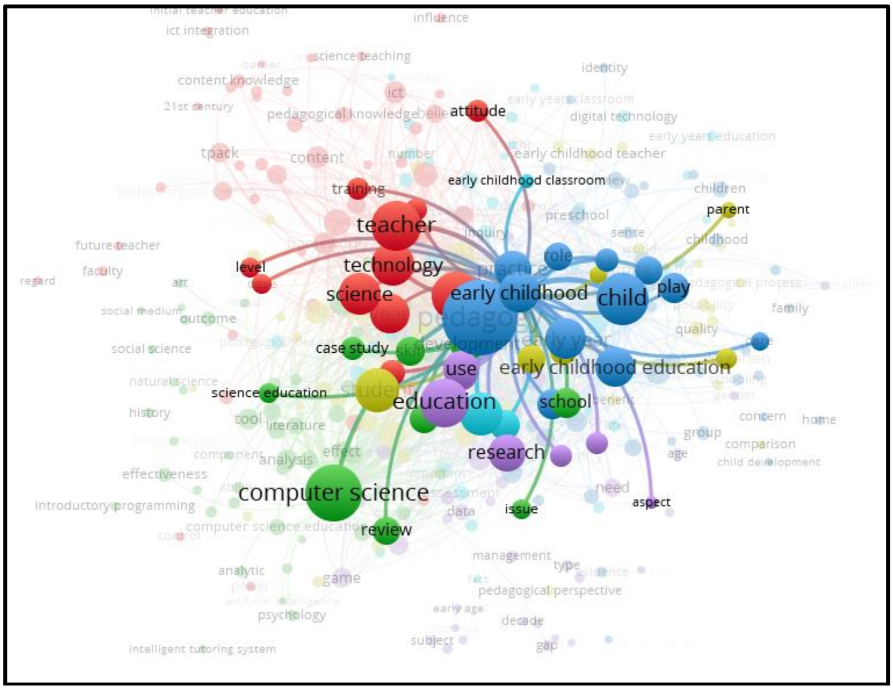

Fig. 6. Network visualization of early childhood term

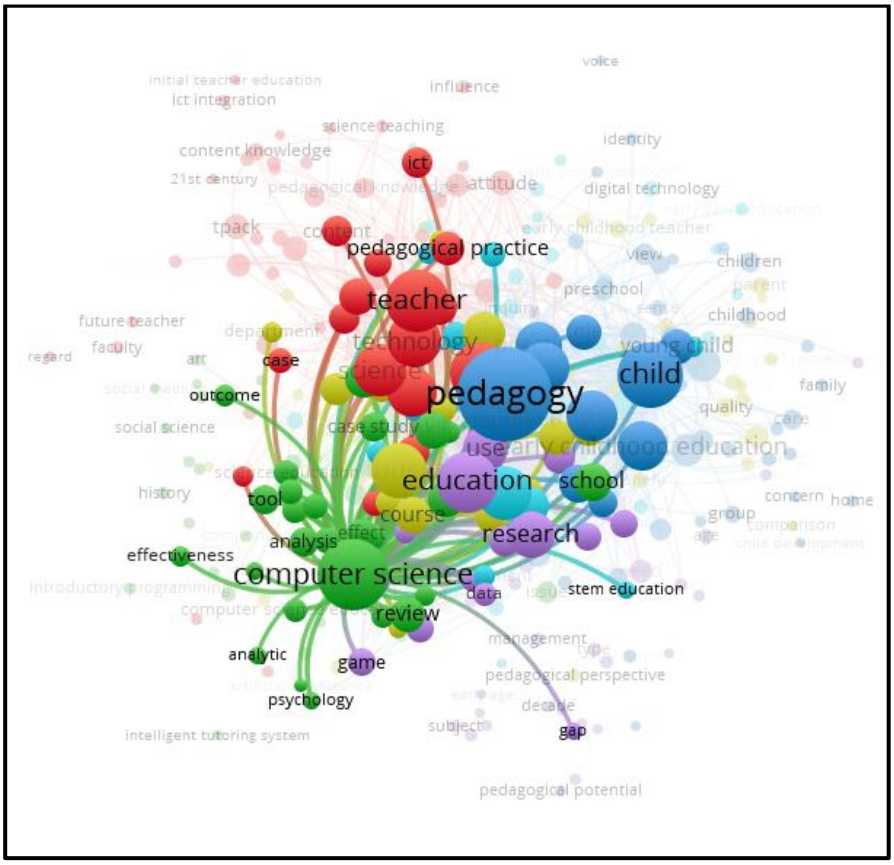

Fig. 7. Network visualization of computer science term

Based on the above data, it can be inferred that pedagogy for early childhood still has a relatively low link strength with computer science. The mapping results show that pedagogy for early childhood is included in Cluster 3 where the theme itself has a strong link and is possible to relate with other themes. On the contrary, computer science is still included in Cluster 2 where it has a low relevance with the other themes.

4. Conclusion

This research has the aim to perform a computational mapping analysis towards bibliometric research articles. The scope of this research is about pedagogy for early childhood and computer science. Based on the findings of this study, it can be concluded that the integration of computer science in early childhood education has significant potential in developing computational thinking skills. The analysis shows that research trends in this area continue to evolve, with a focus on game-based approaches and interactive learning strategies. The findings confirm the importance of developing more adaptive curricula as well as increasing the capacity of educators in teaching computer science concepts from an early age. However, this study has several limitations, including limited data coverage of articles in specific databases as well as the use of bibliometric analysis that does not explore the effectiveness of interventions directly. Therefore, future research is recommended to conduct empirical studies to measure the real impact of different methods of teaching computer science in early childhood. In addition, further exploration of more inclusive and culturally-based pedagogical strategies is also needed to ensure the relevance of learning in various educational contexts. Thus, this research provides an initial contribution to understanding the development of computer science in early childhood education while opening up space for further research that is more in-depth and applicable.

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