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Analysis of Bibliographic Systems Thinking: A Review in the Science Education

Syaiful Rochman[1], Nuryani Rustaman[1]*, Taufik Ramlan Ramalis[2], Andi Suhandi[2], Supriyadi Supriyadi[3], Ismail Ismail[1]

[1]Departement of science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]Departement of Physic Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
[3]Department Physic Education, Universitas Musamus, Merauke, Indonesia

ORCID
Nuryani Rustaman: https://orcid.org/0000-0003-1956-9494
Taufik Ramlan Ramalis: https://orcid.org/0000-0002-7188-5673
Andi Suhandi: https://orcid.org/0000-0001-9912-7308/
Supriyadi: https://orcid.org/0000-0002-5944-3055
Ismail: https://orcid.org/0000-0002-4672-2928

Abstract.
In the last decade research background in science, technology, and social formal education has enlarged our knowledge about complex systems. A study informing conceptual framework across disciplines which is inclusive in system thinking (ST). Its usage in science education has increased rapidly and has also been adapted and elaborated by research networks all over the world. Mix method was used in this review to illustrate ST development in science education. Tabulation of literature inquiry resulted from Scopus database was used to conduct bibliometric and literature review. The number of publications used were within the last decade, namely from 2012 up to 2022. Annotated scores were used to analyze the trend and identify popular and potential publications. Annotated network and diagram of researchers' network together to be analyzed and identified as a group of articles and researchers in various networking roles. Infiltering relevance resulted in about 1867 publications. Bibliographic analysis identified five groups of annotated and distinctive common authors/writers according to general geography, research focus, institutional inspiration, or affiliation. As a set of loosely related science, many researchers in systems thinking have developed various system thinking aspects based on underlying perspectives. A preliminary study was inspired by education-related literature, meanwhile another group adopted the largely inclusive comprehension which combined/integrated knowledge and related system approach. System thinking is concluded as a discussion topic that was getting popular in system thinking comprehension and its approaches in science are openly probable to be studied. In depth recognizing and developing these ideas and groups of authors/writers in system thinking literature can give clarification and possibility or instruction, research, and further developments.

Keywords: bibliographic, systems thinking, science education

Corresponding Author: Nuryani Rustaman; email: nuryanirustaman@upi.edu

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1. INTRODUCTION

The system is a group of goals that are interconnected and organized to achieve something. It can be said that a system is a set or combination of parts that form a complex whole that has a functional relationship and a purpose [1]. The agribusiness system is a system consisting of several subsystems that are related to each other, ranging from input subsystems, production subsystems, marketing subsystems, processing subsystems and supporting subsystems. Therefore, in solving problems that exist in the agribusiness system, the concept of systems thinking can be used.

Systems thinkers should think holistically not reductionist in all situations. What is meant by holistic here is not reducing the problem to smaller parts (segmentation) or not only thinking partially. According to Muhamadi et al. [2], to think that the system requires an awareness to appreciate an event as a system (systemic approach). Events, both physical and non-physical, are seen as a whole as an interaction between system elements. In developing an agribusiness system, the problems studied should not only concern one subsystem but also need to be considered as a whole from the upstream subsystem to the downstream subsystem and also the supporting subsystems.

Systems thinking is an alternative form of way of thinking outside the mechanistic and reductionist paradigms which sees a phenomenon through the analysis of its parts separately [1]. In systems thinking perspective, a comprehensive understanding of a phenomenon resulting from the analysis of various levels of components by looking at the interrelationships between a component that characterizes a part of a system. Systems thinking is a cognitive capital to gain a thorough understanding. However, systems thinking is neither intuitive nor innate. need time to practice this skill very explicitly [3]. Various pedagogical strategies used in the context of higher education are related to continuous learning, including visionary projects that focus on developing future thinking skills, such as the development of back casting strategies [4], pun strategies [5], strategy concept mapping [6], development of learning and assignment models [7, 8], and development through software applications [9]. In addition to focusing on generating new ideas, the development of systems thinking skills in learning must also involve common pedagogical elements.

Research is a process of collecting and analyzing data systematically in achieving certain goals. Evaluation of research activities depends on the availability of data from scientific research activities. In 1958, Eugene Garfield founded the Scientific Information Institute, an organization that later founded the Science Citation Index (SCI). SCI is the first large reference database to introduce impact factors, namely the first prestige

indicator for scientific journals [10]. In the last ten years, much literature has been accessed on systems thinking by various research methods, but no bibliometric analysis of systems has been reported in Scopus indexed journal publications. This means that there is a need for bibliometric analysis research on program coordination. Research on the topic of systems thinking in science education using the bibliometric method has not been carried out, so it cannot find articles on this topic. The novelty of this research is using the bibliometric analysis method, so the author wants to know how much international articles have developed with the topic of program coordination from 2012 to 2022.

The formulation of the problem in this study is as follows: (1) how is the trend of publishing articles on systems thinking in science education in 2012-2022; (3) how is the writer's cooperation regarding systems thinking in science education in 2012-2022; (4) What is the trend term in the title of the article about systems thinking in science education in 2012-2022; (5) What is the trend of the author's keywords in articles about systems thinking in science education in 2012-2022?; (6) How is the trend of abstract terms about systems thinking in science education in 2012-2022; (7) What are the state statistics in the article on thinking systems in science education in 2012-2022?. Bibliometric analysis was used to see the distribution of the number of publications and citations from various literatures. Topics in bibliometric analysis can be described qualitatively and quantitatively [9].

Bibliometric indicators can provide a level of development of a science at a higher level by looking at the nature and progress of the science concerned. Reliability in bibliometric indicators is influenced by two main aspects, including the selection of databases, namely the number of bibliometric databases, several multi-disciplinary and others in certain areas and identification of publications based on the address given by the author. Bibliometric indicators are stronger at higher levels of aggregation and are more suitable for analyzing patterns in large groups (large research teams) and less suitable for individual evaluations or small research teams [10].

The selection uses Scopus, because Scopus is one of the databases (data center) of scientific citations/literature owned by the world's leading publisher, Elsevier. Scopus was introduced generically in 2004. Data that are at the center of attention in bibliometric analysis tend to be massive (e.g., hundreds, if not thousands) and objective (e.g., number of citations and publications, occurrence of keywords and topics), although interpretation often depends on objective (e.g., performance analysis) and subjective (e.g., thematic analysis) evaluations established through informed techniques and procedures [11]

2. RESEARCH METHOD

In this study, researchers used data from international publications sourced from the Scopus database (www.scopus.com). Data collection through searches with the keywords “System Thinking in Science Education”. The data obtained through searching on Scopus, then analyzed using bibliometric analysis which consists of four steps, namely the search stage, filtering stage, examination of bibliometric attributes, and bibliometric analysis. The research steps are as follows.

2.1. Search Stage

Scopus is used to search for bibliographies as the source of the database to be used. The choice to use Scopus is because Scopus is one of the largest databases providing peer-reviewed literature and publications. In this study, the bibliographic search was limited to several aspects. First, the type of bibliography used in the journal article titles, abstracts, and keywords. Second, the key words used are “System Thinking in science education”. Second, restrictions are placed on English searches.

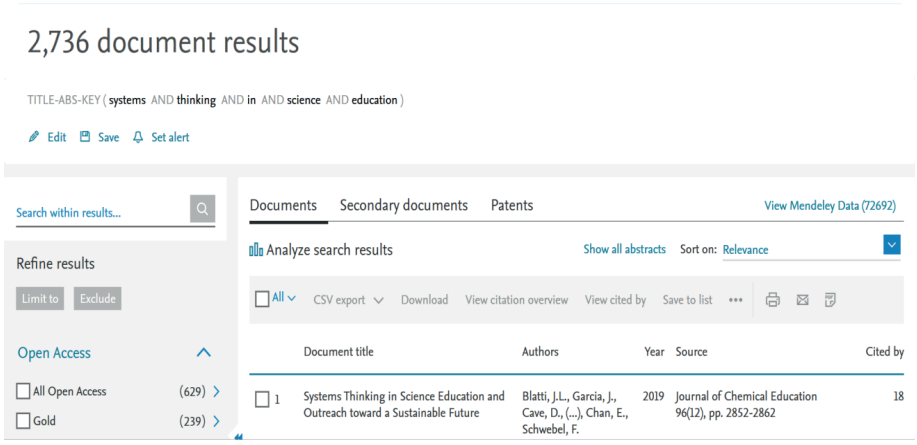
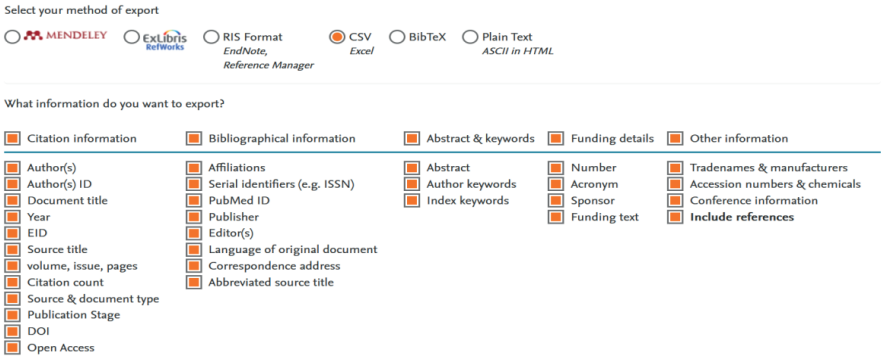


Figure 1: Bibliography search in scopus application.

2.2. Filtering Stage

At the filtration stage, a selection is made to select the journals to be analyzed. The bibliography selected and used is the type of article title, abstract, keyword, article or review. The initial data search through the Scopus application resulted in 1,867 bibliographies, with limited search criteria with the keywords “system thinking in science education”.



Source: www.scopus.com

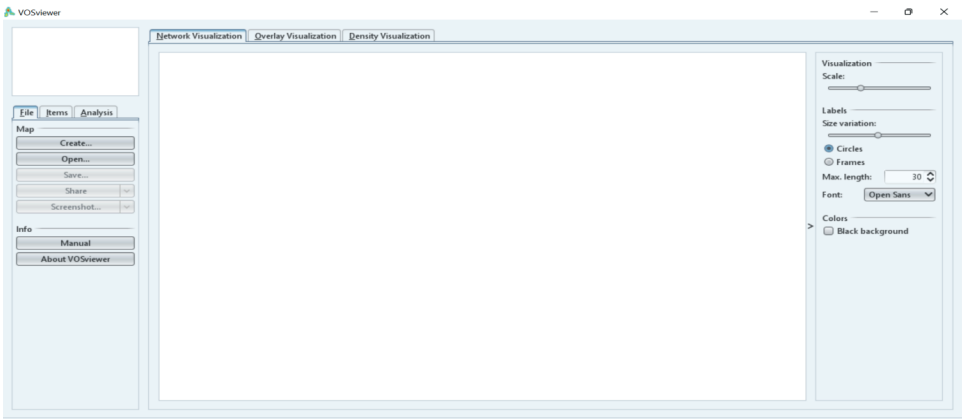
Figure 2: Export documents on scopus.

2.3. Bibliometric Analysis Stage

In this study, will analyze based on the seven aspects contained in the formulation of the problem. With bibliometric analysis, it is expected to be able to answer the questions in the problem formulation that have been stated at the beginning. The author uses the VOS viewer application to assist bibliometric analysis by visualizing the results of the analysis. VOS Viewer is a computer program used to visualize bibliometric maps. The text-mining function can be used to visualize a network or co-relation in an article citation. This bibliometric analysis greatly benefits from computerized data processing and in recent years there has been a large increase in the number of publications. In addition, bibliometric analysis does not only rely on computerization in its processing, but must enter certain volumes of data sequentially to be statistically reliable. VOS Viewer can present and visualize special information about bibliometric graph maps so that it is easier to interpret a relationship or network (Jan Van Eck, 2010). The first step in the bibliometric analysis is the filter results on Scopus that have been given limiting criteria, then the document is exported by selecting the Excel CSV type (Figure 2). Furthermore, the exported file can be used in the VOS viewer application.

The next step is to select create (in Figure 3). Then select create a map base on bibliographic data, click next, select read data from bibliographic database files (Supported file types: Web of Science, Scopus, Dimensions, and PubMed), click next, select Scopus, input the extracted file from Scopus (in csv format), click next, then select co-occurrence co-authorship/co citation, click next, click finish.

3. RESULTS AND DISCUSSION



Source: VOS Viewer

Figure 3: Log in to Vos viewer to visualize analysis results.

3.1. Citation Analysis

Citation analysis is one of the basic properties of scientific work. The citation relationship of scientific papers is the main basis of citation analysis. Citation analysis uses a variety of methods, including mathematical, statistical, comparative, induction, abstraction, generalization, and logical methods. This method is used to analyze various scientific journals, papers, citation objects, and cited phenomena to determine the inherent characteristics of the bibliometric analysis method. Citation analysis was introduced in the 1920s. In 1927, Gross et al. conducted the first citation analysis in the history of literature. They analyzed references from articles in several chemical engineering magazines and core magazines in chemical education. More and more papers on citation analysis have been presented in the field of bibliometrics. This method can be applied effectively to many areas with practice, and it is playing an increasingly important role. One way to assess the quality of a scientific publication is to count the number of times it has been cited by other researchers. Quoting a scientific work means that it has a useful meaning in the field of science. How often a work is cited indicates how often it is the subject of discussion among scientists. In this study, the results of the analysis of articles that emerged from 2012-2022 were 1,867 articles. Collaboration in research is highly expected, because research is not always done individually. For this reason, collaboration between researchers and between agencies is needed both in terms of ideas, funds, facilities and infrastructure as well as opportunities to share knowledge, and certain techniques in a science.

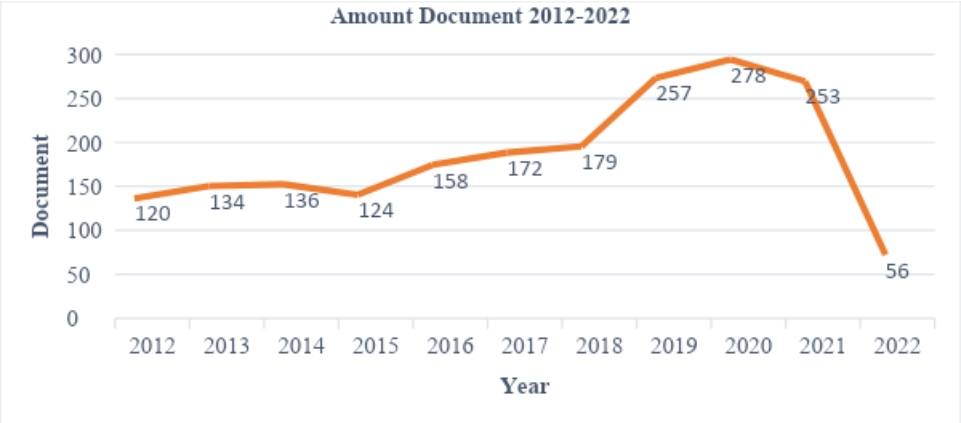
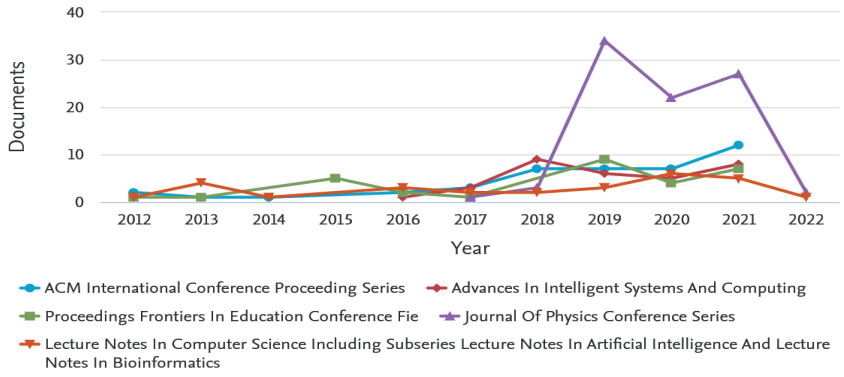


Figure 4: The development of the number of articles every year.

3.2. Source Trend Analysis



Source: www.scopus.com

Figure 5: Source trend analysis.

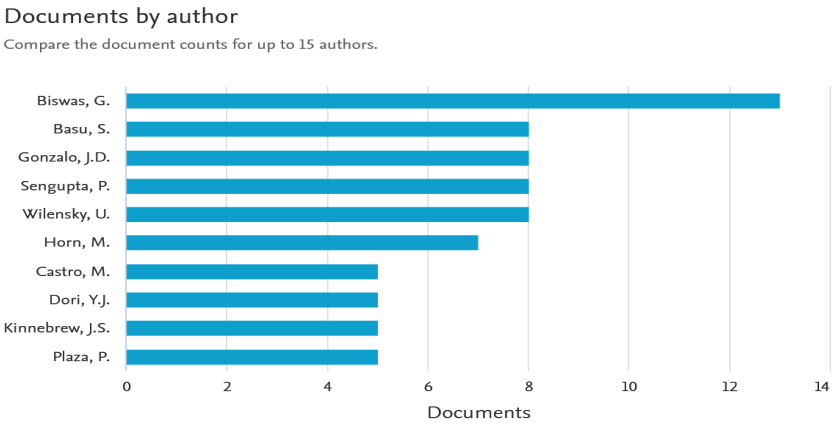
Journal of Physics Conference Series amounted to 89, ACM International Conference Proceeding Serie amounted to 42, Advances in Intelligent Systems and Computing amounted to 32, Proceedings Frontiers in Education Conference Fie amounted to 30, Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes In Bioinformatics amounted to 28, Communications in Computer and Information Science amounted to 19, Journal Of Chemical Education amounted to 18, Journal Of Geoscience Education amounted to 17, Sustainability Switzerland amounted to 16, International Journal Of Technology and Design Education amounted to 12.

3.3. Publication Trend Analysis

The productivity of the top 10 researchers with the 2012-2022 system thinking program indexed by Scopus shows that the productivity of researchers ranges from 5-13 publications. Based on graph 2, Biswas, G., with the number of Publications 13, Basu, S., with the number of Publications 8, Gonzalo, J.D., with the number of Publications 8, Sengupta, P., with the number of Publications 8, Wilensky, U., with the number of Publications 8, Horn, M., with Number of Publications 7, Castro, M., with Number of Publications 5, Dori, Y.J., with Number of Publications 5, Kinnebrew, J.S., with Number of Publications 5, Plaza, P., with Number of Publications 5 , Repenning, A., with Number of Publications 5, Sancristobal, E., with Number of Publications 5, Blazquez, M., with Number of Publications of 4, Carro, G., with Number of Publications of 4, Dagiene, V., with Number of Publications of 4 , Gipson, K.G., with the number of Publications 4, Grover, S., with the number of Publications 4, Lavi, R., with the number of Publications 4, Orion, N., with the number of Publications 4 Wilujeng, I., with the number of Publications 4, Wolpaw , D.R., with Publications 4, Avsec, S., with Publications 3, Bain, C., with Publications 3, Barcelos, T.S., with Publications 3, Barnes, S .K., with number of Publications 3, Basawapatna, A., with number of Publications 3, Boehm, B., with number of Publications of 3, Chiu, J.L., with number of Publications of 3, Crawley, E.F., with number of Publications of 3, Diethelm, I ., with Number of Publications 3, Forbes, Hwang, G.J., with Number of Publications of 3, Iyer, S., with Number of Publications of 3, Jordan, R.C., with Number of Publications of 3, Koh, K.H., with Number of Publications of 3, Lally, D. , with Publications 3, Lewis, S., with Publications 3, Mahaffy, P.G., with Publications 3, Mills, K., with Publications 3, Orgill, M.K., with Publications 3, Pancratz, N., with Number of Publications 3, Pea, R., with Number of Publications 3, Prins, R.J., with Number of Publications of 3, and Rustaman, N.Y., with Number of Publications 3.

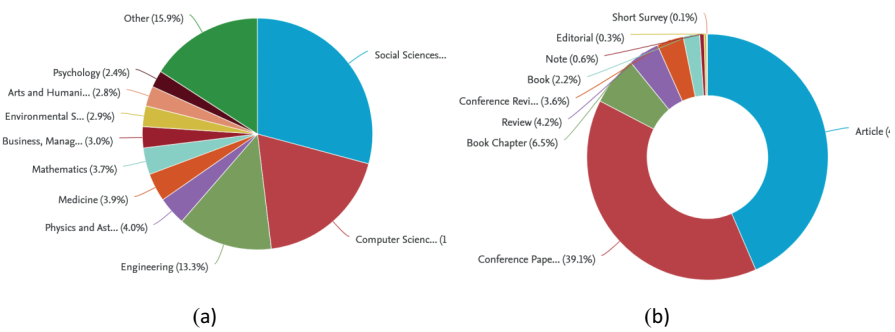
3.4. Analysis of Subject Areas and Types of Articles of Publication

Based on the graph, it can be seen that the 8 largest subject areas are medicine as much as 43% or 225 documents, nursing as much as 10.7% or 56 documents and engineering as much as 8.0% or 42 documents can be seen in diagrams (a) and (b). Articles with a total of 811 (43.4%), Conference Papers with a total of 730 (39.1%), Book Chapters with a total of 121 (6.5%), Reviews with a total of 78 (4.2%), Conference Reviews with a total of 67 (3.6%), Book with a total of 41 (2.2%), Notes with a total of 11 (0.6%), Editorial with a total of 6 (0.3%), Short Survey with a total of 2 (0.1 %).



Source: www.scopus.com

Figure 6: Greatest author of article publications.



Source: www.scopus.com

Figure 7: Subject area with systems thinking (a) and abstract network of terms (b).

Social Sciences with 946 publications (92.9%) Computer Science with 614 publications (18.9%), Engineering with 433 publications (13.3%), Physics and Astronomy with 129 publications (4%), Medicine with 128 publications (3.9%), Mathematics with 121 publications (3.7%), Business, Management and Accounting with 96 publications (3.0%), Environmental Science with 94 publications (2.9%), Arts and Humanities with 91 publications (2.8%), Psychology with 77 publications (2.4%), and other (15%) and Pharmaceutics with 14 publications (92.9%), Dentistry with 8 publications (92.9%), Immunology and Microbiology with 7 publications (92.9%), Veterinary with 1 publications (92.9%).

3.5. Trend Analysis Terms Title

At this stage of analysis, the aim is to analyze the content, patterns and trends of a collection of documents by measuring the strength of terms and counting the number of keywords that appear simultaneously in the articles under study.

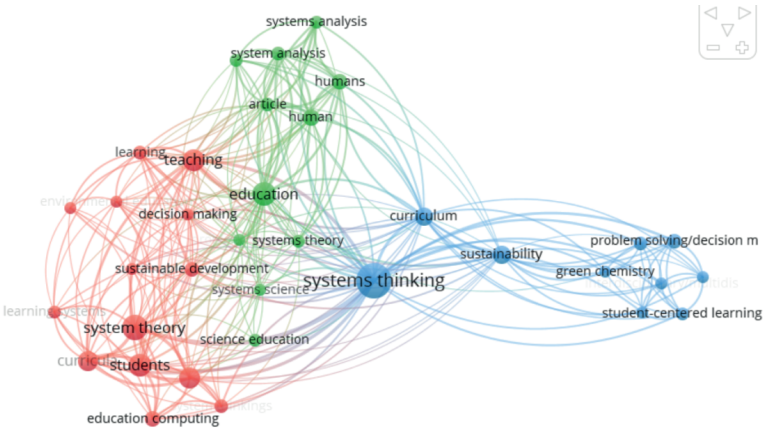


Figure 8: Visualization of terms in article titles.

3.6. Country Statistical Analysis

United States with 630, China with 130, Russian Federation with 82, United Kingdom with 82, Indonesia with 81, Australia with 75, Canada with 55, Germany with 51, Spain with 42, and India with 41. Affiliation documents are Vanderbilt University with 22 articles, University of Nebraska–Lincoln with 19 articles, Arizona State University with 13 articles, NC State University with 13 articles, Pennsylvania State University with 12 articles, University of Washington with 12 articles, University of Maryland, College Park with 12 articles, Technion - Israel Institute of Technology with 12 articles, Indiana University Bloomington with 11 articles, University of California, Berkeley with 11.

Current changes in science education emphasize professional development as a means to improve student science achievement [12]. Professional development based on intensive and ongoing training around concrete tasks focused on subject matter knowledge, linked to specific standards for student performance, and embedded in a systemic context [13]. The quantity of professional teacher development is closely related to the practice of teaching systems thinking relevant to an investigative-based classroom culture [14]. In addition, [15] the preparation of science content also has a strong influence on teaching practices and classroom culture in enhancing systems thinking skills. [16] Said that in facing the era of the industrial revolution 4.0, all professions are required to adapt. Not only to be able to adapt to technology, but to optimally utilize technology [17]. The identification results were evaluated using a system thinking approach to produce recommendations for lecture material for students at the undergraduate level [18]. The application of system thinking is expected to help undergraduate study programs to evaluate and develop curricula that can adapt to needs and changes [19]. Systems

thinking can contribute to supporting industry 4.0 which focuses on things that cannot be replaced by technology by acting innovatively. [20] Systems thinking can develop an individual point of view as part of a system and act as a subsystem that will optimize the work of the system. In addition, [21] the ability to think systems can improve holistic abilities based on data, creative abilities, and adapt to change. In addition to knowledge, the attitude demanded from teachers 4.0 is to focus on complex problem solving, focus on leadership skills and focus on people skills by having interpersonal skills.

4. CONCLUSION

Bibliometric analysis is a scientific method that can be useful for researchers who wish to pursue a retrospective of a broad and rich field of research. Bibliometric methodologies have gained great popularity in recent times due to the omnipresence and usefulness of bibliometric software and databases that facilitate the acquisition and assessment of large volumes of scientific data. An important and relatively recent application of bibliometrics is in program coordination. Based on the results and discussion, it can be concluded that publications on program coordination during the period 2012-2022 show that the highest Scopus index occurred in 2020 which reached 278 publications. The countries that published the most articles on program coordination were the United States. Biswas is a researcher who has the highest productivity with 13 publications. In the title term analysis, 8 clusters were formed. The most widely used term in the title in program coordination articles was “social science” with a total of 946 (92.9%). The author suggests the need to add new keywords to get more research results so that it is more comprehensive

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