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Bibliometric Profile of Science Education Research on Argumentation and the Contribution of Indonesia

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ABSTRACT
This study aims to describe the profile of argumentation research in science education and reveal the contributions of researchers from Indonesia based on the Scopus database education. It is used bibliometric analysis. Based on the visualization analysis of the research profile, "science education argumentation" resulting in three major clusters and one little cluster: (1) argumentation in the theoretical domain (2) argumentation in the implementation domain (3) argumentation in the development models domain and (4) argumentation in the scientific argumentation discourse domain. Erduran is the most productive researcher, but Osborne is the most influential researcher in the field of scientific argumentation. The direction trend of argumentation research is developing from theoretical, philosophical to practical. Implementation matters to improve students' argumentation skills on increasingly broad material topics. The research findings are expected to help related researchers to recognize the trend of argumentative research in science education globally and recommend directions for further study.

Keywords: *Argumentation, Bibliometric, Science Education, VOSviewer.*

1. INTRODUCTION

The life of the 21st century demands various skills that someone must master. Wagner [1] emphasizes seven skills that students need to face in the 21st century: critical thinking skills and problem-solving, collaboration and leadership, agility and adaptability, initiative and entrepreneurial spirit, able to communicate effectively and both orally and in writing, able to access and analyze information and have curiosity and imagination. Education is currently expected to train 21st-century skills that are considered universal needs today [2]. Education is expected to support human resources development, especially students prepared to become successful and independent individuals in life [3].

Many experts place critical-thinking skills and problem-solving as essential skills. Critical thinking, according to Kuhn, is a combination of two inseparable basic skills, inquiry skills and argumentation skills [4]. Argumentation skill is an output process that involves constructing a reasoned argument to justify a decision. Argumentation contributes to the two goals of conventional science education, both "science for all" and "science for prospective scientists". From this conclusion, we will say that argumentation is the solution to most science education problems. On the one hand, it is a solution to some learning problems. It helps students learn difficult things except through argumentation (e.g., evaluating evidence). On the other hand, as holding the potential to help us better understand and support the learning process in the science classroom [5].

In the last decade, the teaching and learning of argumentation have emerged as an important educational goal in educational curricula in various countries. Argumentation is a fundamental discussion process in science and should be taught and studied in science classes as part of scientific inquiry and scientific literacy [6]. Arguments emphasize evidence-based justification of knowledge claims and support reasoning across science, technology, engineering, and mathematics (STEM) domains. However, it is still rare for research to discuss the development of this trend in the study of scientific argumentation. Choosing a dissertation research topic that can generate novelty requires an understanding and deepening of the results of previous research.

Therefore, our goal in this study is to investigate how scientific argumentation research has developed. Also, to choose the focus of scientific argumentation research that has the latest in the dissertation being worked on.

Previous researchers have carried out several studies on the trend of argumentative research in science education. Erduran has carried out an argumentation research trend using the journal content analysis method described with qualitative and quantitative techniques [6]. Meanwhile, this research seeks to collect data on scientific publications about arguments from various sources in the world. Bibliometric analysis is used in this study to publish a paper to advance knowledge [7] [8]. Bibliometric indicators, including the area of research, source documents, publications, source documents, distribution of countries and institutions, authors, number of citations, and author keywords, have been frequently used to analyze trends [7] [8] [9]. The research aims to explore the 'trend' of" argumentation" research in science education. Also, to understand the global development pattern of" argumentation" research. This study focused on the research trend on argumentation in science education with six research questions:

To what extent did the profile of publication output of argumentation?

(1) To what extent did the distribution of publication of argumentation across countries and institutes in the world?
(2) Who were the top authors in researching argumentation in the world?
(3) How did the publication patterns of argumentation?
(4) How did the visualization results of the research trend of argumentation?
(5) To what extent did the contribution of Indonesian authors on researching argumentation?

2. METHODS

This study follows the guidelines of previous bibliometric research steps [9][8][10][11]. Researchers utilize the Scopus database because it has many sources, including journals, conference proceedings, and books considered more relevant by the scientific community and consistency in data collection and periodicity. Data collection was carried out in June and July 2021 with the following steps: (1) choosing the most suitable keywords to be included in the Scopus search engine, (2) selecting research papers that met the specified criteria and compiling data, (3) analyzing the data obtained in the form of .ris extensions and Microsoft Excel files based on criteria, (4) presenting data analysis in graphical images and multi-dimensional scale diagrams with the help of the VOSviewer software, and (5) provide reviews and discussions [11] [12][13].

3. RESULTS AND DISCUSSION

3.1. Productivity Document Output, and Document Sources

By using the most appropriate keywords "Science Education Argumentation" on the Scopus literature search engine, 744 documents that met the search criteria throughout the year were obtained. Of the 744 papers that meet these criteria, a Scopus database includes four types of document sources (journal, book, conference proceedings, and book series).

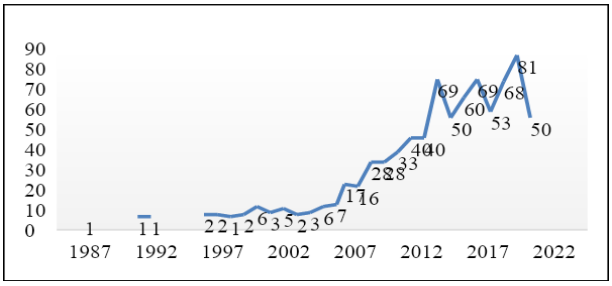

Figure 1 The number of documents on argumentation on science education all years.

The use of the term "Science Education Argumentation" first appeared in 1987 in the journal "Physics Education" by Hermann Bondi. Still, the use of the word did not continue to appear every year and was immediately popular. The term "Science Education Argumentation" has continuously appeared in scientific publications since 1996 and has continued to increase since 2007 until it is popular today. It can be seen in Figure 1. Meanwhile, the number of articles based on sources indicated the dominance of articles in the journal (545 documents). It was followed by conference proceedings (164) and books (39). The book series accounted for the fewest sources of documents (28 documents) (see Figure 2).

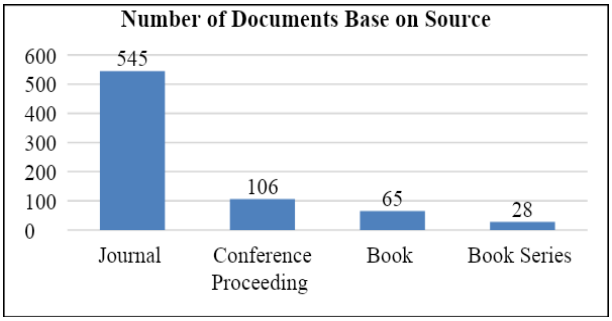

Figure 2 The number of articles of argumentation on science education based on source categories.

3.2. Publication Distribution of Countries and Institutes

Based on the number of documents from various countries, the USA dominates publications with 252 papers (34%). Next, the top 5 countries that contributed were Turkey, United Kingdom, Germany, and Indonesia, with 75, 54, 47, and 27 documents (See Figure 3).

The number of documents of argumentation across the institution could be seen in Table 1. It was clear the dominance of the USA institutions. There are six institutions in the top rank, Stanford University, Pennsylvania State University, Boston College, Arizona State University, and Purdue University, with 14, 13, 13, 11, 11, and 11 documents.

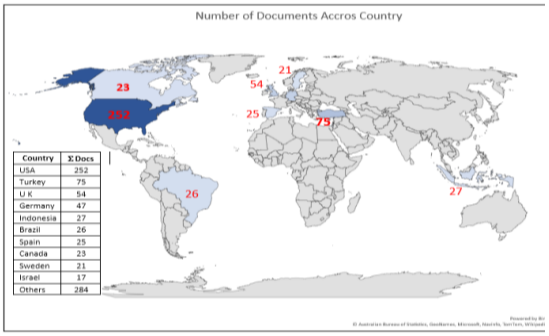

Figure 3 Number of documents based on countries .

Table 1. Number of documents of argumentation in science educations across the institution

No	Institution	Number of Documents
1	Stanford University, California, USA	14
2	Pennsylvania State University, USA	13
3	Boston College, Massachusetts, USA	13
4	Arizona State University, USA	11
5	Purdue University, West Lafayette, Indiana, USA	11
6	University of California, Berkeley, USA	11
7	Bolu Abant İzzet Baysal Üniversitesi, Turkey	10
8	University of Limerick, Ireland	10
9	Ludwig-Maximilians-Universität München, Germany	10
10	Universitas Pendidikan Indonesia, Indonesia	10

3.3. Top Authors in Researching of Argumentation in Science Education

In terms of most productive authors, Table 2 indicates the top ten authors researching argumentation in science education. Erduran, Osborne, McNeil, Archila, Fischer, Gonzales, Kelly Belland, Cetin, and Clark were the most productive authors on this topic. Generally, the performance of authors is in line with the top citation of the article all years, as indicated in Table 3.

If we pay closer attention to the article citations in Table 3, Jonathan Osborne's name dominates the top 10 citations of the article. There are six articles involving his name, where there are two works that list him as the first author to place the paper at number 2 and 6 rank order. Jonathan Osborne collaborates with several prominent researchers, such as Driver, Erduran, Duschl, and Newton. It will be proven in the visualization of research collaboration in the next section (See Figure 6).

Table 2. Top authors in researching of argumentation on science education

Author	Number of Documents
Erduran, S.	24
Osborne, J.	14
McNeil, K. L.	13
Archila, P. A.	10
Fischer, F.	9
Ganzales Howard, M.	7
Kelly G. J.	7
Belland, B. R.	6
Cetin, P. S.	6
Clark, D. B.	6

Table 3. Top citation of the article of all years

Author	Title	Source	Citation
Driver, R., Newton, P., Osborne, J. (2000)	Establishing the norms of scientific argumentation in classrooms	Science Education 84(3), pp. 287-312	1120
Osborne, J., Erduran, S., Simon, S. (2004)	Enhancing the quality of argumentation in school science	Journal of Research in Science Teaching, 41(10), pp. 994-1020	719
Erduran, S., Simon, S., Osborne, J. (2004)	Tapping into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse	Science Education 88(6), pp. 915-933	594
Duschl, R.A., Osborne, J. (2002)	Supporting and promoting argumentation discourse in science education	Studies in Science Education 38(1), pp. 39-72	575
Sadler, T.D. (2004)	Informal reasoning regarding socioscientific issues: A critical review of research	Journal of Research in Science Teaching 41(5), pp. 513-536	558
Osborne, J. (2010)	Arguing to learn in science: The role of collaborative, critical discourse	Science 328(5977), pp. 463-466	446
Newton, P., Driver, R., Osborne, J. (1999)	The place of argumentation in the pedagogy of school science	International Journal of Science Education 21(5), pp. 553-576	394
Sandoval, W.A., Millwood, K.A. (2005)	The quality of students' use of evidence in written scientific explanations	Cognition and Instruction 23(1), pp. 23-55	356
Squire, K.D., Jan, M. (2007)	Mad city mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers	Journal of Science Education and Technology 16(1), pp. 5-29	283
Sampson, V., Clark, D.B. (2008)	Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions	Science Education 92(3), pp. 447-472	264

3.4. Publication Patterns: Source Titles (Journal or Proceeding)

Table 4 illustrates the most contribution journal or proceeding on the research of argumentation in science education. Journal of International Journal of Science Education was a leading journal containing articles about argumentation in science education (see Table 4).

Table 4. Number of documents of argumentation in science education across source titles

No	Source Title	Number of Documents
1	International Journal of Science Education	47
2	Journal of Physics Conference Series	34
3	Journal of Research in Science Teaching	27
4	Research in Science Education	19
5	Science and Education	18
6	Science Education	16
7	Cultural Studies of Science Education	15
8	International Journal of Science and Mathematics Education	15
9	Computers and Education	13
10	Journal of Science Teacher Education	11
11	Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics	11
12	Journal of Science Education and Technology	10
13	Journal of Geoscience Education	8
14	Proceedings of International Conference of The Learning Sciences Icls	8
15	Research in Science and Technological Education	8

3.5. Visualization of Bibliometric Profile Research on Argumentation Using VOSviewer Software

Among those 744 papers related to argumentation research in the Scopus database, the researchers visualized the research profile on this topic assisted with VOSviewer software. This effort helps find the novelty of the research on this domain. Figure 4 indicates the whole picture research on argumentation. Let's look at the profile of argumentation research along with the publication timeline (See Figure 5). The research trend is moving from discussing theoretical and philosophical to practically teaching argumentation skills.

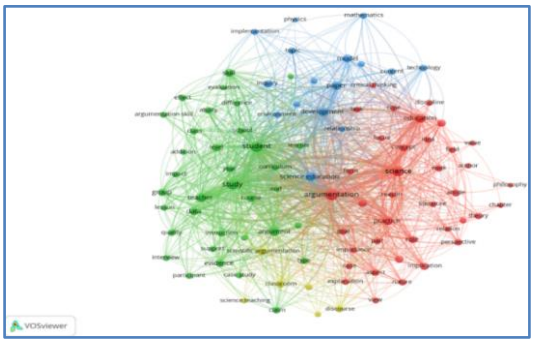

Figure 4 Profile of argumentation research as a whole and its clusters.

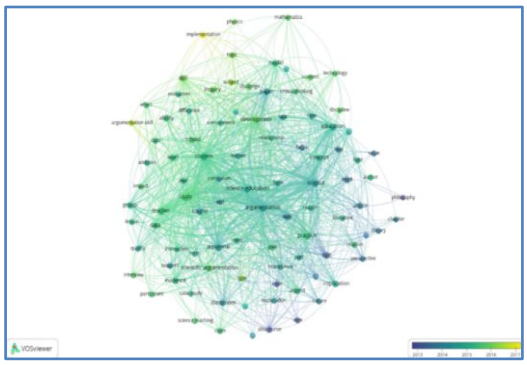

Figure 5 Profile of argumentation research with the publication timeline.

We found some findings if we broke down each cluster into the specific connection among variables to capture the trend and novelty of researching argumentation. In the first cluster, emphasized research on argumentation in the theoretical (concept, perspective, theory, and role) domain. Based on the results of the visualization of the collaboration of researchers using the VOSviewer application, which can be seen in Figure 6, it depicts the top global researchers on argumentation and their co-authorships. Furthermore, let's look at the profile of the collaboration of argumentative researchers in science education accompanied by an image of the publication timeline (See Figure 6).

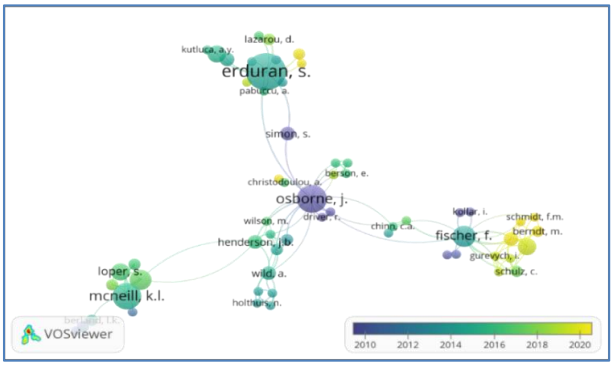

Figure 6 Authors collaboration profile with the publication timeline.

3.6. The Contribution of Indonesian Researchers on argumentation

In total, Indonesia contributed 27 documents related to argumentation all over time from 744 papers. Of this number, it was 23 belongs to the proceedings or the results of the conference paper, while the remaining four is in the form of journal papers.

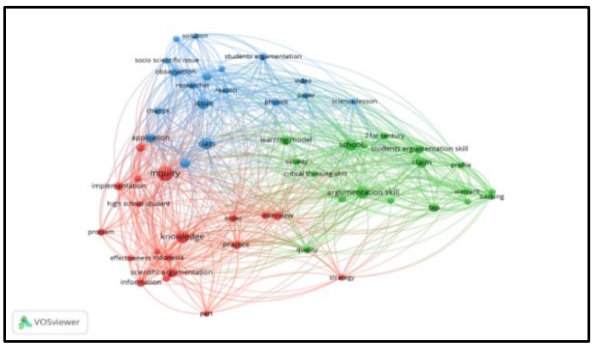

Figure 7. Profile of argumentation research by Indonesian researchers

If researchers in the world produced 4 clusters related to argumentation in science education research, then there were 3 clusters produced by Indonesian researchers (see Figure 7). The first cluster (red colour) was argumentation in relating to inquiry and knowledge. Meanwhile, the second cluster (blue) was the argumentation of class, issue, and science learning. Then, the third cluster is green. It was" argumentation" in connecting with school, argumentation skill and TAP (Toulmin's Argument Pattern).

Table 5. Number of documents of argumentation among Indonesian institution

No	University	Number of Document
1	Universitas Pendidikan Indonesia	10
2	Universitas Sebelas Maret	4
3	Universitas Negeri Malang	3
4	Universitas Negeri Surabaya	2
5	Universitas Lampung	2
6	Institut Agama Islam Negeri Syekh Nurjati Cirebon	2

Table 5 illustrates how the rank of Indonesian institutions in producing documents on argumentation. Universitas Pendidikan Indonesia is the leading university on the research of argumentation. Meanwhile, the top Indonesian researchers on argumentation and their co-authorships. It lists that the name such as Widyastuti, F. (4 docs), Probosari, R.M. (3 docs), Prayitno, B.A. (3 docs), Suwono, H. (3 docs) and Widodo, A. (3 docs) were the most productive authors in this topic from Indonesia. The first use of the term argumentation in science education research was in 1987 in the journal "Physics Education" by Hermann Bondi. The number of publications continues to fluctuate so that no less than 50 documents per year begin to occur from 2014 to 2021. From this trend, it can be predicted that the number of articles in 2021-2025 will increase dramatically. Similar findings of the trend in the development of the number of argumentative studies also occur in Erduran's research (2015) in the scope of the top three educational journals [6] and Rapanta's research (2019) based on the Web of Science database [14].

Based on the number of documents from various countries, the USA dominates publications with 252 papers (34%). Next, the top 5 countries that contributed were Turkey, United Kingdom, Germany, and Indonesia, with 75, 54, 47, and 27 documents. Institutions ranked first to sixth are occupied by institutions from the USA. Stanford University, California, USA, has ranked first with 14 papers. Indonesia places its one institution in the seventh rank. Universitas Pendidikan Indonesia in the seventh rank with ten documents, along with three other institutions with the same number of records: Bolu Abant İzzet Baysal Üniversitesi, Turkey, University of Limerick, Ireland, and Ludwig-Maximilians-Universität München, Germany. According to the ranking, the top 10 most productive authors, Erduran is the most productive researcher. Meanwhile, Driver was the most author with the top citation of the article all years. Although Osborne does not rank the highest in productivity and citations, we can confirm his work was the main reference argumentation in science education research.

In this study, researchers produced three primary clusters and one secondary cluster. If we broke down each group into the specific connection among variables to capture the trend and novelty of researching on argumentation, then we found some findings: (1) Research on argumentation in the theoretical domain related to philosophy, literature, reasoning, practice and implication [15] [16]. (2) Research on argumentation in the theoretical domain related to student, teacher, study, lesson, argumentation skill, and evaluation [17]. Indonesian researchers more examined this point. (3) Research on argumentation in the development models domain related to topic, content, physics, mathematic, technology, inquiry, and assessment [18] [19]. (4) Research on the scientific argumentation domain related to classroom, discourse, and science teaching [20]. There were four dominant groups of authorships: Osborne et al., Erduran et al., McNeill et al., and Fischer et al., as the top researcher and its cluster in researching argumentation, similar to Rapanta's findings [14]. Meanwhile, within the scope of Indonesian researchers, the name Widyastuti, Probosari, Prayitno, Suwono, and Widodo were the top 5 most productive authors in this topic.

4. CONCLUSION

Based on the results of the analysis and discussion, it can be revealed the facts that the number of documents of argumentation across the year was increased, which were dominated by articles in the journal. The USA contributed the most documents on argumentation, where the USA listed six of its institutions in the top six rankings. The contribution of Indonesian researchers in argumentation research is still low. The visualization of the research trend on argumentation resulted in three major clusters and one little cluster: (1) argumentation in the theoretical domain, (2) argumentation in the implementation domain, (3) argumentation in the development models domain and (4) argumentation in the scientific argumentation discourse domain. The research trend moves from discussing theoretical and philosophical argumentation to how to implement argumentation in a practical way to teach argumentation skills to students. The research findings could aid related researchers to recognize the trend of argumentation in science education research globally and recommend directions for further investigation.

AUTHORS' CONTRIBUTIONS

Setyo Admoko: conceptualization, method, data curation, data visualization, and drafting manuscript. Mukhayyarotin Niswati Rodliyatul Jauhariyah: Data curation, data visualization, and editing; Eko Hariyono: Review and editing of manuscript, and Madlazim: Review and editing of manuscript.

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