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Research on Bibliometric Analysis of Toulmin's Argument Pattern (TAP) in Learning Physics in the Last Ten Years

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ABSTRACT

Objective: Toulmin's Argument Pattern (TAP) is the most widely used argumentation pattern and was first used in science education. TAP has a significant contribution as literature in explaining the concept of argumentation. This study aims to identify the contribution and describe the research profile of applying TAP in physics education during the last ten years. **Method:** The method used in this research is a bibliometric analysis based on Scopus data with the help of MS Excel and VOSviewer. The results of this study obtained 67 documents related to TAP. **Results:** Based on the results of bibliometric data visualization related to TAP, 4 clusters (1) discuss TAP focused on learning processes and activities in the classroom. (2) the application of TAP focused on assessing argumentation and critical thinking skills (3) TAP was associated with the identification of the components of scientific argumentation (4) TAP related to contextual problem-solving in improving scientific literacy. **Novelty:** Physics is the subject that appears the most in research related to the use of TAP, among other science subjects. Based on the results of this study, TAP has several contributions to physics learning in improving students' argumentation skills so that it can be an opportunity for further research. That way, the next one will be able to discuss more deeply related to the TAP, which is applied to physics learning to improve argumentation and critical thinking skills.

INTRODUCTION

Modern life demands mastery of several essential skills to participate and compete in global competition. Competition in the 21st century encourages everyone to strive for qualified skills (Chalkiadaki, 2018). 21st-century skills are synonymous with 4C: critical thinking, creativity and innovation, communication, and collaboration (Erdoğan, 2019; Jan & Jrf, 2017). Education in the 21st century provides new provisions for the skills students must possess to succeed academically and in life (Erdoğan, 2019). In the 21st century, communication skills are critical. The target is skilled and effective oral and written communication (Chalkiadaki, 2018). In building a skilled and knowledgeable society, 21st-century skills are needed, one of which is arguing (Gonçalves & Silva, 2015; Mishra & Mehta, 2017).

Research on argumentation in science education has grown and intensified over the last twenty years. Argumentation is major in science education (Chan & Erduran, 2022). Argumentation in science education has many benefits, including developing critical skills, promoting a spirit of inquiry, increasing conceptual understanding, and improving student academic performance (Faize et al., 2017). Argumentation is a

reasoning process that aims to provide reasons for a decision or choice by choosing among several alternatives (Vassiliades & Bassiliades, 2021). The argumentation strategy aims to clarify and improve the ideas that will be conveyed to make reasonable and appropriate decisions (Wahyunan et al., 2021). The ability of students to express opinions shows their thinking skills (Hasnunidah et al., 2019). It is essential to teach arguments because students who have an opinion can accept other opinions that are also reasonable based on data or reasons that do not weaken someone's position (Rapanta, 2019). However, students' argumentation skills still need to improve due to the learning process that does not maximize students' argumentation skills (Yuliance, 2021).

As educators, giving students the opportunity to argue is very important. The importance of argumentation is taught in science education. After all, by arguing in class, students can construct their knowledge because students can express ideas (Zhao & Watterston, 2021), ask questions, provide feedback, and evaluate all forms of ideas, but students find it challenging to argue well students need to learn more a lot about how to argue that is good and right (Guilfoyle et al., 2020; Nation & Feldman, 2021). One of the techniques to assess students' arguments' quality is to use the TAP (Lazarou & Erduran, 2020; Yang, 2022). The argumentation model of TAP is very good to be used as a reference in analyzing forms of argumentation (Lentika & Admoko, 2022). Students' argumentation skills at the primary level will increase after the TAP is applied with this pattern; students' argumentation skills become focused and easily understood by other students (Janssen & Graaff, 2021; Soysal, 2021). The TAP model is described in **Figure 1**.

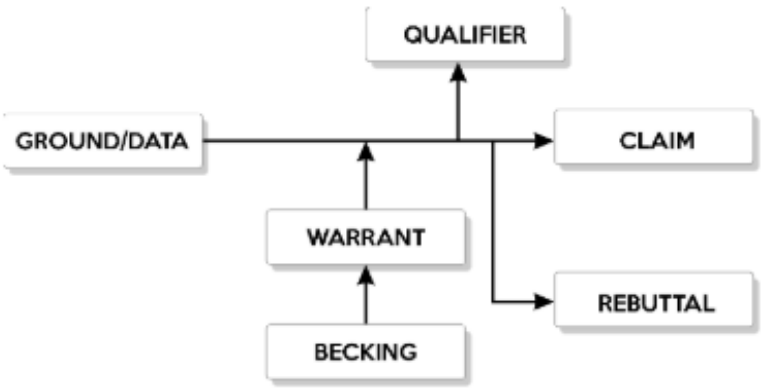

Figure 1. Six components of TAP.

The TAP shown in **Figure 1** is used to identify, model, and organize arguments. The essence of the argument is to make a conclusion, some data or evidence to support the claim, and an explanation (warrant) that relates the data to the claim (Moon et al., 2016). To strengthen a warrant, the backing is needed to justify or support the warrant. Qualifiers provide a limit under what conditions claims in the core argument are still valid. Rebuttal identifies weaknesses in arguments by undermining either the use of a component in the core argument or the content of a component in the core argument (Moon et al., 2016; Admoko et al., 2021a). With the argumentation pattern above, it is expected that students will lead to six components, namely ground, claim, warrant, backing, qualifier, and rebuttal so that the argument is built from complete components and has a good logical structure (Abdollahzadeh et al., 2017; Bermani, 2017). From these complete components and a good structure, students' arguments can be understood

easily, and their quality can be measured easily (Chun & Sauder, 2021; Küng & Leimeister, 2021).

Considering the importance of using TAP in learning, it is necessary to see the development of TAP applications in educational research. Based on this background, it is very important to research how TAP trends in developing students' argumentation skills. Previous research has the co-occurrences of the keywords TAP found to be used most frequently in the articles: argumentation, abstract argumentation, discourse analysis, argumentation theory, critical thinking, computational complexity, and argumentation semantic (Atabey, 2021). However, there is no related research related to bibliometric analysis in TAP. In the last ten years, many experimental and literature studies have been conducted on the application of TAP in educational research, but no bibliometric analysis research on TAP has been reported or published in the Scopus-indexed journal. This means that there is a need for bibliometric analysis research on TAP. Bibliometric analysis was used to see the trend and distribution of publications and citations from various literature. This study aims to discover the latest TAP research trend in the last ten years. The formulation of the problem in this research are:

1. How has the number of publications about TAP increased in the last ten years?
2. What is the trend of publishing articles on TAP in the last ten years?
3. Who was the most prolific TAP writer in the last ten years?
4. Which journal has the highest citation of TAP in the last ten years?
5. What journal publishers have been the most prolific about TAP in the last ten years?
6. What languages are often used in TAP publications in the last ten years?

RESEARCH METHOD

This literature study was analyzed using the previous bibliometric analysis guidelines (Admoko et al., 2021b; Kulakli & Osmanaj, 2020). Researchers utilize the Scopus database because it has many sources, including journals, conference proceedings, and books deemed more relevant by the scientific community and consistency in data, collection, and periodicity. Data collection was carried out in May 2022 in **Figure 2**.

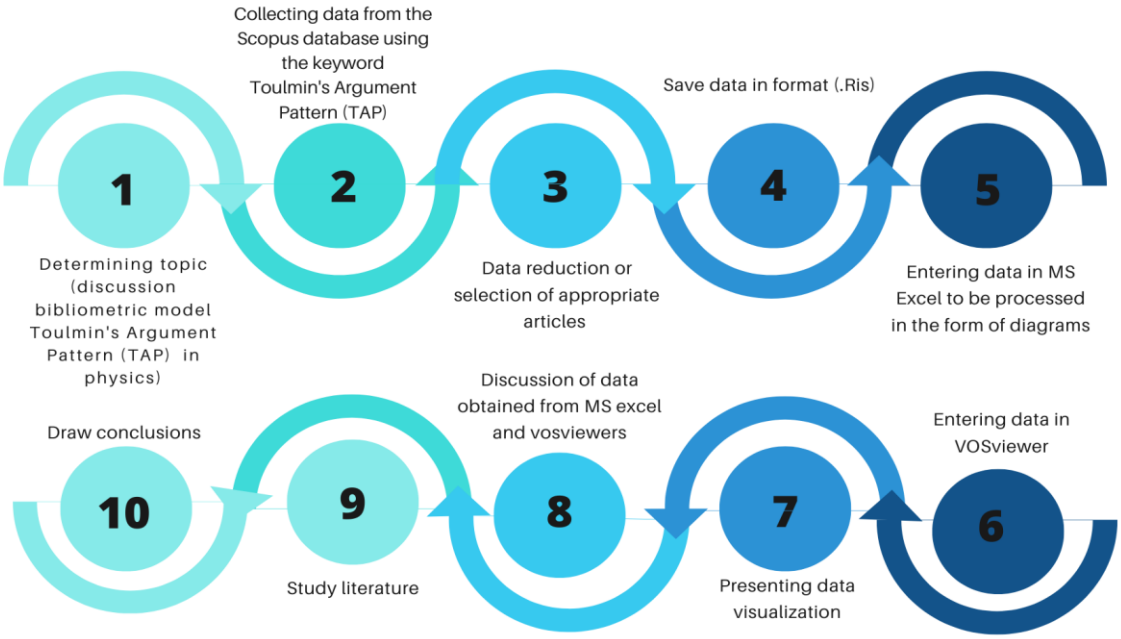

Figure 2. Toulmin's Argument Pattern order chart of bibliometric analysis.

RESULTS AND DISCUSSION

Results

Productivity Document Output and Document Sources

Using the most appropriate keyword, "Toulmin-Argument-Pattern," in the literature, Scopus produced 93 documents, and those that met the search criteria throughout the year obtained 67 documents. Of the 67 papers that meet these criteria, the Scopus database includes four types of document sources (articles, conference proceedings, book series, and reviews). The decrease in the number of publications each year is due to the existence of the year affecting the number of citations obtained. In addition, the top citation of articles throughout the year is also influenced by the quality of the authors (Murphy et al., 2018). Furthermore, it can be seen the development of research on the "Toulmin-Argument-Pattern" in the last ten years presented in **Figure 3**.

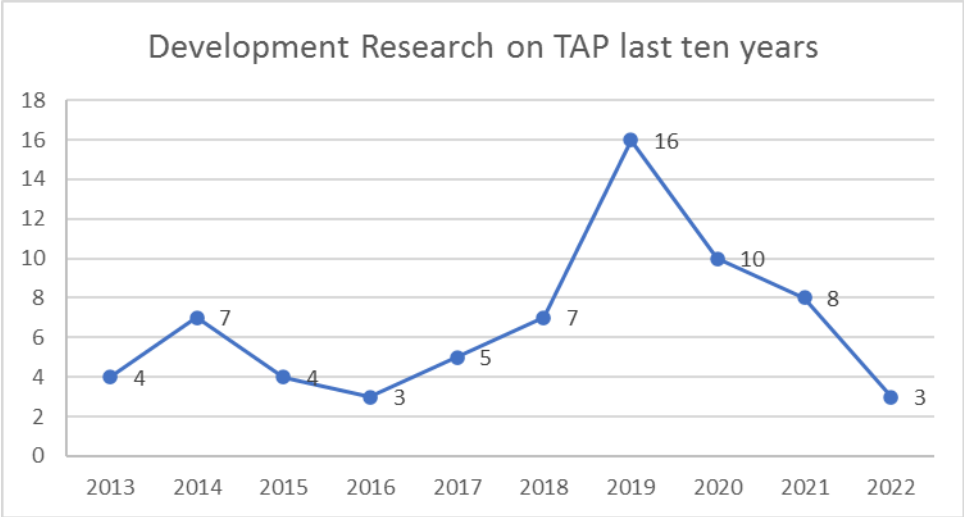

Figure 3. The number of research developments TAP in the last ten years.

The use of the term "Argument Pattern" was first proposed by Stephen E. Toulmin in 1958 entitled "*The Uses of Argument,*" and the word "Toulmin's Argument" continues to appear every year in scientific publications. In general, there has been an increase in the number of publications per year in the last ten years but fluctuates. It can be seen in **Figure 3**, the graphic diagram of the last ten years, that the highest research on the "Toulmin Argument Pattern" was in 2019, with many studies of 16 documents, and the lowest research in 2016 and 2022, which only had three documents. In 2022 there was a very significant decrease in the number of publications; this is because data collection is carried out before the middle of the year, namely May, so the number of publications is still in progress.

The results of the articles in the last ten years are classified based on what can be seen in **Figure 4**; the source shows the dominance of articles in journals (38 documents), then conference proceedings (25), books (2), and reviews (2). When related to the data in **Table 3**, it is found that journal articles are the most common type of document but are scattered in many journals. At the same time, conference proceedings are the second most common type of document, dominated by two conferences, namely the Journal of Physics Conference Series and AIP Conference Proceedings. This is a positive trend of TAP research because TAP's discussion has become the attention of all educational research journals and is widely discussed in physics conferences. This is to research (Suprapto et al., 2021) that articles dominate the existing publications.

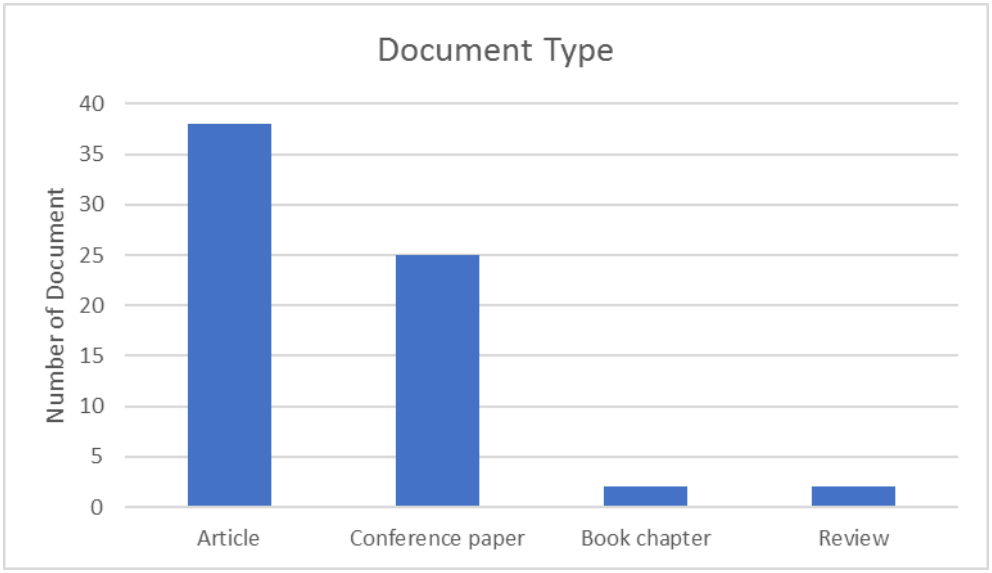

Figure 4. Number of argumentative articles on science education by source category.

Top Authors in Researching Toulmin's Argument Pattern in Science Education

In terms of the most productive authors in the last ten years, there are the top 7 authors who researched Toulmin's Argument Pattern in Science Education, namely Pimvichai; Widodo, A.; Yuenyong, C.; Muslims; Deta, U. A.; Buaraphan, K.; Rudsberg, K. Authors from the Southeast Asian countries Thailand and Indonesia dominate the top 7 productive authors in the TAP research. However, if it is related to the data in Table 2, it is found that no one of an author whose work is included in the Top 7 Citation. Almost all documents from the top 7 productive authors are conference proceedings. Where conference proceedings are considered publications that have lower quality than articles in a journal, so they are rarely cited.

Table 1. Top Authors in researching TAP in science education.

Author	Number of documents	Country
Pimvichai	5	Thailand
Yuenyong, C.	5	Thailand
Widodo, A	5	Indonesia
Muslim	4	Indonesia
Data, U.A.	3	Indonesia
Buaraphan, K.	3	Thailand
Rudsberg, K.	3	Swedia

The results of the visualization of collaboration between authors are presented in **Figure 5**; this image shows that collaboration between researchers still needs to be done. There are only two pairs of collaborations between authors of research on TAP. The first collaboration between Pimvichai and Yuenyong, C. collaborated on research articles and produced four. Pimvichai involves his name, whereas, in the five articles, Pimvichai is the first name. Meanwhile, the second collaboration is between Widodo and Muslim, who collaborated on producing two articles together. The low collaboration between researchers on TAP shows there is still vast opportunities for research on TAP and opportunities for collaboration.

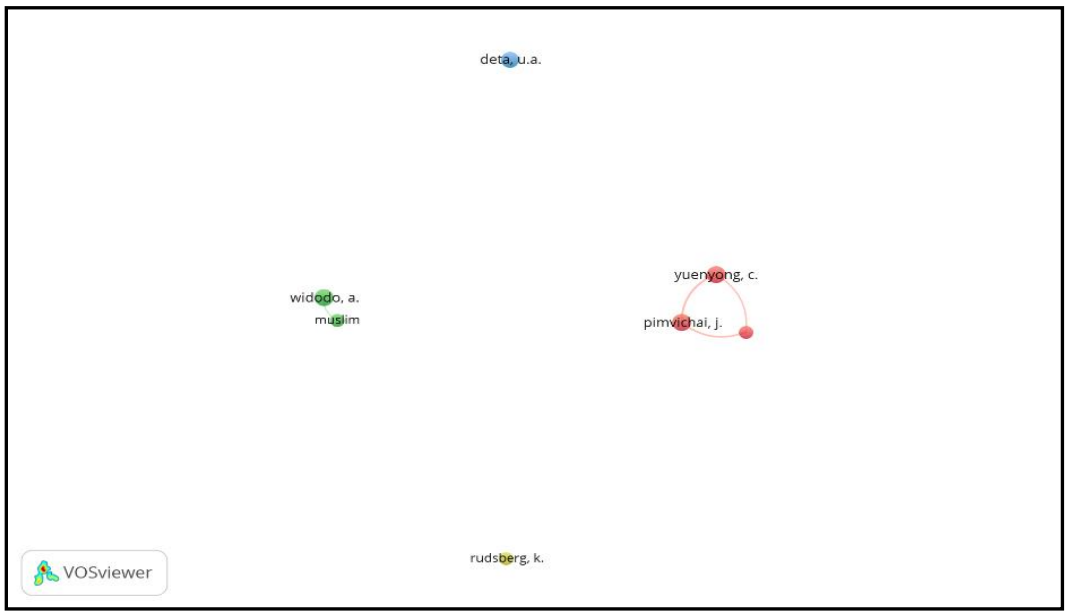

Figure 5. Visualization of Vosviewers on the most productive authors.

Table 2. The top 7 citations on TAP articles.

Author	Year	Country	Source	Citation	Quartile	H-Index	SJR
Rudsberg, K., ÖHman, J., ÖStman, L.	2013	Thailand	Science Education 97(4), 594-620	36	Q1	121	2.96
Kulatunga, U., Moog, R.S., Lewis, J.E.	2013	Thailand	Journal of Research in Science Teaching 50(10), 1207-1231	35	Q1	139	2.71
Dawson, V., Carson, K.	2017	Indonesia	Research in Science and Technological Education 35(1), 1-16	31	Q1	34	0.71
1. Stapleton, P., Wu, Y.	2015	Indonesia	Journal of English for Academic Purposes 17, 12-23	28	Q1	63	1.38
Moon, A., Stanford, C., Cole, R., Towns, M.	2016	Indonesia	Chemistry Education Research and Practice 17(2), 353-364	24	Q1	49	0.85
Gray, R., Kang, N.-H.	2014	Thailand	International Journal of Science Education 36(1), 46-65	23	Q1	115	1.15
Nam, Y., Chen, Y.-C.	2017	Swedia	Eurasia Journal of Mathematics, Science and Technology Education 13(7), 3431-3461	17	Q2	44	057

Citations are notes placed in the main text of an academic publication that gives a bibliographic reference to published work that has been used or quoted by the author. The higher number of citations a document receives indicates the high usefulness of the document and is said to be of higher quality. Likewise, in a journal, the higher the number of citations obtained, the higher the quality, and has a high impact factor and high ranking (Maryono & Surajiman, 2017; Nugroho, 2019). The most citations are entitled "Analyzing Students' Learning in Classroom Discussions about Socio-scientific Issues," written by Rudsberg, K., Hman, J., Stman, L. and published in 2013 and have been cited 36 times. This study shows that TAP is used to understand the meaning of students in arguing, and the purpose of the analysis is to use TAP to clarify the role of the practice of argumentative discussion. The second was written by Kulatunga, U., Moog, R.S., Lewis, J.E. entitled "Argumentation And Participation Patterns In General Chemistry Peer-Led Sessions" and has been cited 35 times. This study explains that the researcher commodifies students in small groups and has provided a framework. TAP helps observe the group and individual participation patterns. Furthermore, the final

result of this study shows that students are able to resolve their claims which were initially wrong, by arguing without the help of colleagues.

Number of Documents of TAP in Science Education Across Source Titles

It can be seen in **Table 3** that the Journal of Physics Conference Series is the most productive in publishing 15 journals on Toulmin's Argument Pattern in the last ten years. Several journals on bibliometric analysis also mention that the journals that produce the most documents are Journal of Physics Conference Series (Machmuda et al., 2022)

Table 3. Contribution of journal publishers to TAP in science education.

Source Title	Number of documents	Quartile	H-Index	SJR
Journal of Physics Conference Series	15	Q4	85	0,21
AIP Conference Proceedings	4	-	75	0,19
African Journal of Research in Mathematics Science and Technology Education	3	Q3	16	0,28
Cultural Studies of Science Education	3	Q1	32	0,9
Science And Education	3	Q1	49	0,94
Eurasia Journal of Mathematics Science and Technology Education	2	Q2	44	0,57
International Journal of Science Education	2	Q1	115	1,15
Research In Science and Technological Education	2	Q1	34	0,71

Top 5 Uses of Language in Journals

Identification of the use of language types in research publications related to TAP obtained five languages, as presented in **Table 4.**

Table 4. Top 5 uses of language in journals.

Language	Number of documents
English	61
Spanish	5
Purtugies	1
Korean	1

The language used in writing the most articles is English, with 61 documents. Spanish followed them with five documents, Portuguese and Korean with 1 document. This is in line with research (Shahriyor, 2022; Vera et al., 2022), which states that English is a language that international writers often use because English is an international language that is often used almost all over the world.

Visualization of Results Using Vosviewers

Based on the 67 documents related to TAP that met the criteria, the research profile was then visualized using the VOSviewer software. This effort aims to find clusters of research that have been carried out related to TAP in educational research. **Figure** 6 shows the results of visualization trends in applying TAP in education.

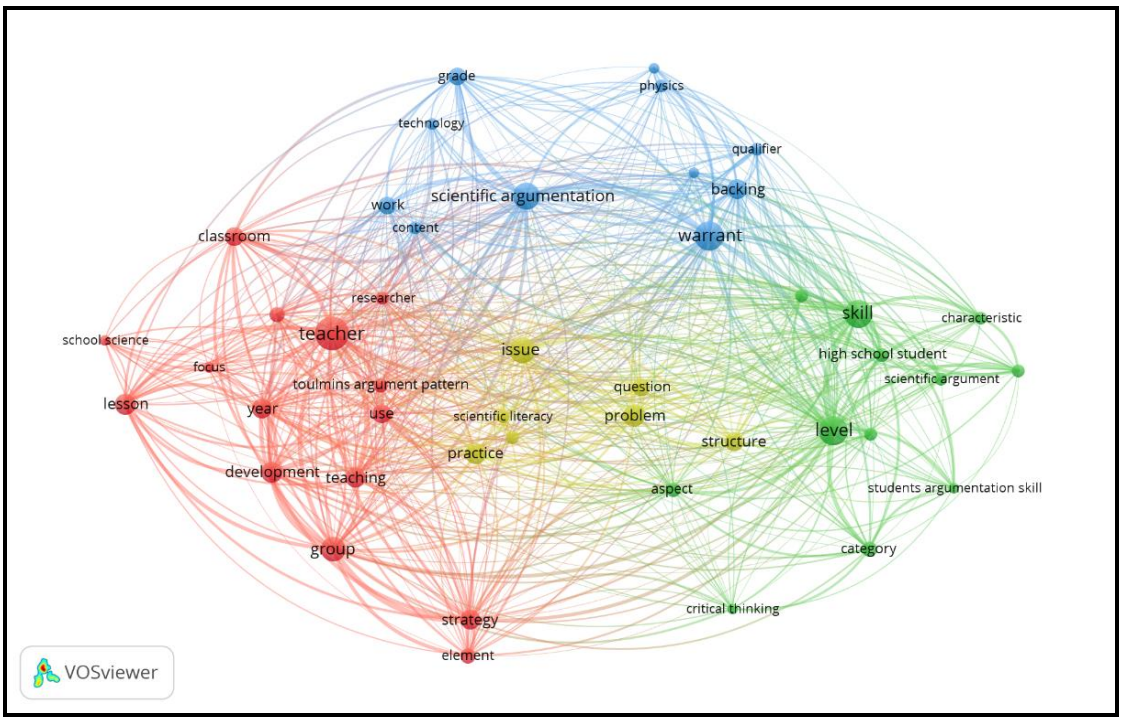

Figure 6. Visualization using Vosviewer.

Based on **Figure 6**, the visualization results of VOSviewer obtained 4 clusters in educational research. The first red cluster comprises keywords: teacher, teaching, lesson, classroom, development, TAP, strategy, element, group, focus, and researcher. Based on the analysis of the relationship between keywords, it is clear that this first cluster discusses TAP focused on learning processes and activities in the classroom. Teachers can also use TAP in learning strategies, who usually form groups and give each other opinions on the topic. This is in agreement with the research (Mardiati et al., 2022). The second green cluster comprises keywords: level, skill, category, aspect, scientific argument, student argumentation skill, critical thinking, and a high school student. Analysis of the relationship between keywords found that this second cluster discussed the application of TAP focused on assessing argumentation and critical thinking skills. This aligns with research (Hakim et al., 2022; Rubini & Pursitasari, 2022), which states that the TAP can also measure critical thinking, creative thinking, and argumentation skills. The third blue cluster comprises keywords: scientific argumentation, warrant, backing, qualifier, content, physics, work, technology, and grade. The analysis results of the third caster keyword relationship found that the discussion of TAP was associated with identifying the components of scientific argumentation. The fourth yellow cluster comprises keywords: structure, issue, problem, question, scientific literacy, and practice. Based on the analysis of keyword relationships, the fourth cluster discusses the application of TAP related to contextual problem-solving in improving scientific literacy. Research from (Fakhriyah et al., 2022), the scientific argumentation measurement pattern could be found by using TAP.

Distribution in Science Subjects

Based on identifying the TAP application related to teaching subjects, the results are shown in **Figure 7. Figure 7** shows the top three subjects often associated with TAP in research: Physics, chemistry, and biology. Physics is the subject most often associated with TAP; this aligns with the data in Table 3, which shows that two physics

conferences are included as the top 2 sources of TAP application publications. Another data that also strengthens is shown in **Figure** 6, which shows the appearance of physics in the VOSviewer visualization. It can be seen in **Figure 7** the most researched TAP in the field of physics.

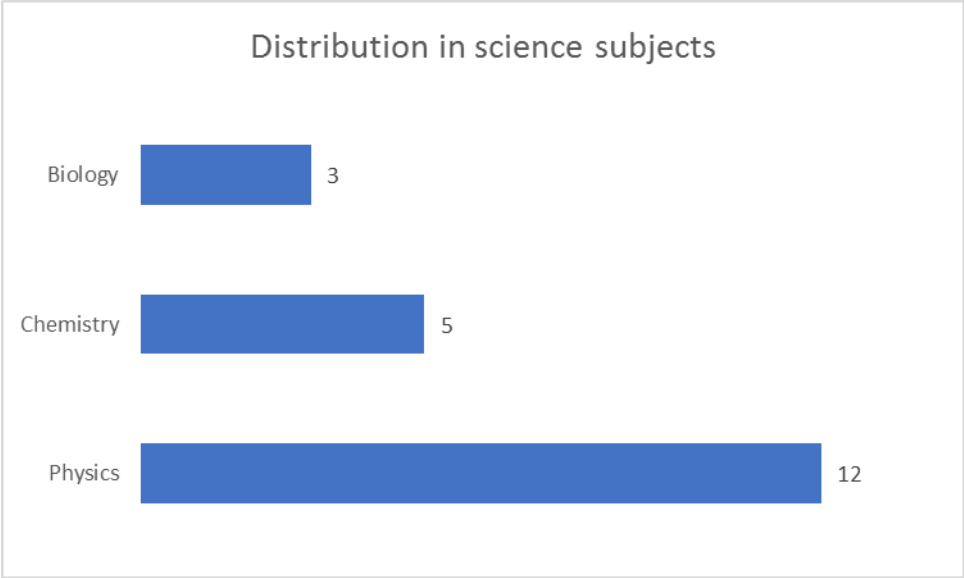

Figure 7. Distribution application TAP in science subjects.

List of Physics Journals Using TAP

Based on the results of further research on 12 TAP research documents connected to physics lessons, data were obtained as presented in **Table 5.**

Table 5. List physics journal.

Authors	Title	Year
Ain, T.N., Wibowo, H.A.C., Rohman, A., Deta, U.A.	The Scientific Argumentation Profile Of Physics Teacher Candidate In Surabaya	2018
Dunac, P.S., Demir, K	Stacking Up Against Alternative Conceptions: Using Uno Cards To Introduce Discourse And Argumentation	2013
Syerliana, L., Muslim, Setiawan, W.	Argumentation Skill Profile Using "Toulmin Argumentation Pattern" Analysis Of High School Student At Subang On Topic Hydrostatic Pressure	2018
Breivik, J.	Argumentation Skills Profile On 8th Grade Students Using Toulmin's Argument Pattern On Controversial Topic	2020
Safrina, I., Maknun, J., Hasanah, L.	Analysis Of Student's Skills On The Concept of Dynamic Electricity	2017
Pimvichai, J., Sivabhaedya, S., Yuenyong, C.	Thai Urban School Students' Scientific Argumentation In Physics Learning Weblog	2015
Pimvichai, J., Yuenyong, C., Anantasook, S.	Enhancing Metacognition Through Weblog In Physics Classroom Thai Context	2014
Deta, U.A., Yanti, V.K., Misbah, Mahtahari, S., Alamsyah	The Scientific Argumentation Profile Of Annular Solar Eclipse Phenomenon June 21st2020 Of Physics Undergraduate Student In Universitas Negeri Surabaya	2021
Guimarães, R.R., Massoni, N.T.	The Use Of Stephen Toulmin's Standard Model Of	2021

Authors	Title	Year
	Argumentation In Science Teaching Within The Physics Discipline: Some Research Results And Reflections From Classroom Debates	
Ambarawati, D.S.H.E., Muslim, Hernani	Profile Of Students' Argumentations Ability On The Topic Of Environmental Pollution	2020
Pertiwi, R.P., Sinensis, A.R.	Profile Of Elementary Student's Argument Ability On The Energy Topic	2019
Pratami, A.R., Widhiyanti, T., Widodo, A.	Analysis Of Senior High School's Reasoning Skill	2019

Discussion

As physics teacher candidates, students are expected to learn more about the existing phenomena (Ain et al., 2018). In the research "The scientific argumentation profile of physics teacher candidate in Surabaya," it was found that students' ability was still weak in the level of providing claims, and some students could not provide rebuttals. As students In the study entitled "Stacking up against alternative conceptions: Using Uno cards to Introduce Discourse and Argumentation," the researcher presents the TAP framework so that students can analyze the provided discourse and argue in groups. The pattern of individual participation will increase. In some situations, the teacher encourages students to explain, using their language, the concept of energy transformation with the help of the TAP framework (Dunac & Demir, 2013).

Argumentation skills by analyzing the results of essay tests on a controversial topic, namely pollution. The research "Argumentation skill profile using "Toulmin Argumentation Pattern" analysis of high school students at Subang on the hydrostatic topic" explains that the argumentation skills obtained by students are low, and the lowest score is in the warrant section (Syerliana et al., 2018). The research "Argumentation Skills Profile on 8th Grade Students using TAP on Controversial Topic" showed that basic argumentation skills dominated the students' argumentation skills. Based on existing data, students should be encouraged to provide ideas based on their data or knowledge when they learn about science. The results of this study provide a reference for further research and system development related to argumentation. In addition, the structured argument scaffolding and TAP developed in this study can be applied to both formal and informal science curricula. It is known in research related to TAP in the field of physics it can be seen that students still need to improve in arguing with the TAP framework. Furthermore, if TAP is applied in the daily learning process, it can improve scientific argumentation skills.

CONCLUSION

Fundamental Finding: Based on the results of the analysis and discussion, it is known that the development of TAP articles every year has increased and decreased in the last ten years. The year 2019 was the year that produced the most documents, as many as 16, and the fewest years, namely 2016 and 2022, which only produced three documents. Pimvichai, Yuenyong, C.; Widodo, A dominates among the seven most prolific writers with five articles. The most citations are entitled "Analyzing Students' Learning in Classroom Discussions about Socio-scientific Issues," written by Rudsberg, K., Hman, J., Stman, L. and have been cited 36 times. Research visualization using VOSviewers produces 4 clusters, (1) discusses TAP focused on learning processes and activities in the classroom. (2) the application of TAP focused on assessing argumentation and

critical thinking skills (3) TAP was associated with the identification of the components of scientific argumentation (4) TAP related to contextual problem-solving in improving scientific literacy. Physics is the field of science that produces the most research on TAP, with 12 documents. **Implication:** Based on the results of this study, TAP has many contributions to physics learning in improving students' argumentation skills, so it can be an opportunity for further research. **Limitation:** As for the limitations in this study, every year, there will always be new research on TAP, so the opportunity for researchers to examine the bibliometric of TAP. **Future Research:** That way, the next one will be able to discuss more deeply related to the TAP, which is applied to physics learning to improve argumentation and critical thinking skills.

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