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# Research Trend of Dynamic Fluid in Learning: A Bibliometric Analysis

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**Abstract**

This article provides an extensive bibliometric literature review on dynamic fluid in learning. This study aims to analyze research trends related to dynamic fluid in learning topics in 2019-2023 through bibliometric analysis with the Scopus database. Based on the criteria obtained, 327 articles were obtained from 1598 documents. The articles have already been analyzed from the journal and conference proceedings indexed in Scopus. Dynamic fluid research trends in learning are also reviewed based on the number of articles published each year, sources of publication (both journals and proceedings), the most productive countries, the most productive authors based on the number of documents, and co-occurrences using VOSviewer. The results show that the dynamics of learning are increasing every year. JPCS has published the most dynamic fluid articles in learning. The United States, as the most productive country, researches this topic. In addition, most of the prolific authors come from the US. A visualization of dynamic fluid research trends in learning using VOSviewer software obtained five clusters. The results of this study provide direction for further research on fluid dynamics in learning.

**Keywords**: bibliometric analysis, dynamic fluid, physics learning

## INTRODUCTION

The application of fluid physics is very closely related to everyday life. Fluid Dynamics is part of Fluid Mechanics which underlies several phenomena and technologies in everyday life (Permana et al. 2021), as for analyzing the phenomenon of human blood flow (Wulandari et al. 2022). The use of Computational Fluid Dynamics (CFD) as an important tool to predict fluid flow behavior in many industrial sectors (Strönisch et al. 2022), in chemical engineering (Ansari et al. 2022), Calculating Aerodynamic Forces in Aircraft Design (Zhao et al. 2022), designing the shape of the hull (Kim et al. 2022). The use of CFDs and nondimensional concepts, with the help of machine learning techniques, to predict the wind power potential of a group of wind turbines (Mortezazadeh et al. 2022).

Based on the data in Scopus, there are many articles about the application of fluid physics in various fields (Maulik et al. 2021; Saharuddin et al. 2021; Zeng et al. 2021; Khan et al. 2022; Lu et al. 2022), but it is still rare to find articles about the application of fluid physics in learning. This article provides an extensive bibliometric literature review on the dynamic fluid in learning. This study aims to analyze research trends related to dynamic fluid in learning topics in 2019-2023* through bibliometric analysis with the Scopus database. Some of the research questions in this study are: 1) What is the number of publications on the topic of dynamic fluids in learning each year? 2) Top 10 most published sources on this topic? 3) Which 10 countries research heavily on this topic? 4) Who are the 10 best authors on this topic based on the number of documents? and 5) Is the visualization and overlay network on this topic based on co-occurrence analysis?

## METHODS

In this study, the research used was bibliometric literature analysis (Zupic and Čater, 2015). Bibliometric analysis is the quantitative study of bibliographic material. Literature and metadata searches were carried out using the Scopus database with the keywords "dynamic fluid" AND teaching OR learning obtained 1598 documents. The data collection will be carried out on June 18, 2023. The obtained documents are then reduced based on: Open access, the year 2019-2023, Document type: article and conference paper, Publication stage: final, Source type: journal and conference proceeding, and Language: English. Based on the criteria obtained, 327 from 1598 documents. Documents yang diperoleh terdiri dari 83% articles dan 17% conference paper. The results of the documents were then analyzed using VOSviewer software to analyze co-occurrence. The steps in this bibliometric analysis are presented in FIGURE 1.

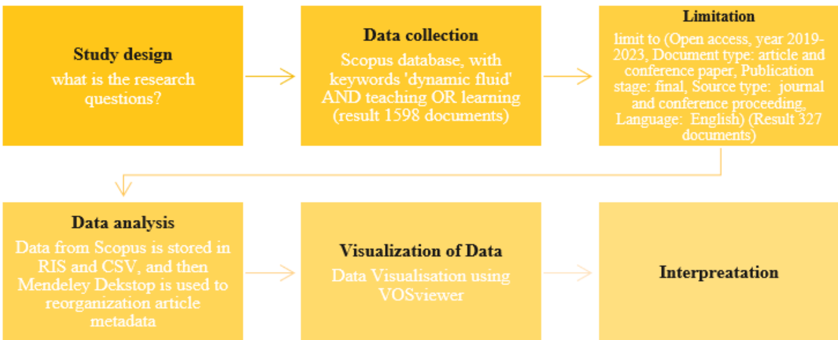


**FIGURE 1.** The steps of Bibliometric Analysis in Dynamic Fluid Topics

## RESULTS AND DISCUSSION

Based on the Scopus database on this topic, the number of documents published in 2019-2023 is obtained, as shown in FIGURE 2.

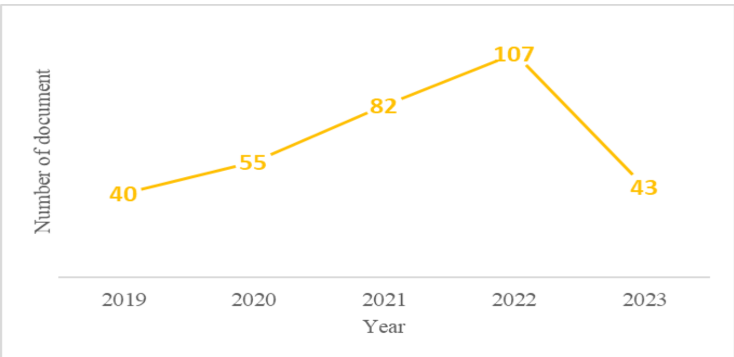


**FIGURE 2.** Dynamic Fluid Publication in 2019-2023*

In FIGURE 2, publications from 2019-2022 have increased on this topic, and this year the number will continue to increase until the end of 2023. The increase in published articles is inseparable from the concept of dynamic fluids that benefit various aspects of life. CFD numerical simulation is used to assess solar stills performance (AlSaleem et al. 2022), Fluid dynamic approaches for predicting spray drift from ground pesticide applications (Hong et al. 2021), and others.

The ten most published sources on this topic from both journals and proceedings are presented in TABLE 1.

**TABLE 1.** Top 10 Sources on Dynamic Fluid Topics

| No | Source Title | Number of Documents | Category | Q | Publisher |
|---|---|---|---|---|---|
| 1 | Journal Of Physics Conference Series | 29 | Conference Proceeding | Q4 | IOP Publishing |
| 2 | Energies | 7 | Journal | Q1 | Multidisciplinary Digital Publishing Institute (MDPI) |
| 3 | Applied Sciences Switzerland | 6 | Journal | Q1 | MDPI |
| 4 | Fluids | 6 | Journal | Q2 | MDPI |
| 5 | AIP Conference Proceedings | 5 | Conference Proceeding | Q4 | American Institute of Physics |
| 6 | Frontiers In Neuroscience | 5 | Journal | Q2 | Frontiers Media S.A. |
| 7 | Neuroimage | 5 | Journal | Q1 | Elsevier |
| 8 | AIP Advances | 4 | Journal | Q2 | American Institute of Physics |
| 9 | Computers And Fluids | 4 | Journal | Q1 | Elsevier |
| 10 | Energy | 4 | Journal | Q1 | Elsevier |

In TABLE 1, it is obtained that most of the sources that publish articles on this topic are dominated by journals originating from Q1 and Q2. In addition, the publisher is also dominated by MDPI and Elsevier. The most widely published source of this article is the Journal of Physics Conference Series, which publishes many articles on dynamic fluids in learning (Diansah and Asyhari 2020; Halim et al. 2021; Koes-H et al. 2021; Ramli and Serevina 2021).

Here are ten countries that have researched a lot on this topic listed in FIGURE 3.

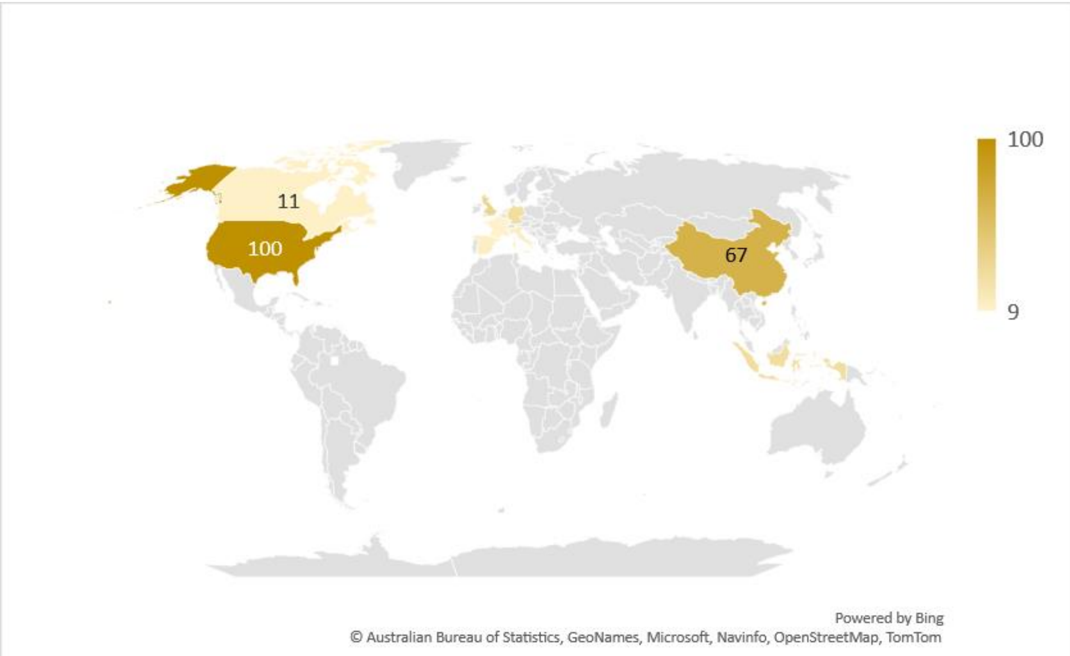


**FIGURE 3.** Top 10 Countries Published Articles on The Topic of Dynamic Fluids

FIGURE 3 shows that the United States is ranked as the most productive country on this topic, with 100 articles. Then followed by China with 67 articles United Kingdom with 37 articles. Sequences 4 and 5 with the same number of documents of 28 pieces were obtained by Germany and Indonesia. The next order is the Netherlands with 15 articles, Italy with 13 articles, Spain with 12 articles, Canada with 11 articles, and France with nine articles.

The US, as many of the most productive countries researching this topic, corresponds to the most authors achieved by San, as many as six documents also from the US (Maulik et al. 2019; Tabib et al. 2021; Dabaghian et al. 2022). The ten best authors on this topic based on the number of documents are listed in FIGURE 4.

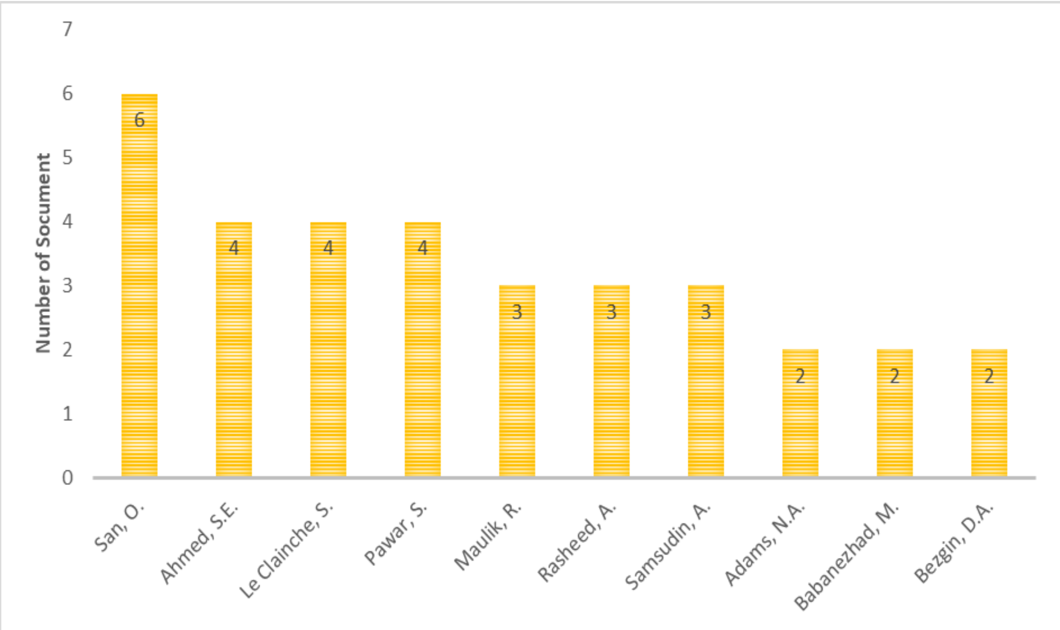


**FIGURE 4.** 10 Best Authors by Number of Documents on Dynamic Fluid Topics

In FIGURE 4, it is obtained that, in general, the authors write articles on this topic at least two articles. Authors San & Ahmed (Ahmed et al. 2019; Ahmed et al. 2020) are both from the US and constitute 1 research team. Pawar and Maulik also come from the US (Maulik et al. 2019; San et al. 2022). Le Clainche is from Spain (Corrochano et al. 2023), while Rasheed is from Norway. In 7th place, there is Samsudin from Indonesia, who researches a lot about process science skills in fluid dynamics (Hasbi et al. 2022), the application of the ALBICI Model on the Debit Concept (Sholihat et al. 2019), and problem-solving skills in fluid dynamic topics (Malik 2019). Generally, these ten best writers are dominated by authors from the US. This corresponds to the US being the most productive country on this topic, 327 from 1598 documents were then analyzed using VOSviewer software to analyze co-occurrence. The results are shown in FIGURE 5 and 6.

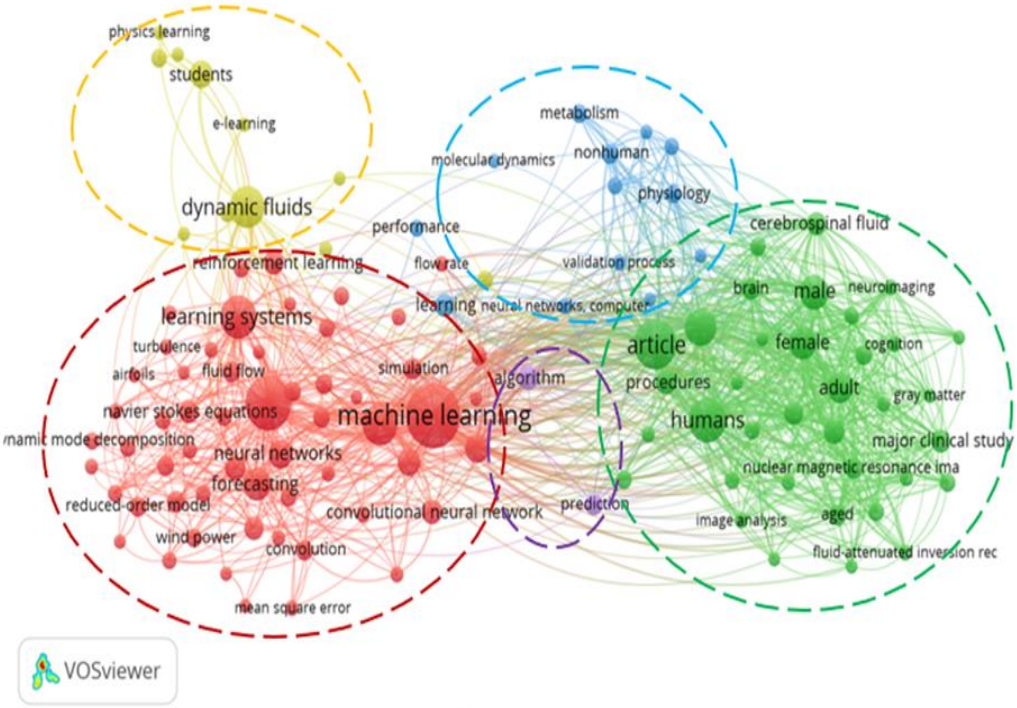


**FIGURE 5.** Network Visualization for Dynamic Fluids

FIGURE 5 shows five clusters characterized by red, green, blue, yellow, and purple. In TABLE 2, each cluster displays the terms that appear in each cluster.

**TABLE 2.** Research Element of Each Cluster

| No | Cluster | Number of items | Keywords |
|---|---|---|---|
| 1 | Red | 57 | Aerodynamics, artificial neural network, computational fluid dynamics (CFD), computer simulation, deep learning, fluid flow, hydrodynamics, learning algorithms, learning systems, machine learning, principal component analysis, reinforcement learning, reynolds n umber, turbulence, velocity, vortex flow, and others |
| 2 | Green | 36 | Adult, alzheimer disease, article, cerebrospinal fluid, cognition, diagnostic imaging, female, fluid-attenuated inversion recovery imaging, humans, male, major clinical study, nuclear magnetic resonance imaging, and others |
| 3 | Blue | 13 | Animal experiment, animals, feature extraction, human experiment, learning, metabolism, molecular dynamics, mouse, neural networks, computer, nonhuman, performance, physiology, and validation process |
| 4 | Yellow | 11 | Active learning, artificial intelligence, dynamic fluids, e-learning, education computing, engineering education, fluid mechanics, iterative methods, learning models, physics learning, and students |
| 5 | Purple | 2 | Algorithm and prediction |

In cluster 1, many discuss CFD dan machine learning. Modern aircraft companies rely heavily on CFD because it offers crucial insights into aerodynamic analysis while obviating the necessity for costly tests and trials (Kiener and Bekemeyer 2022). Numerous applications in the oil and gas (O&G) industry are increasingly turning to machine learning (ML) techniques (Vikara and Khanna 2022). Parts of traditional CFD solvers, such as cell face reconstruction in the finite-volume approach or curvature computation in the Volume-of-Fluid (VOF) method, have been replaced by machine learning (ML) techniques (Buhendwa et al. 2022).

In cluster 4, many discuss the relationship between dynamic fluids and physics learning. Several studies have mentioned that research has been conducted on the development of learning devices, modules, both electronic and not, student worksheets, media, and teaching aids. In addition, there is also a discussion about the application of several learning models on the topic of dynamic fluids.

Developing learning tools based on guided inquiry models on dynamic fluid learning materials can improve students' understanding of concepts,s psychomotor skills, and character (Sumo et al. 2022). Developing static fluid and dynamic fluid e-books based on websites with problem-based learning can improve students' physics problem-solving (Ramli and Serevina 2021). Development of Student Worksheets based on a Scientific Approach to be more effectively used in dynamic fluid learning (Halim et al. 2021). Electronic modules based on self-directed learning (SDL) models effectively helps students understand the concept of dynamic fluids (Diansah and Asyhari 2020). The development of STEM dynamic fluid-based E-Modules has the potential to simulate students' HOTS (Sari and Suyatna 2021). Development of science literacy-based e-books on dynamic fluid topics (can be used to train skills in students (Kholiq & Khoiriah 2021). Developing electronic modules with a cooperative model of the Assisted Individualization Team (TAI) type equipped with HOTS questions on dynamic fluid materials can be used as independent teaching materials (Astra et al. 2022). The development of dynamic fluid modules based on authentic learning can be used to train students' problem-solving skills (Wati, Safiah & Misbah 2021). The development of Android Physics Applications (APA) media can be used as a dynamic fluid learning medium in the classroom (Fathurohman et al. 2021).

Developing educational comics integrated with character education can be used in fluid learning (Muliyati et al. 2021). Development of dynamic fluid trainers for senior high school (Herdayanti and Manurung 2020; Sani 2021).

Application of STEM education in designing simple water pressure booster pumps (Koes-H et al. 2021). the application of the ALBICI Model can change students' conceptions of the concept of Discharge (Sholihat et al. 2019). Applying to learn using the PBL model through the STS approach on dynamic fluid topics can increase student learning interest (Maidan et al. 2020).

The use of educational games for learning physics on dynamic fluids that are suitable inside and outside the classroom (Muliyati et al. 2022). The Cooperative Problem Solving (CPS) model can be used as an alternative learning model to improve students' problem-solving skills on dynamic fluid materials (Malik 2019).

Based on several existing studies, it is found that there is still a rare use of inquiry models on the topic of dynamic fluids, and it is still rare to examine critical thinking skills and problem-solving abilities in the 2019-2023 period.

Dynamic fluid research in physics learning at the university level (Ramli and Serevina 2021), SMA (Sholihat et al. 2019; Diansah and Asyhari 2020; Herdayanti & Manurung 2020; Fathurohman et al. 2021; Halim et al. 2021; Kholiq and Khoiriah 2021; Wati et al. 2021; Sumo et al. 2022). Based on this explanation, it is known that research on the topic of dynamic fluids at the university level is still rarely carried out.

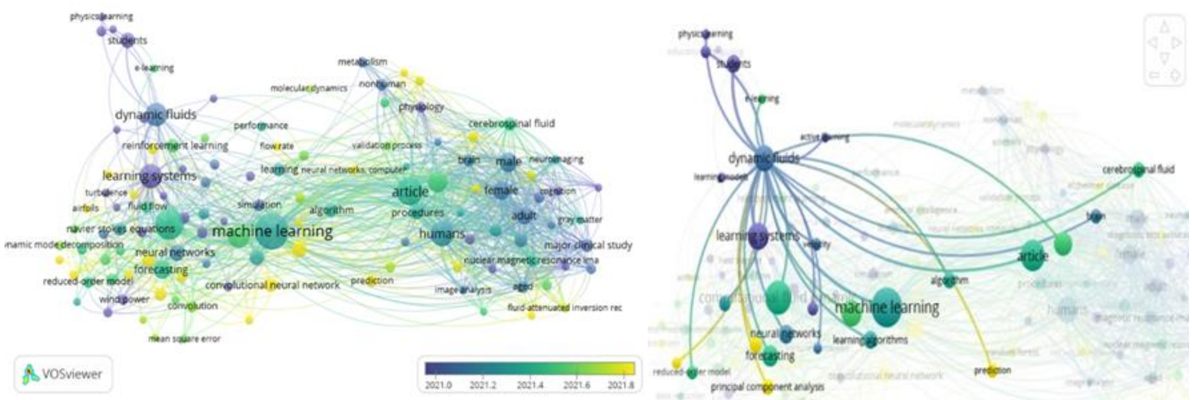


**FIGURE 6.** Visualisasi Overlay untuk Fluida Dinamis dalam Pembelajaran

The size of the circle indicates the frequency of the term that appears during the analysis. The larger the size of the circle means that the term appears on the title and abstract of the analyzed article. In Figure 6, it is obtained that dynamic fluids are more associated with CFD and machine learning (Babanezhad et al. 2020; Zeng et al. 2021; Lu et al. 2022), and in the last two years, dynamic fluids have been more associated with Principal Component Analysis (PCA) (Benner et al. 2020; Dabaghian et al. 2022; Corrochano et al. 2023). Although dynamic fluids are connected to physics learning, active learning, and e-learning, the circle size is still small. This shows that these keywords still appear little in the title or abstract, so this has the opportunity to be investigated further.

## CONCLUSION

The results show that dynamic fluid is increasing every year, from 2019-2022 the results of review have increased in fluid topics and this year the number will continue to increase until the end of 2023. but there is still little discussion in learning. The United States contributes most of the research globally on this topic. Top 10 authors by many documents related to fluid dynamics played by authors from the US. Visualization trend Fluid dynamic research on learning using the VOSviewer software obtained five clusters. 5 clusters are generated, represented by 5 colors, clusters with red color contribute many items or keywords with many about CFD and machine learning. It is necessary to conduct further research on the topic of fluids. fluid is one of the fields of physics that is closely related to daily life, so that in its research it can continue to be developed and researched more deeply. Hopefully, in future studies researchers can explain more deeply about research trends on fluid topics, as well as conduct in-depth research by covering many countries. The results of this study provide directions for further research on fluid dynamics in learning.

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