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A scoping review with bibliometric analysis of topic fluid in science education: State of the art and future directions

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Abstract: The aim of this scoping review is to provide an overview of scoping reviews in the literature on the topic of fluid science education through bibliometric analysis. The data search was carried out based on the Scopus database, then limitations were carried out based on certain criteria to obtain 146 documents. Publications on this topic have increased, especially in 2019-2023*. Then the author with the most citations was published in an international journal indexed by Scopus with quartile 1. Based on visualization using VOSviewer, 4 clusters were obtained and based on research in the last 2 years, both static and dynamic fluids are often associated with teachers, senior high schools, teaching, student learning, online learning. This research is the basis for further research related to the topic of fluids in science education. For example, fluid topics are rarely studied at the university level.
Keywords: bibliometric analysis; fluid; research trend; science education

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Introduction

Physics is a branch of science that examines facts, symptoms, and natural occurrences (Lori, 2011; Mellu et al., 2022). Fluid is one of the physics materials. As a collection of molecules held together by cohesion and adhesion as well as by the forces exerted by the container wall, fluids are defined as such. In this context, the term "fluids" refers to fluid mechanics.

The field of fluid mechanics known as static fluid deals with still gases and liquids (Kundu et al., 2015; Rajagopal, 2015). Pressure, hydrostatic pressure, Pascal's law, Archimedes law, capillarity, viscosity, and surface tension are all included in this idea. Fluid Dynamics is a subset of fluid mechanics, which is the science that underpins many phenomena and modern technology (Permana et al., 2021).

Everyday life and the application of fluid physics are inextricably linked. This idea has numerous practical implications in daily life (Adam et al., 2019). The Archimedes and Pascal laws are also applied in hydraulic technologies, such as hydraulic jacks and brake systems (Agrawal et al., 2018; Syadzili, 2018). Wind turbines, jet engines, water filtration, and artificial hearts are examples of projects in fluid mechanics (Garcia, 2023). In various industrial areas, such as chemical engineering (Ansari et al., 2022), calculating aerodynamic forces in aircraft design (Zhao et al., 2022), and etc.

The application of fluids is often found in everyday life, both in technology and other fields. It is important to teach fluid applications to students, so that students not only understand fluid concepts/principles, but also understand how they are implemented in life (Kariotoglou & Psillos, 2019; Permana et al., 2021). Students must be taught fluid physics using a variety of approaches, frameworks, methodologies, and teaching tools (Maulik et al., 2021; Zeng et al., 2021). Fluid mechanics-related topics must be covered in an engaging and interactive manner (Pérez-Sánchez & López-Jiménez, 2020). Based on the Scopus database, there are not many studies that comprehensively examine this fluid concept in the teaching and learning process as a whole. Through a bibliometric examination of the literature on fluid in science education, this paper aims to provide a thorough explanation. This approach is useful in many different fields to explain the current research direction (see Table 1). The purpose of this study was to address the following questions: (1) How many publications have there been on the topic of fluid in science education since 2019-2023*? (2) Who are the 5 best authors based on the number of citations? and (3) How to visualize the results of fluid research trends in science education?.

Table 1. Previous Studies of Bibliometric Analysis

No	Title	Topic Discussion
1	A Bibliometric analysis of Covid-19 research using VOSviewer (Hamidah et al., 2020).	Using a bibliometric analysis, this study examines the breadth of Covid-19 research.
2	A bibliometric analysis of management bioenergy research using vosviewer application (Soegoto et al., 2022).	Using mapping capabilities in the VOSViewer, this study analyzes data on the management of bioenergy and its growth over a five-year period (2017–2021).
3	Research mapping in the use of technology for fake news detection: Bibliometric analysis from 2011 to 2021 (Gunawan et al., 2022).	This study serves as a reference for future studies on the usage of false news detecting technology as well as a discussion of recent advancements in that field.
4	A bibliometric analysis of augmented reality in higher education (Utami et al., 2023).	This research explains everything trends regarding research progress in the field of AR in higher education.
5	A bibliometric analysis of deep learning for education research (Saputra et al., 2023).	This research discusses the role, trends, and developments of deep learning in education.

Method

This study utilizes a bibliometric analysis step consisting of five stages, including: 1) study design; 2) data collection; 3) data analysis; 4) visualization of data; 5) interpretation analysis (Misbah et al., 2022). Data collection was conducted in October 2023, based on the criteria obtained 146 articles from 23852 documents. The criteria used are documents from articles and proceeding papers with the source type namely journals and proceedings, then the publication stage is final, the document is in English, the scope is in science education, and within the 2019-2023* time period. The articles have already been analyzed from the international journal indexed by Scopus. The Scopus database was chosen because it is a source that has high credibility besides the web of science. Data from Scopus has ever been stored in RIS and CSV, more over Mendeley Dekstop has been utilized to reorganization article metadata. Furthermore, VOS viewer software as a visualization of research trend data with the topic fluids in the range 2019-2023* has been implemented. The bibliometric stages of analysis utilized is depicted in the Figure 1.

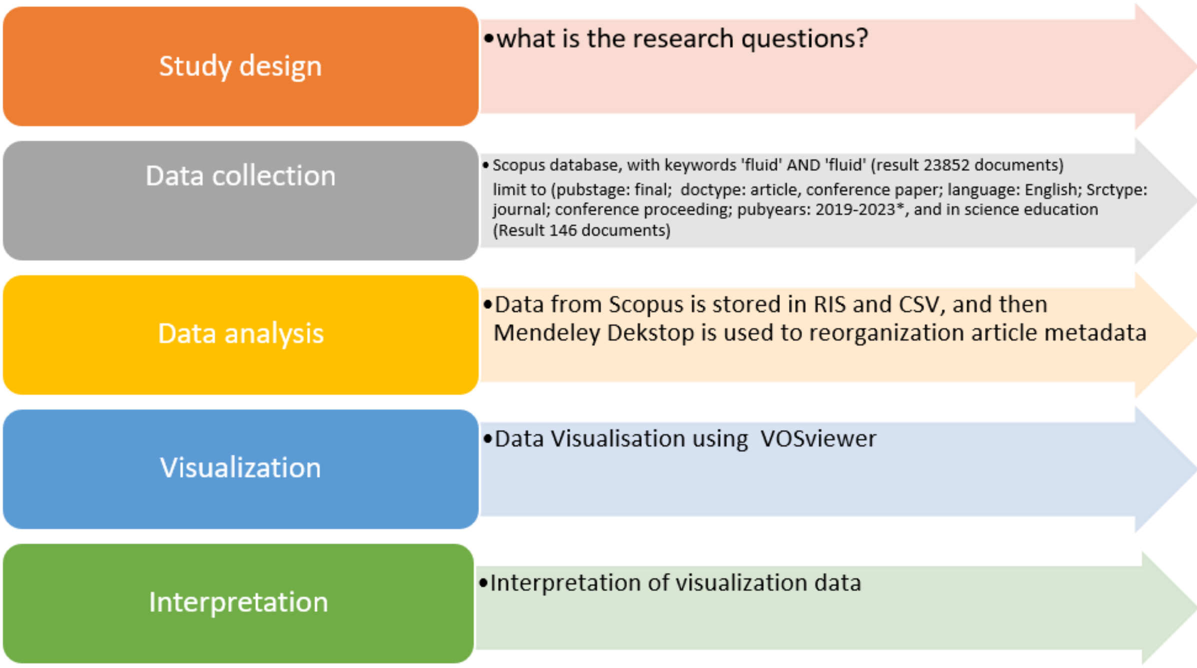

Figure 1. Research Scheme of Bibliometric in Fluid in Science Education

Results and Discussion

*Publications on fluid in science education in 2019-2023**

The following is the number of fluid in science education publications for 2019-2023* which is presented in Figure 2.

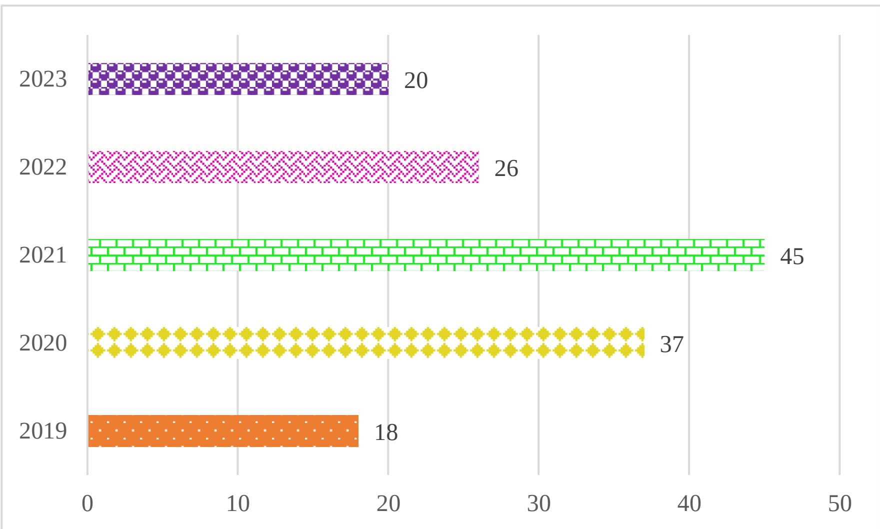

Figure 2. The Number of Fluid in Science Education Publications for 2019-2023*.

In Figure 2 shows that the number of publications on this topic has increased, especially in 2019-2021. Publications in 2021 are the highest compared to other years because the articles published this year are the results of previous research, for example, in 2020. Meanwhile, in 2022, there has been a decline in 2021 because since COVID-19 occurred, many studies have been hampered from completion. This will affect the number of publications in 2022. This is in line with research on critical thinking skills (Costa et al., 2020; Misbah et al., 2022) and creative thinking skills (Park & Lee, 2022; Smare & Elfatihi, 2023).

Five best authors based on the number of citations on the topic of fluid in science education

Following are the data for the top five authors based on the number of citations on the topic of fluids in science education, shown in Table 2.

Table 2. Top Five Authors Based on The Number of Citations on The Topic of Fluid In Science Education

No	Authors	Cited	Research Findings	Source	Quartile & SJR	Publisher
1	(Minichiello et al., 2021)	16	The goal of the mobile instructional particle image velocimetry tool is to increase knowledge of mathematical ideas as they apply to fluid mechanics while also igniting interest in and intuition about fluid flow.	Computer Applications in Engineering Education	Q1 0.651	John Wiley and Sons Inc
2	(Boettcher & Behr, 2021)	16	A virtual reality fluid mechanics laboratory gives the students the chance to understand how conservation laws are derived and to alter the flow in order to experiment with and evaluate the fundamental ideas of theoretical structures.	International Journal of Engineering Pedagogy	Q1 0.464	International Association of Online Engineering
3	(Wandel et al., 2020)	15	The framework produces models that can handle a variety of fluid phenomena, including the Magnus effect and Kármán vortex streets, and can do quick fluid simulations.	ICLR 2021 - 9th International Conference on Learning Representations	Q4	International Conference on Learning Representations, ICLR
4	(Syafei et al., 2020)	11	The usage of static fluid material in an e-learning environment with STEM-based Schoology is extremely possible and acceptable.	Journal of Physics: Conference Series	Q4	Institute of Physics Publishing
5	(Zhao et al., 2019)	9	The virtual tours gave students a general overview of the fluid mechanics lab as a pre-lab instruction aid. Students thought the virtual tours were very useful and educational, and that the virtual reality pump lab was simple to use and quick.	ASME International Mechanical Engineering Congress and Exposition, Proceedings (IMECE)		American Society of Mechanical Engineers (ASME)

Table 2 shows that the author's widely cited article on fluids was published by a Scopus indexed international journal with quartile 1 (Boettcher & Behr, 2021; Minichiello et al., 2021).

Visualization of fluid in science education research trends

VOS viewer can provide bibliometric analysis mapping with three different visualizations, namely network visualization listed in Figure 3. There are 54 identifiable items of 4 clusters characterized by different colors namely red, green, blue, and yellow.

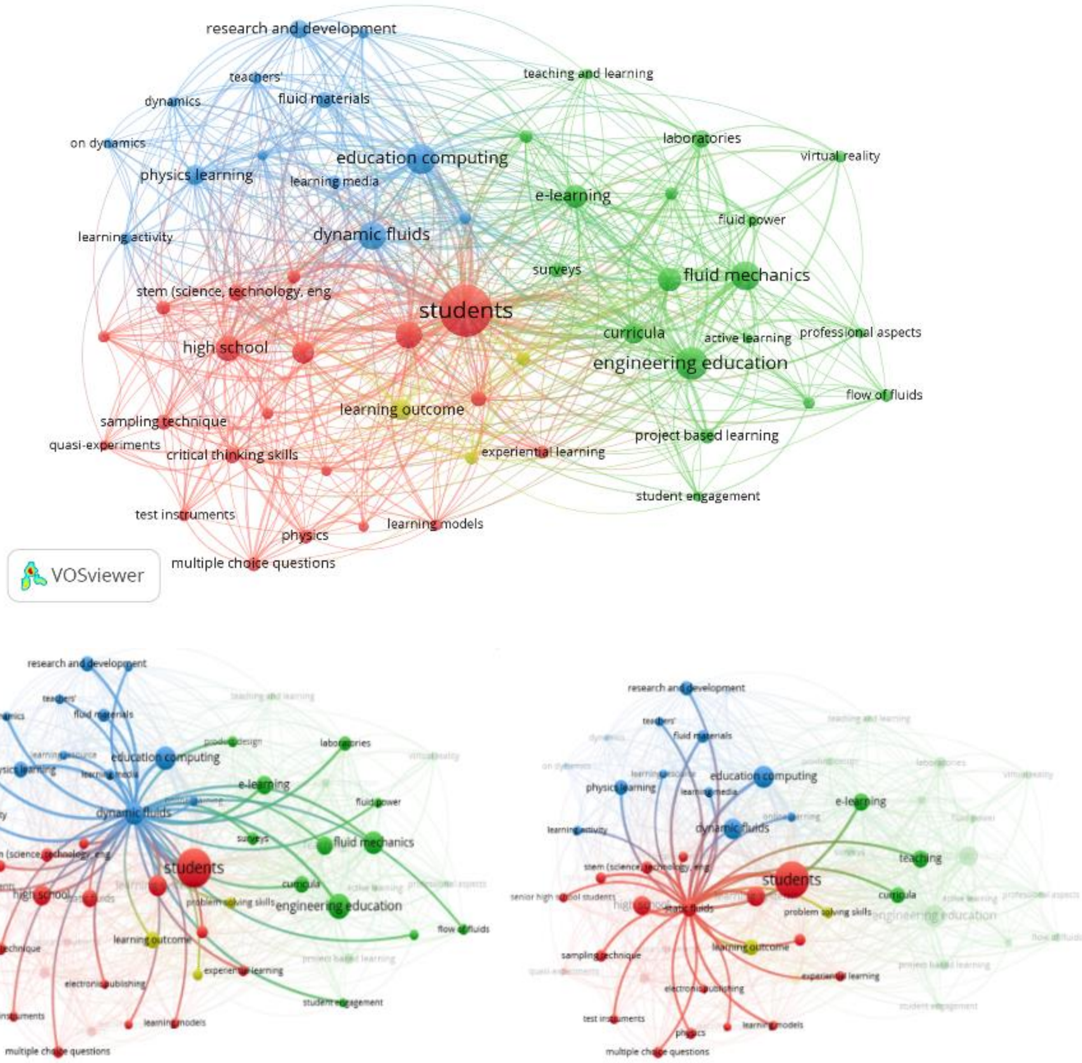

Figure 3. The Network Visualization of Fluid in Science Education

Each cluster shows the development of fluid in science education that can be observed in Table 3.

Table 3. Research Development of Each Cluster

No	Cluster	Number of Item	Keywords
1	Red	20	creative thinking, critical thinking skills, electronic publishing, experiential learning, high school, learning models, learning process, learning systems, multiple choice questions, physics, problem based learning, quasi-experiments, research methods, research subjects, sampling technique, senior high school students, static fluids, stem (science, technology, engineering and mathematics), students, test instruments
2	Green	18	active learning, computational fluid dynamics, computer aided instruction, curricula, e-learning, engineering education, flow of fluids, fluid mechanics, fluid power, laboratories, project based learning, professional aspects, product design, student engagement, surveys, teaching, teaching and learning, virtual reality
3	Blue	13	dynamic fluids, dynamics, education computing, fluid materials, learning activity, learning media, learning resource, on dynamics, online learning, physics education, physics learning, research and development, teachers'
4	Yellow	3	learning outcome, problem solving skills, student learning

Figure 3 and Table 3 show that cluster 1 which is colored red, fluid topics, such as static fluids, are taught to students through problem-based learning (Parno et al., 2021), STEM (Permana, et al., 2021). Apart from that, this fluid topic is mastered to train creative (Permana et al., 2021) and critical thinking (Saregar & Susanti, 2020). This fluid research is often applied at senior high school level (Parno et al., 2021; Saregar & Susanti, 2020). Apart from that, the topic of this fluid is research and development on learning models and test instruments (Saputra et al., 2020). In cluster 2, the fluid topic is associated with technology in the learning process such as e-learning and virtual reality (Boettcher & Behr, 2021; Syafei et al., 2020). This fluid topic is taught using active learning, for example using project-based learning (Pérez-Sánchez & López-Jiménez, 2020). Fluids are also applied in engineering education. In cluster 3, the topic of fluids or dynamic fluids is researched not only on fluid materials, learning activities, learning media, online learning (Boettcher & Behr, 2021; Syafei et al., 2020). And this topic is also applied in physics education (Parno et al., 2023; Permana et al., 2021; Sukariasih et al., 2020; Syafei et al., 2020). In cluster 4, fluid topics are associated with learning outcomes, problem solving skills, student learning (Parno et al., 2021; Sukariasih et al., 2020).

VOS viewer can provide bibliometric analysis mapping with three different visualizations, namely overlay visualization listed in Figure 4.

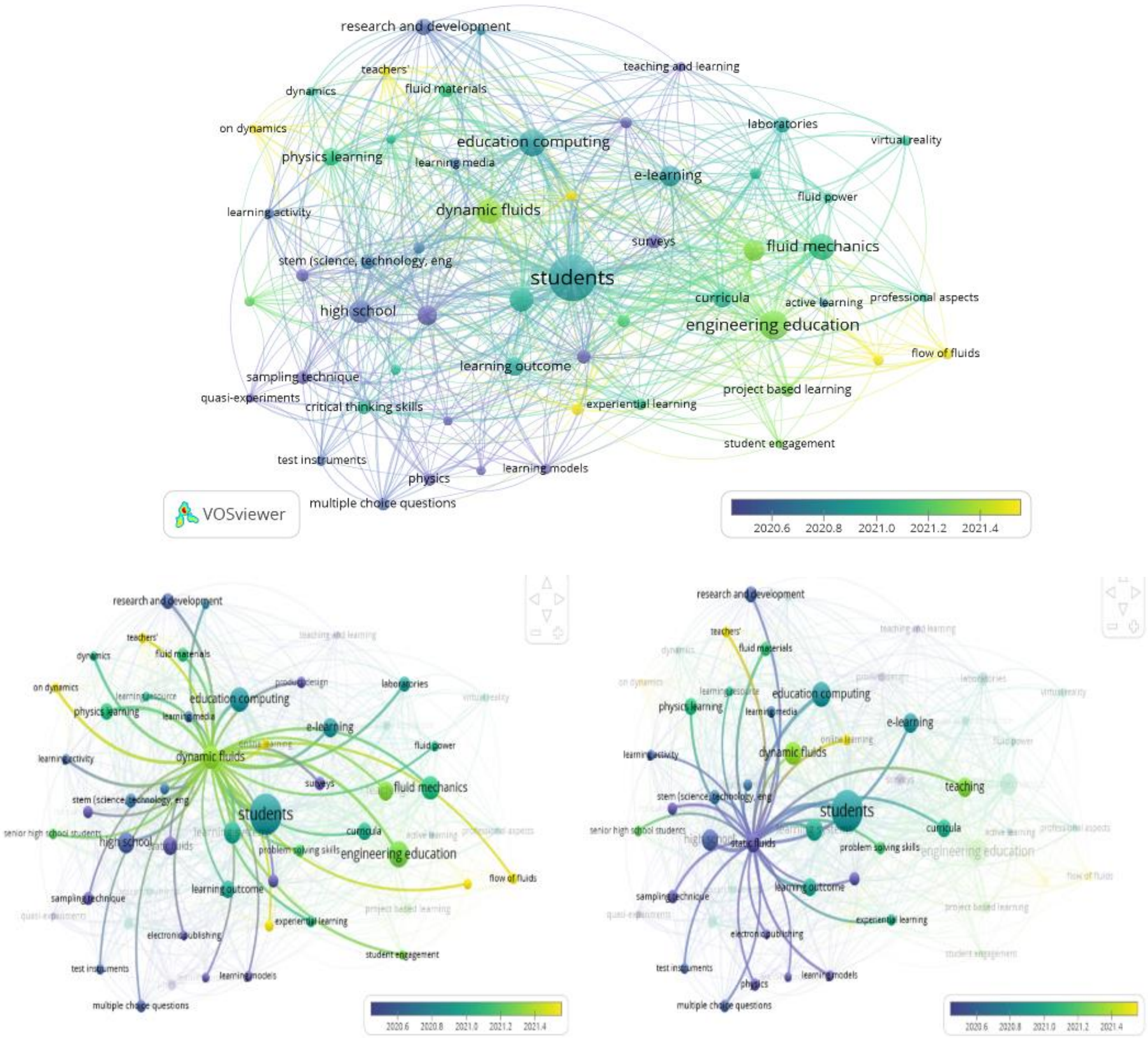

Figure 4. The Overlay Visualization of Fluid in Science Education

Based on Figure 4, in the last 2 years the topic of fluid dynamics has been linked to teachers, student learning, and online learning (Gamez-Montero et al., 2021). Meanwhile, the static fluid topic is connected to senior high schools, teaching, teachers, and online learning (Bhagavanulu, 2020; Syafei et al., 2020). Learning tools using social media are effective for improving students' communication skills on fluid material at junior high school level (Fatimawati & Odja, 2020). The application of STEM-based Schoology e-learning media on static fluid material is very feasible and suitable for use as learning media at the high school level (Syafei et al., 2020). There was a significant reduction in misconceptions about the concept of static fluids after implementing the interactive media EduPlasa (image-based interactive media) at the high school level (Halim et al., 2020). Android-assisted learning media (e-module) fluid material can be used by students as fun material and increases students' knowledge (Sari et al., 2019). The use of video tracking in experiments to determine the viscosity coefficient provides the highest increase in conceptual understanding compared to experiments using magnetic sensors and manual observations at the university level (Susilawati et al., 2020). The implementation of the flipped classroom method and threshold concepts in the Fluid Engineering course contributes to increasing the use of active learning (Gamez-Montero et al., 2021).

Conclusion

There have been more articles published on this subject, particularly in 2019–2023. The author with the greatest citations was then published in an international journal that was quartile 1 indexed by Scopus. Four clusters were identified based on visualization with VOSviewer, and data from the previous two years indicates that both static and dynamic fluids have a connection to teachers, senior high schools, teaching, student learning, and online learning. This study provided numerous key terms for academics to use as a starting point for additional research on the subject of fluids in scientific education. Given the growing quantity of publications on this subject, this is also an opportunity.

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