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EARLY VIEW

Bibliometric Analysis of Science Online Learning Medium in Indonesia 2017-2022

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Abstract: This study aimed to analyze the landscape of science online learning mediums in Indonesia through bibliometric analysis sourced from Google Scholar and Scopus spanning from 2017 to 2022. A total of 259 articles were sampled for analysis. The findings revealed an upward trend in research on science online learning mediums in Indonesia from 2019 to 2021, followed by a decline in 2022. Video-based Science Learning Mediums, Websites, and E-Modules emerged as the top three mediums for online science learning. The results of data visualization and content analysis indicated that research methodologies in this field predominantly employed the research and development approach, complemented by data analysis tools such as questionnaires and quantitative descriptive data analysis. Furthermore, the research primarily focused on the Elementary School level, with minimal attention given to studies conducted at the University level. Additionally, the examination of learning outcomes associated with science online learning mediums predominantly centered on cognitive learning outcomes. The implications of these findings offer valuable insights and recommendations for future research endeavors in this domain.

Keywords: Bibliometric Analysis, Learning Medium, Online Learning, Science Learning

INTRODUCTION

The 21st century is known as an era of globalization and digitalization, where science and technology have advanced rapidly (Budiman, 2017; Santika, 2021). The development of information technology

has also led to significant changes in the learning process across various levels of education (Sudihartono, 2020). One learning process that has undergone significant changes is online learning, which leverages technology. According to Pilco et al. (2022), online learning is based on relatively new methods, such as content delivery via the internet, and emphasizes digital communication and digital learning resources. However, despite this, the online learning process must still consider the formulation of the organization of learning materials, learning strategies, and the management of learning while taking into account the factors of learning objectives, learning barriers, and student characteristics (Oktaviani et al., 2021). In addition to that, online learning heavily relies on the internet to help students study material effectively, interactively, productively, and enjoyably, with the emergence of various online learning medium available to support the learning process (Manurung et al., 2021).

Learning medium play a crucial role in the success of the learning process, with their various characteristics, functions, and needs (Fitri & Ardipal, 2021; Maharuli, 2021). These characteristics are categorized into several types of mediums. As noted by Salsabila et al. (2020), these include audio mediums, visual mediums, audio-visual mediums, and multimodal mediums. In online learning, preparations and processes differ significantly from traditional learning activities, requiring both teachers and students to adapt and effectively manage online learning to achieve educational goals (Syahmina et al., 2020). One key preparation involves selecting appropriate mediums for online learning. Various educational levels in Indonesia utilize a range of learning mediums (Veygid et al., 2020). Educational technology platforms and applications, which may be available in both free and paid versions, are used across different education levels. Some examples of these platforms include gamified applications (Solviana, 2020), video-based learning mediums (Widad et al., 2021), WhatsApp Groups, Zoom Meetings, Edmodo, Email, Google Classroom, Schoology (Septiani & Setyowati, 2020), mobile learning applications (Talakua et al., 2020), Google Sites (Mardin & Nane, 2022), PowerPoint (Rahmawati et al., 2020), and JB Class (Kurniawan, 2020), among others.

Currently, learning medium are employed not just in offline settings. The advancements in science and technology have led to the development of various platforms that enable the use of learning medium in online learning. Online learning typically employs two forms of communication: synchronous and asynchronous. Synchronous communication includes methods like chat and video conferencing, while asynchronous communication often relies on a Learning Management System (LMS) (Irfan & Ariandi, 2021). As noted by Dari et al. (2021), popular tools used in both synchronous and asynchronous online learning environments include WhatsApp (29%), Zoom Meetings (21%), Google Meet (21%), and Spada UNRAM (28%), along with other platforms such as Timelink, Line, and YouTube (1%). Selecting the appropriate online learning tool is crucial to ensure that it aligns with educational goals and facilitates the achievement of desired learning outcomes. Moreover, a reliable internet connection

is vital for the success of online learning, as it cannot be conducted effectively without it (Safiti et al., 2021).

Research into online learning medium for science is expanding rapidly due to the increasing adoption of blended or hybrid learning models by educational institutions. To identify trends and opportunities in this field, bibliometric analysis can be employed. Historically, bibliometric analyses related to science online learning mediums have been conducted in previous studies, such as Dewi et al. (2021) on web-based inquiry in science learning, Yuliani et al. (2022) on mapping research in multimodal biology, and Subagja et al. (2022) on the updated mapping of science learning medium research using bibliometric analysis based on Google Scholar data. These studies often focus on a single medium, such as web-based or multimodal platforms, and rely on a single data source like Google Scholar. In the current bibliometric analysis, however, a broader range of mediums, platforms, and data sources (including both Google Scholar and Scopus) is utilized, along with content analysis. Analyzing science online learning mediums is crucial for identifying the most effective tools for both teachers and students to achieve learning objectives. Additionally, this analysis offers insights for future research, highlighting trends, limitations, and opportunities in the field of online science learning mediums.

This study aims to identify and characterize publications on science online learning mediums through bibliometric analysis. Bibliometrics is a statistical method used to analyze publications (Phoong et al., 2022; Wang et al., 2021; Zyoud et al., 2022). It serves as a valuable tool for determining the most influential and widely recognized publications in a specific field of study (Zyoud et al., 2022) and provides comprehensive insights into the complexities of science, mathematics, and statistics involved in the quantitative analysis of knowledge (Zhang et al., 2019). The research questions in the bibliometric analysis of science online learning medium, sourced from the Google Scholar and Scopus databases, are as follows:

1. How many publications on science online learning medium research were there from 2017 to 2022 in Indonesia?
2. How is research on science online learning medium distributed in Indonesia by Publication Categories, Medium Types, and Communication Methods from 2017 to 2022?
3. Who are the authors with the highest number of citations in research on science online learning medium in Indonesia from 2017 to 2022?
4. How is research on science online learning medium visualized in Indonesia from 2017 to 2022?
5. What research methods are most commonly used in studies on science online learning medium in Indonesia from 2017 to 2022?
6. What data collection tools are most commonly used in research on science online learning medium in Indonesia from 2017 to 2022?

7. What data analysis are most commonly used in research on science online learning medium in Indonesia from 2017 to 2022?
8. At which educational level is research on science online learning medium in Indonesia from 2017 to 2022 most frequently conducted?
9. What effects does research on science online learning medium in Indonesia from 2017 to 2022 have on student learning outcomes?

LITERATURE REVIEW

Learning Medium

According to the AECT (Association for Education and Communication Technology), a medium is a tool or method used to facilitate the learning process by conveying messages or information. Similarly, the NEA (National Education Association) as cited in Asnawar & Usman (2002) defines a medium as any object or tool that can be seen, heard, read, or manipulated, which, when used correctly in learning, significantly influences the success of a program. Gerlach, as referenced in Sanjaya (2008), broadens the definition to include people, equipment, materials, and activities that help the audience receive information, knowledge, skills, attitudes, and the intended content. According to Gerlach & Ely, a medium comprises both materials and human resources used in an event to aid the audience in acquiring knowledge. In essence, a medium is a communication tool that channels messages from the sender to the receiver, thereby engaging students' thoughts, emotions, concerns, and interests during classroom learning (Sadiman, 2011). Learning mediums play a crucial role in education because they directly impact students' learning experiences. The use of appropriate learning mediums can significantly enhance students' interest in learning. With the rapid advancement of technology, these developments can be leveraged to create more effective learning mediums, such as utilizing computers to deliver educational content (Masykur et al., 2017).

Types of Learning Medium

There are several types of learning mediums, including:

1. **Visual Medium:** This type of medium engages the sense of sight. Visual mediums are educational resources designed to present information or subject matter in an engaging way, often through a combination of images, text, motion, and animation, tailored to the needs and age of the students (Komang et al., 2019).
2. **Audio Medium:** This medium is accessed through the sense of hearing. Examples include voice notes, radio, music, and similar audio-based resources (Aryadillah & Fitriansyah, 2017).

3. **Audio-Visual Medium:** This medium involves both sight and hearing, such as videos, short films, slide shows, and similar formats. The use of audio-visual mediums makes educational content more accessible, comprehensive, and effective for students (Fuady & Mutalib, 2018).

Online Learning

Online learning refers to the educational process that relies on an internet connection, enabling communication between teachers and students without the need for physical contact (Pratiwi et al., 2020). This mode of learning requires the support of devices like smartphones, tablets, and laptops, which allow students to access information anytime and anywhere (Gikas & Grant, 2013). The benefits of online learning include: (1) greater flexibility and comfort, leading to improved motivation; (2) easier monitoring of student performance; (3) serving as both a learning resource and medium; and (4) making learning more enjoyable (Stephenson, 2001). Additionally, Emde et al. (2001) highlighted that online learning provides students with new experiences in using technology, which can enhance creativity and critical thinking.

Online learning offers students a valuable opportunity to broaden their educational experiences and stay competitive in the ever-evolving academic landscape (Gilbert, 2015). It enriches the learning process by enabling students to access vast amounts of information online, leading to more meaningful educational experiences (Tareen & Haand, 2020). Students have reported that online learning improves academic achievement, boosts engagement, increases task efficiency, and streamlines the overall learning process (Hongsuchon et al., 2022).

Science Online Learning Medium

Science online learning mediums refer to tools and resources used in online science education, which include visual mediums (such as images, graphs, charts, and text), audio mediums (like video recordings and voice notes), and audio-visual mediums (such as video tutorials, instructional videos, and animations). These mediums can be utilized on both synchronous and asynchronous communication platforms. The choice of appropriate online learning tools should be guided by the subject matter, the capabilities of both teachers and students, the availability of necessary resources, and the type of communication required. By carefully considering these factors, educators can select mediums that align with the desired learning outcomes. In essence, science online learning mediums facilitate the online application and practice of scientific concepts, enhancing the overall learning experience (Manullang & Satria, 2020; Rahmat et al., 2021; Sudarmo et al., 2021).

METHODOLOGY

This study aims to identify publications related to science online learning medium and visualize them.

1. Research Design

This study employed bibliometric visualization and bibliometric analysis methods. Bibliometric analysis, as described by (Garfield, 2009), is a quantitative approach that uses evaluative and descriptive techniques to illustrate research trends and the characteristics of various publications. The bibliometric visualization method helps to depict the structural landscape of a specific research area. This method was chosen because bibliometric analysis effectively summarizes extensive bibliometric data, revealing the intellectual framework and emerging trends within a research topic or field. It is particularly useful when the review scope is extensive and the dataset is large. The analysis integrates both quantitative (evaluation and interpretation) and qualitative (interpretation only) approaches.

2. Research Subjects

The study sample consisted of 259 publications sourced from the Google Scholar and Scopus databases using the search term (keywords) *"Science, Online Learning, and Learning Medium."* Among these 259 publications, the majority were journal articles, conference proceedings, and repository entries.

3. Research Indicators

The chosen publications span the past 6 years (2017-2022) and were analyzed using Publish or Perish Software and VOS Viewer. The study focuses on indicators such as the number of publications, citation counts, overall network strength among items shown in the data visualization, and content analysis, which includes methods, data collection tools, data analysis, education levels, and the impact on student learning outcomes.

4. Languages of Articles, Data Inclusion and Exclusion Criteria

a. Languages of Articles

The articles reviewed are published in both Indonesian and English.

b. Data Inclusion Criteria

The included data consists of articles, conference proceedings, and research results available in repositories.

c. Data Exclusion Criteria

The excluded data from the research are books, book chapters, book reviews, and any information unrelated to science online learning medium.

5. Research Procedures

Metadata related to science online learning mediums was gathered from the Google Scholar and Scopus databases for the period 2017-2022. The Publish or Perish software was utilized to search for articles within these databases. Subsequently, VOS Viewer software was employed to analyze, visualize, and assess the collected publication data, including aspects such as the number of publications, document sources, types of online learning mediums, communication platforms used, and citation counts. VOS Viewer is a tool designed to visualize network terms commonly used in specific fields and is frequently applied in bibliometric analysis (Eck & Waltman, 2010; Shah et al., 2020). According to Dewi et al. (2021), bibliometric analysis involves five stages, as illustrated in Figure 1.

Figure 1. Bibliometric analysis method stages

Figure 1 outlines the five stages of the bibliometric analysis method:

1) **Keyword Research or Selection:** Identify keywords for data collection, in this case, **"Science, Online Learning, and Learning Medium,"** before beginning data gathering.
2) **Initial Search Reduction:** Classify or group search results to focus solely on the predetermined keywords, using Google Scholar and Scopus to locate relevant articles.
3) **Refinement of Search Results:** Manually sift through the search results using VOS Viewer software to set appropriate thresholds.
4) **Compilation of Initial Statistical Data:** Organize the data into topic descriptions, including visualization results for the number of publications, document sources, types of online learning mediums, communication platforms used, citation counts, and content analysis (methods, data collection tools, data analysis, education level, and impact on student learning outcomes).
5) **Data Interpretation and Analysis:** Explain the research findings based on the selected results, using VOS Viewer and Microsoft Excel for manual content analysis. VOS Viewer provides data representation through variable maps related to keywords and offers potential for further development.

RESULTS

Publication Results and Document Sources

The initial search in the Google Scholar database yielded 958 publications related to science online learning medium. However, not all of these were relevant to the topic. A selection process using the Publish or Perish software refined the results to 259 pertinent publications, as shown in Figure 2.

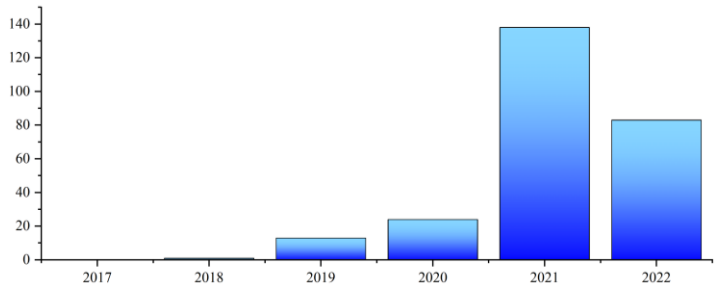

Figure 2. Quantity of article publications on online science learning medium in Indonesia (2017-2022)

Out of the 259 publications, 196 were journal articles, 20 were conference proceedings, and 43 were sourced from repositories.

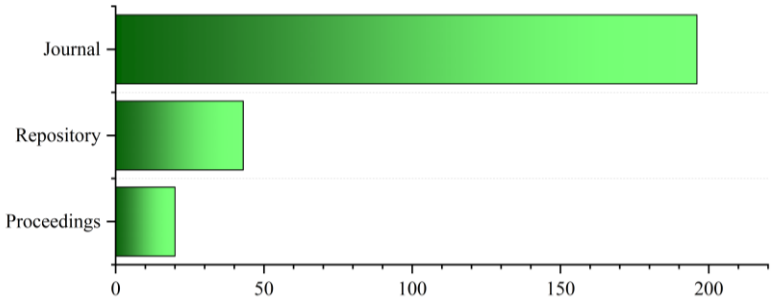

Figure 3. Number of documents based on sources

Distribution of Publications on Online Science Learning Medium by Publication Categories, Medium Types, and Communication Methods

Among the 259 identified documents, they are categorized into National Journals, International Journals, National Proceedings, International Proceedings, and Repositories. The distribution of these documents by publication category is illustrated in Figure 4.

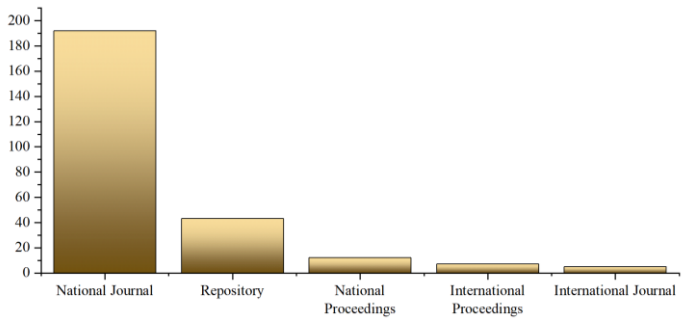

Figure 4. Distribution of documents by publication type

The distribution of science online learning mediums in Indonesia from 2017 to 2022 is presented in Table 1.

Table 1. Number of publications related to science online learning medium 2017-2022

Learning Online Medium	∑ Publication
Video	30
Website	15
E-Modul	15
E-Book	13
Quizizz	12
E-LKPD	11
Audio Visual	10
E-Comic	10
PhET	9
PowerPoint	9
Android Apps	8
Education Game	7
Animation	6
Wordwall	5
Virtual Lab	3

Table 2 displays the distribution of science online learning medium platforms in Indonesia from 2017 to 2022, categorized by communication type (synchronous and asynchronous).

Table 2. Types of communication in science online learning medium from 2017 to 2022

Online Learning Platform	Types of Communication
Edmodo	Asynchronous
Google Classroom	Asynchronous
Moodle	Asynchronous
Rumah Belajar	Asynchronous
Rumah Eksis	Asynchronous
WhatsApp Group	Asynchronous
YouTube	Asynchronous
Zoom Cloud Meetings	Synchronous
Google Meetings	Synchronous
Microsoft Teams	Synchronous

Highest Number of Citations in Publications on Science Online Learning Medium

In Indonesia, research on science online learning mediums has covered a wide range of platforms, including Video Mediums, Websites, E-Modules, E-Books, Quizizz, E-LKPD, Audio-Visual content, E-Comics, Phet, PowerPoint, Android Applications, Animation, Educational Games, Wordwall, and Virtual Labs. The publication with the highest number of citations for science online learning mediums is detailed in Table 3.

Table 3. Highest number of citations in publications on science online learning medium from 2017 to 2022

Author	Title	∑ Citation
Daheri et al. (2020)	Efektifitas Whatsapp Sebagai Media Belajar Daring	430
Nurhayati (2020)	Meningkatkan Keaktifan Siswa dalam Pembelajaran Daring Melalui Media Game Edukasi Quiziz pada Masa Pencegahan Penyebaran COVID-19	290
Batubara et al. (2020)	Penggunaan Video Tutorial untuk Mendukung Pembelajaran Daring di Masa Pandemi Virus Corona	229
Salsabila et al. (2020)	Pemanfaatan Aplikasi Quizizz Sebagai Media Pembelajaran di tengah Pandemi pada Siswa SMA	213
Ramdani & Jufri (2020)	Pengembangan Media Pembelajaran Berbasis Android pada Masa Pandemi COVID-19 untuk Meningkatkan Literasi Sains Peserta Didik	136
Wulandari et al. (2020)	Pengembangan Media Video Berbasis Powtoon pada Mata Pelajaran IPA di Kelas V	104

Author	Title	∑ Citation
Lathifah et al. (2021)	Efektifitas LKPD Elektronik Sebagai Media Pembelajaran pada Masa Pandemi COVID-19 untuk Guru di YPI Bidayatul Hidayah Ampenan	102
Mahardini (2020)	Analisis Situasi Penggunaan Google Classroom pada Pembelajaran Daring Fisika	100
Dewa et al. (2020)	Pengaruh Pembelajaran Daring Berbantuan Laboratorium Virtual Terhadap Minat dan Hasil Belajar Kognitif Fisika	94
Misbahudin et al. (2018)	Penggunaan Power Point Sebagai Media Pembelajaran: Efektifkah?	88

Visualization of Science Online Learning Medium in Indonesia

Visualization Based on Network Relationships

A total of 259 articles on science online learning mediums in Indonesia were analyzed using VOS Viewer software for visualization. This tool assists in identifying novel patterns or inter-network relationships related to science, which can help analyze trends and uncover opportunities for future research on online learning mediums in Indonesia. Figure 5 illustrates the visualization of science online learning mediums in Indonesia, which is divided into nine clusters. Three primary clusters are highlighted in purple, blue, and green:

- **Purple Cluster:** Represents the use of science online learning mediums in Indonesia.
- **Blue Cluster:** Details the types and platforms of these mediums.
- **Green Cluster:** Focuses on the development and application of science online learning mediums across different educational levels.

In addition, six secondary clusters are depicted in red, light blue, yellow, orange, pink, and brown:

- **Red Cluster:** Highlights the activities associated with using science online learning mediums.
- **Light Blue Cluster:** Relates to the types of communication used in online science learning.
- **Yellow Cluster:** Pertains to the application of online science learning mediums at the junior and senior high school levels.
- **Orange Cluster:** Addresses the phenomena associated with science online learning mediums.
- **Pink Cluster:** Examines the effectiveness of these mediums.
- **Brown Cluster:** Identifies constraints and challenges related to science online learning mediums.

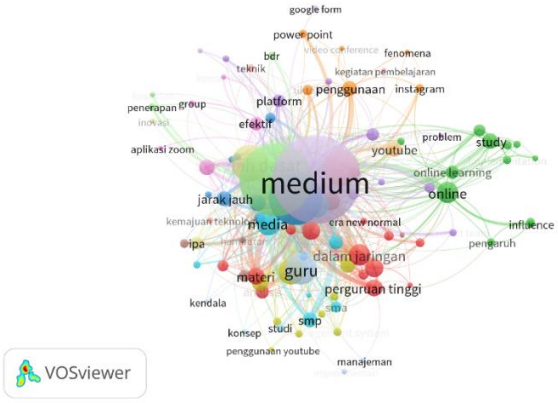

Figure 5. Science online learning medium relations network in Indonesia

Visualization of the Quantity of Research on Science Online Learning Medium in Indonesia

The volume of research on science online learning mediums in Indonesia from 2017 to 2022 is illustrated in the Overlay Visualization using VOS Viewer software. As shown in Figure 6, the red areas indicate a high frequency of studies on the use of science online learning mediums, while the light green areas represent numerous studies on the types and platforms of these mediums.

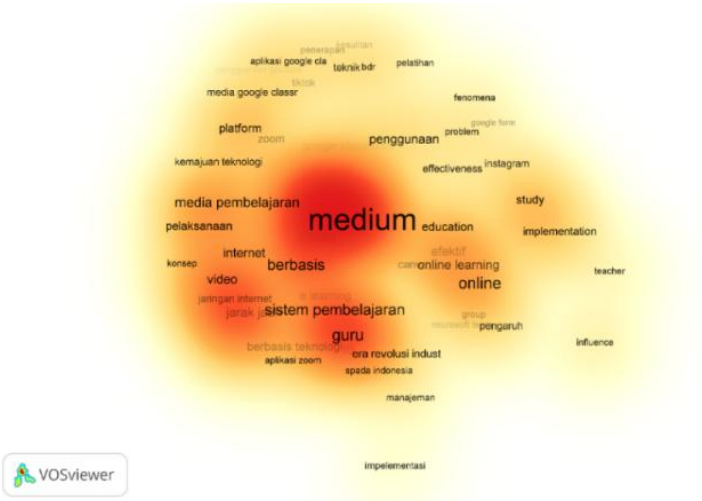

Figure 6. The quantity of research conducted on science online learning mediums

Visualization of Research Opportunities in Science Online Learning Mediums

The research opportunities in science online learning medium, as illustrated in Figures 7 (a), (b), (c), and (d), suggest that areas like student learning activities and learning outcomes, science online learning medium development, diverse communication platforms (in this context, comparing the quality of learning based on the type of communication used is an interesting area of study), and learning management systems are crucial for future study. This focus arises because much of the current research

has concentrated on the implementation and use of these medium. Additionally, the visualizations highlight specific aspects of science online learning medium that have yet to be fully explored. By considering these opportunities, research on science online learning mediums will become more diverse and yield valuable information for future science learning. Learning medium are one of the crucial aspects supporting the learning process; however, other elements involved are also important to explore in order to enhance the quality of learning.

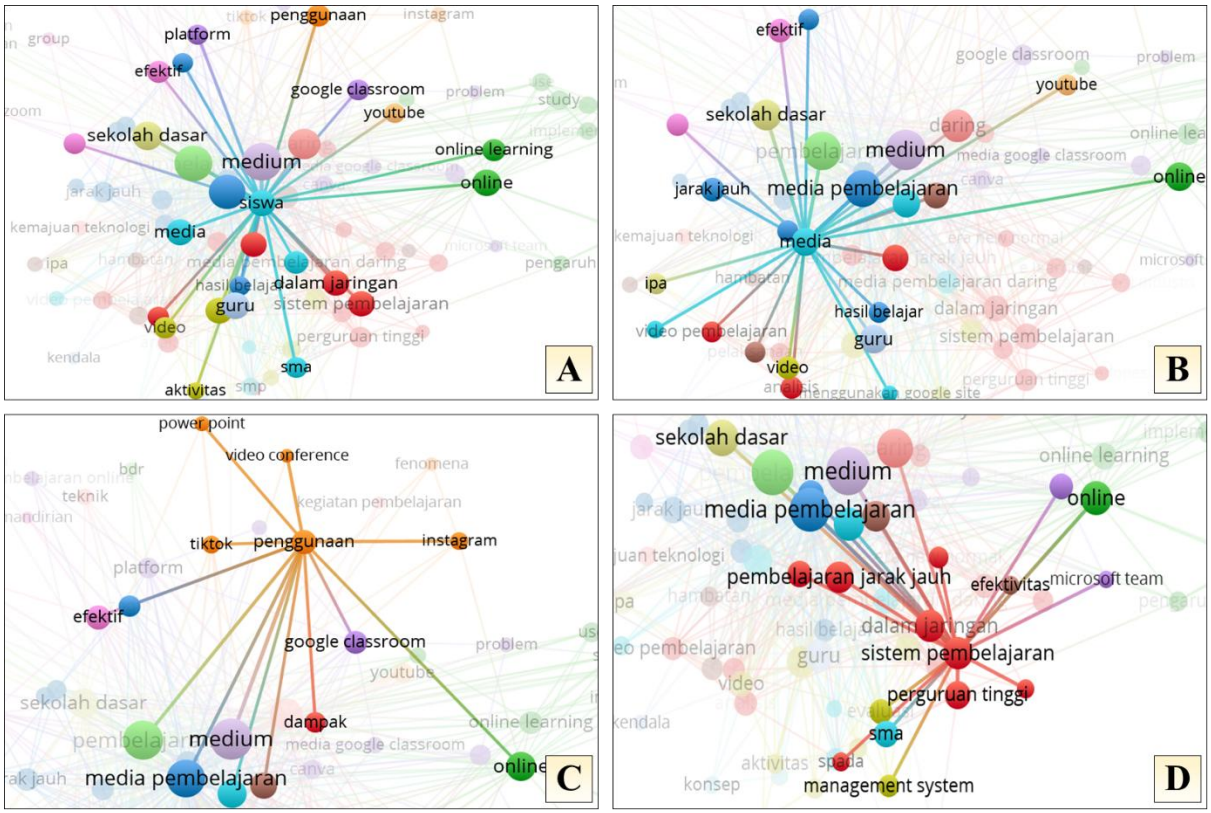

Figure 7. (a) The effect of online science learning mediums on student learning activities and learning outcomes; (b) Development of online learning platforms for science; (c) Various communication platforms (both synchronous and asynchronous) are available for science online learning mediums; and (d) Current research primarily focuses on the application of these mediums, while aspects such as learning management system, implementation challenges, and innovations remain underexplored.

Content Analysis Findings

Research Methods in Science Online Learning Medium Research

The analysis of research methods in studies on science online learning mediums is conducted manually by examining the abstracts of the articles. If the method is not specified in the abstract, the methods

section of the article is reviewed. Among the 259 articles analyzed, the Research and Development method was the most frequently used *(f = 89)*, followed by Descriptive Research *(f = 75)*, and Experimental Research *(f = 44)*. Detailed data is presented in Figure 8 below.

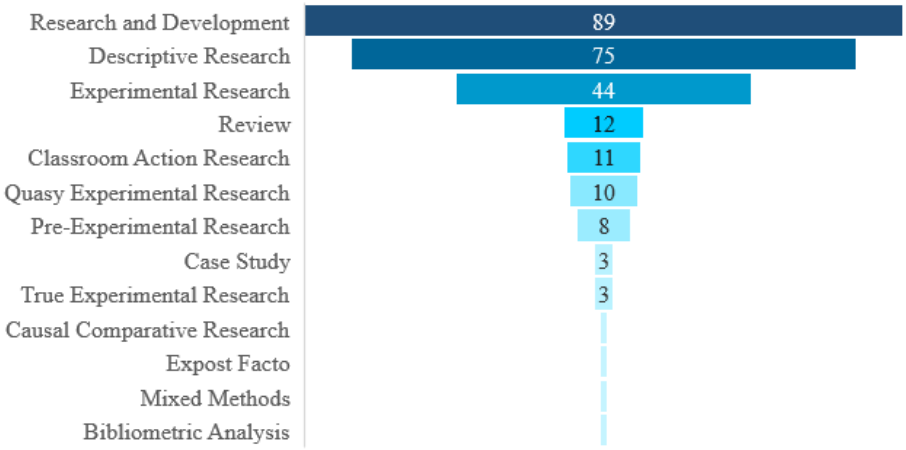

Figure 8. Research methods in Science online learning medium research

Data Collection Tools in Science Online Learning Medium Research

In the research on science online learning mediums, data collection tools used across 259 articles revealed that Questionnaires were the most frequently employed method *(f = 145)*, followed by Tests *(f = 79)*, and Literature Reviews in third place *(f = 17)*. The details are shown in Figure 9 below.

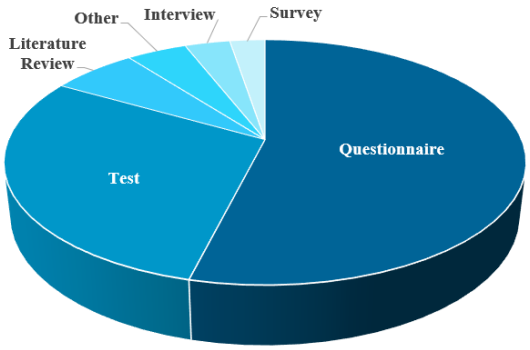

Figure 9. Data collection tools in Science online learning medium research

Data Analysis in Science Online Learning Medium Research

In research on science online learning mediums, data analysis methods predominantly include Quantitative Descriptive analysis *(f = 138)*, followed by Qualitative Descriptive analysis *(f = 49)*, and T-tests *(f = 44)*. The details are illustrated in Figure 10.

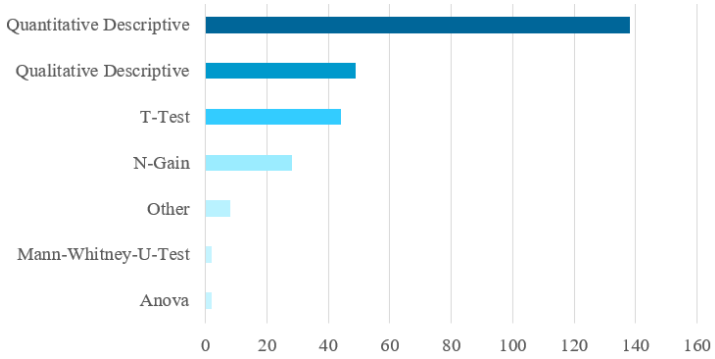

Figure 10. Data analysis in Science online learning medium research

Educational Level in Science Online Learning Medium Research

Data on educational levels in research related to science online learning mediums indicates that the majority of studies were conducted at the Elementary School level *(f = 105)*, followed by Senior High School *(f = 65)* and Junior High School *(f = 63)*. At the University level, there were only 26 studies on this topic. The full data is shown in Figure 11 below.

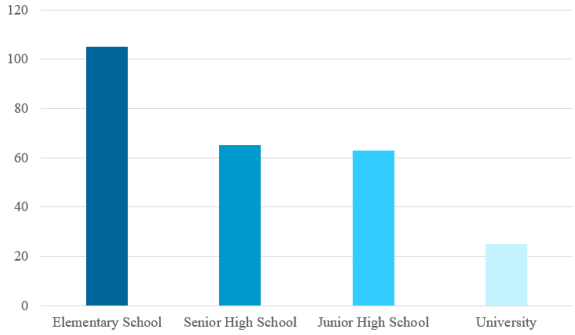

Figure 11. Educational level in Science online learning medium research

The Impact of Science Online Learning Medium Research on Student Learning Outcomes

The impact of science online learning mediums on student learning outcomes across various educational levels (elementary school through university) includes enhanced interest, motivation, learning outcomes, independent learning, critical thinking, and conceptual understanding. Detailed data is provided in Table 4.

Table 4. The Impact of Science online learning medium research on student learning outcomes

Education level	Source	Types of medium	Impact on student learning outcomes
Elementary School	Nissa & Renoningtyas (2021)	Wordwall	Increase students' interest and motivation to learn
	Herawati et al. (2020)	Video	Improving students' cognitive learning outcomes
Junior High School	Linda et al. (2021)	E-Modules	Enhancing students' independent learning and overall educational achievements
	Hasyim et al. (2020)	PhET	Improve the critical thinking skills of junior high school students
Senior High School	Sembiring et al. (2021)	E-Modules	Help students learn independently
	Suyanta et al. (2022)	Virtual Labs	Help students understand the learning materials
University	Kurniawan et al. (2020)	PhET	Phet can meet students' practical needs, arouse student enthusiasm for learning, and increase student understanding.
	Prawijaya et al. (2021)	E-Modules	Improve students' conceptual understanding

DISCUSSION

From the 259 documents identified between 2017 and 2022, the publications are categorized as 194 articles in national journals, 5 articles in international journals, 13 articles in national proceedings, 7 articles in international proceedings, and 43 articles in repositories. The top three science online learning mediums are Video Mediums, Websites, and E-Modules. These mediums are applied across educational levels from elementary to tertiary education. Research on science online learning mediums increased in 2021 but descreased in 2022.

The rise in research on science online learning mediums in 2021 can be attributed to the COVID-19 pandemic, which led to the widespread adoption of online learning systems globally, including in Indonesia. Research from that year includes studies on analysis (Afiani & Faradita, 2021; BatuBara et al., 2021; Nurliana & Nugroho, 2021), effectiveness (Hidayati & Aslam, 2021; Sidabutar, 2021), utilization (Mu'minah et al., 2021; Saputra, 2021; Suwarto et al., 2021), influence (Annisa & Erwin, 2021; Maulidah & Aslam, 2021; Nissa & Renoningtyas, 2021), and development (Donna Safira et al., 2021; Herlina & Hadiyanti, 2021; Puspita et al., 2021). In contrast, research in 2022 saw a descrease,

likely due to the improvement in the COVID-19 situation, which shifted the learning process from online to blended learning.

The author with the highest number of citations in research on science online learning mediums from 2017 to 2022 is Daheri et al. (2020), with 430 citations. The second is Nurhayati (2020) with 290 citations, followed by Batubara et al. (2020) with 229 citations, Salsabila et al. (2020) with 213 citations, and Ramdani & Jufri (2020) with 136 citations. The most cited articles focus on effectiveness, trials, development, analysis, and the impact of online learning mediums on student outcomes. Daheri et al. (2020), Lathifah et al. (2021), and Misbahudin et al. (2018) explore the effectiveness of online learning mediums, which is crucial for understanding their benefits in education. Salsabila et al. (2020) and Batubara et al. (2020) discuss the use of mediums as educational tools, emphasizing the importance of selecting effective mediums based on prior research to achieve the best learning outcomes.

Ramdani & Jufri (2020) and Wulandari et al. (2020) focused on developing online learning mediums, which requires advanced IT skills to effectively create mediums that meet the researchers' objectives. Mahardini (2020) performed an analysis of the effects of using these mediums in learning, emphasizing the need for clear indicators, which should be based on validated expert rubrics to ensure accurate results. Dewa et al. (2020) investigated the impact of medium use on student learning outcomes, highlighting the importance of referencing mediums that have been proven effective and useful. By considering these aspects, researchers can achieve optimal results by understanding the impact of the medium on student learning. Overall, research on science online learning mediums encompasses a broad range of activities, including development, analysis, evaluation, utilization, and assessing the impact of these mediums in online learning.

The types of online learning mediums used in science education in Indonesia include Video Medium (Mu'minah, 2021; Karimah & Arifin, 2022; Laksono et al., 2020), Websites (Safira et al., 2021; Mukti et al., 2020; Rofiah et al., 2021), E-Modules (Linda et al., 2021; Puspita et al., 2021; Rofiyadi & Handayani, 2021), E-Books (Awwaliyah et al., 2021; Handayati & Handayati, 2020; Puspitasari et al., 2021), Quizizz (Ainur Rofiq et al., 2022; Annisa & Erwin, 2021; Hidayati & Aslam, 2021), E-LKPD (Fuadi et al., 2021; Lestari & Muchlis, 2021; Wahyuni et al., 2021), Audio-Visual (Dewi et al., 2021; Fridayanti et al., 2022; Nurhidayat et al., 2021), E-Comic (Ayu et al., 2021; Kasih et al., 2022; Widari & Putra, 2022), PhET (Fauzia et al., 2021; Hasyim et al., 2020; Mardhatilla, 2021), PowerPoint (Mardhika et al., 2021; Purwanti et al., 2020; Suartawan et al., 2021), Android Applications (Panggabean, 2021; Wardani et al., 2021), Animation (Kusumahwardani et al., 2022; Sukarini et al., 2021), Educational Games (Saputro & Persada, 2021), Wordwall (Nissa & Renoningtyas, 2021), and Virtual Labs (Herunata et al., 2022; Suyanta et al., 2022). The most commonly used mediums are Video, Websites, and E-Modules. These are popular due to their accessibility and the fact that they can be

easily developed without advanced IT skills. Videos, for instance, are readily available on platforms like YouTube, and numerous websites and e-modules can be accessed for free online. Consequently, teachers and students are familiar with these mediums and can either utilize existing resources or create new ones based on their needs.

Communication platforms for online science learning are categorized into synchronous and asynchronous types. Asynchronous platforms include Edmodo (Utami et al., 2021), Google Classroom (Prasetyo et al., 2022), Moodle (Simbolon et al., 2021), Rumah Belajar (Marlina Negeri & Abang, 2021), Rumah Eksis (Herawati, 2022), WhatsApp Group (Irwandi et al., 2021), and YouTube (Suwarto et al., 2021). Synchronous platforms include Zoom Cloud Meetings (Rasyid et al., 2020), Google Meetings (Adnyana, 2020), and Microsoft Teams (Afiani & Faradita, 2021). Asynchronous platforms are more commonly used due to conditions in Indonesia, such as uneven and unstable internet access, the varying quality of devices used by students and teachers, and cost considerations. Asynchronous platforms are suitable for environments with lower internet connectivity, less advanced devices, and lower costs, unlike synchronous platforms, which require stable, high-speed internet, compatible devices, and higher costs.

Research on science online learning mediums is predominantly focused on the elementary school level, with less emphasis at the university level (Figure 11). This trend is attributed to the specific needs of younger students, such as requiring user-friendly mediums, adequate devices, reliable internet access, and ease of monitoring by teachers. In contrast, at the senior high school, junior high school, and university levels, research often centers on evaluating new mediums or assessing their effectiveness on learning outcomes rather than addressing the same foundational needs.

According to bibliometric analysis, research on science online learning mediums in Indonesia is organized into nine clusters. The first cluster focuses on the medium used in science online learning, the second cluster addresses the types and platforms of these mediums, and the third cluster deals with their development and application across various educational levels. The remaining clusters indicate areas with potential for future research and innovation, including: (1) activities involving science online learning mediums, (2) communication types used in science online learning, (3) application of these mediums at junior and senior high school levels, (4) phenomena related to online science learning mediums, (5) effectiveness of these mediums, and (6) challenges and difficulties encountered.

The visualization reveals several key findings: (1) The effect of online science learning mediums on student learning activities and learning outcomes; (2) Development of online learning platforms for science; (3) Various communication platforms (both synchronous and asynchronous) are available for science online learning mediums; and (4) Current research primarily focuses on the application of these

mediums, while aspects such as learning management system, implementation challenges, and innovations remain underexplored.

Content analysis of science online learning medium research reveals that the Research and Development method is the most commonly used approach. This finding aligns with the data collection tools and analysis methods employed, where Questionnaires and Quantitative Descriptive Analysis were the predominant tools used from 2017-2022. Research is most frequently conducted at the Elementary School level. Additionally, the impact of science online learning medium research on student outcomes across various educational levels (elementary to university) demonstrates improvements in student interest, motivation, learning outcomes, independent learning, critical thinking, and conceptual understanding.

Research indicates that technology-based learning mediums positively impact student learning outcomes, provided that teachers are proficient in using these digital tools. This proficiency can be enhanced through teacher training (Hillmayr et al., 2020). Tsai & Tsai (2020) found that educational game mediums (Digital Game-Based Learning) effectively boost student motivation and performance. Similarly, E-Modules have proven to be more effective than traditional textbooks (Astalini et al., 2019). Overall, science online learning mediums contribute positively to both the learning process and student outcomes.

CONCLUSION

Bibliometric analysis shows that research on science online learning mediums in Indonesia increased from 2019 to 2021 but descreased in 2022. These studies are published in journals, proceedings, and repositories. Popular science learning mediums include video, websites, and e-modules. The use of these mediums spans from elementary to university education levels. Research in this field predominantly employs the Research and Development method, with data analysis typically using questionnaires and quantitative descriptive techniques.

Research in science online learning mediums has mostly been conducted at the Elementary School level, with minimal studies at the University level. Most investigations focus primarily on cognitive learning outcomes. However, there is ample opportunity for scholars to explore various variables using different methodologies. Although research and development is the dominant approach, incorporating mixed methods could yield more detailed insights. This would allow for a comprehensive evaluation of both the effectiveness of the medium and the extent of learning outcomes achieved by students using these tools.

Qualitative research offers a valuable opportunity for gathering perspectives from educators, students, or relevant authorities about the need, role, and urgency of integrating mediums into online science education. Additionally, evaluating online science learning mediums should include not only cognitive outcomes but also affective and psychomotor dimensions, providing a more complete picture of student learning achievements. Furthermore, there is a limited number of research publications in this field that are shared through international journals indexed by Scopus or Web of Science.

Based on these findings, the bibliometric analysis of science online learning mediums provides a basis for future research recommendations. Researchers are encouraged to explore various methods beyond those currently employed, such as mixed methods, experimental research, qualitative research, and classroom action research. This can help identify a broader range of student learning outcomes, including critical thinking skills, digital literacy, scientific literacy, and communication skills, rather than focusing solely on cognitive learning outcomes. Research should extend to higher education levels, including junior high, senior high, and particularly universities, where online and blended learning are increasingly implemented, even beyond the COVID-19 pandemic. Future studies can benefit from evaluating a range of tested mediums for their effectiveness and impact. Additionally, it is recommended that future literature reviews incorporate a wider array of data sources, such as Google Scholar, Scopus, Web of Science, ERIC, Microsoft Academic Research (MAR), Directory of Open Access Journals (DOAJ), International Copernicus Index (ICI), and EBSCO, to ensure a more comprehensive and international perspective, thereby enhancing the depth of information gathered.

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