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Bibliometric Analysis of Microcontroller-Based Learning Media

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Abstract

This study aims to conduct a bibliometric analysis of the research trends of microcontroller-based learning media. This analysis was carried out using VOSViewer software on articles indexed on Google Scholar during the period 2008 to 2024. The results of the analysis show that there are 526 articles discussing the development of microcontroller-based learning media, with the peak of publication occurring in 2023. The study also identified four main clusters in this study, namely "Science and Technology Learning Media," "Physics Learning Media," "Internet and Technology-Based Learning Media," and "Microcontroller Learning Media." Current research trends tend to focus on the integration of advanced technologies such as the Internet, Arduino, and the Internet of Things (IoT) in learning. This study is expected to be a foundation for other researchers in determining research topics related to the development of microcontroller-based learning media.

Keywords: Bibliometrics; VOSViewers; Microcontroller-Based Learning Media.

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INTRODUCTION

Physics is a science that has objects in the form of real objects when delivered by the lecture method so that the material obtained by students is only an information transaction and is understood as equations and abstract conceptions (Kause & Boimau, 2019). Based on research (Tasnah, 2018) that the effectiveness of the use of the lecture method is not good when used, so that good physics learning can be accompanied by experimental methods. Science learning is closely related to scientific performance and can be developed by hands-on or direct experience through investigation and experiments to improve science process skills in producing mind-on knowledge (Wahyudi et al., 2015).

According to (Nurrita, 2018) said that the world of education has problems that often occur in the weak learning process. In the process of Teaching and Learning Activities, students tend to learn theoretically. Learning in the classroom is more focused on students' ability to understand a subject matter. Learning theoretically will make students feel less meaningful learning because of the lack of application in daily life. This problem causes students to lack a further understanding of the subject matter. In the teaching and learning process, the presence of a teacher can increase the potential and creativity of students, so that students can have practical and not only theoretical knowledge, with the intention that the knowledge can be used with the times.

Students' ability to understand abstract concepts and students' lack of activity needs to be followed up by using learning media in experimental methods.

According to (Daryanto, 2016) learning media can clarify information so that it is not too verbal and can overcome the limitations of space, time, energy, and human senses, give rise to the spirit of learning, and can allow students to learn according to their talents and abilities, visual, auditory and kinesthetic. One of the learning media that has the effectiveness of both explaining abstract conceptions and equations and attracting students' interest in learning physics is teaching aids. Teaching aids are tools used by educators when teaching to help clarify the material of the subjects presented by students and prevent verbalism in students (Murdiyanto & Mahatma, 2014)

Research on microcontroller-based physics props is also widely carried out by several researchers who design various learning media using ATMega328 with Arduino as a microcontroller board, including research conducted by (Permatasari et al., 2019) developing Arduino uno-based sensor props on energy materials by testing products on students at MTs Al Hikmah Bandar Lampung and SMP Budaya Bandar Lampung. In addition, (Azhar et al., 2020) developed a digital "MECHANICS 5 in 1" teaching aid based on the ATMega328 microcontroller as a high school/MA physics learning medium which was tested on students of class X MIA and XI MIA MAN Binjai. Another research was also conducted by (Astrawan, 2020) to develop an Arduino-based sensor trainer as a learning medium in the microcontroller course at Ganesha Education University. Another research was also conducted by (Habibillah, 2023) who developed Arduino-based learning media that is integrated with the STEAM approach on inertial moment material.

Based on the studies that have been conducted, there has been no bibliometric analysis research that maps the development of microcontroller-based physics teaching aids. The purpose of this study is to conduct a computational bibliometric analysis of articles on the development of microcontroller-based physics teaching aids in journals that have been indexed by Google Scholar using VOSViewer software. Through this research, it is hoped that it will be able to become a foundation for other researchers to determine research topics related to the development of microcontroller-based physics teaching aids.

METHODS

This research will be carried out by bibliometric analysis method, this analysis is also called the term scientometrics which is part of the methodology of research evaluation, as well as many types of literature that have been produced and allow bibliometric analysis to be carried out using its own method (Ellegaard & Wallin, 2015). The bibliometric analysis method can help researchers to learn the intent of the bibliographic content, analyze citations on each article that have been obtained from a main data of Harzing's Publish or Perish based on keywords and publication titles.

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from the search results on Harzing's Publish or Perish, Data collected from the Google Scholar Platform from 0-2024, by determining the title of the article sought, namely Learning Media by adding the keyword Microcontroller. After compiling the database, it will be processed with Microsoft Excel to facilitate mapping the number of publications each year and the database will also be processed using VOSViewer to visualize and analyze research trends.

RESULTS AND DISCUSSION

The results obtained from the data search with the Harzing's Publish or Perish application with the predetermined keywords were 526 documents. The number of documents was obtained after sorting the results of publications produced by Harzing's Publish or Perish, the results displayed were 48 articles that did not include the year so that they were eliminated to 526 documents. After obtaining the document, it was processed using Microsoft Excel to find the average growth each year which can be seen in Table 1.

Table 1. Publication Distribution from 2008 - 2024

Year	Number of Document (NoD)	Number of Citations (NoC)	% (NoD)	% (NoC)	Cumulative Frequency (NoD)	Cumulative Frequency (NoD)	Average Growth (NoD)	Average Growth (NoC)
2008	1	0	0.001901	0	0.001901141	0	0%	0%
2009	2	6	0.003802	0.00328	0.005703422	0.003280481	200%	600%
2010	0	0	0	0	0.005703422	0.003280481	0%	0%
2011	3	2	0.005703	0.001093	0.011406844	0.004373975	100%	33%
2012	7	29	0.013308	0.015856	0.024714829	0.020229634	117%	363%
2013	7	22	0.013308	0.012028	0.038022814	0.032258065	54%	59%
2014	13	75	0.024715	0.041006	0.062737643	0.073264079	65%	127%
2015	15	31	0.028517	0.016949	0.091254753	0.090213231	45%	23%
2016	21	49	0.039924	0.026791	0.131178707	0.117003827	44%	30%
2017	38	421	0.072243	0.23018	0.203422053	0.347184254	55%	197%
2018	50	162	0.095057	0.088573	0.298479087	0.435757244	47%	26%
2019	52	222	0.098859	0.121378	0.397338403	0.557135046	33%	28%
2020	59	193	0.112167	0.105522	0.509505703	0.66265719	28%	19%
2021	60	111	0.114068	0.060689	0.623574144	0.723346091	22%	9%
2022	70	466	0.13308	0.254784	0.756653992	0.978130126	21%	35%
2023	111	37	0.211027	0.02023	0.967680608	0.998359759	28%	2%
2024	17	3	0.032319	0.00164	1	1	3%	0.2%
Total	**526**	**1829**	**1**	**1**				

Based on the results of data processing through Microsoft Excel, it was obtained that in 2010 there were no published articles, and in 2023 it is the peak of the highest number of publications from 2008 to 2024, even though 2024 is still running. The high surge in the number of publications was found in the transition from 2022 to 2023, which increased by 41 articles, this shows that the development of microcontroller-based learning media is very developed and shows significant results with the use of microcontrollers in learning media. In addition, reviewing the number of citations, it is shown that in 2022 there are a high number of 466 citations, and the results of the data obtained can be seen in Figure 1.

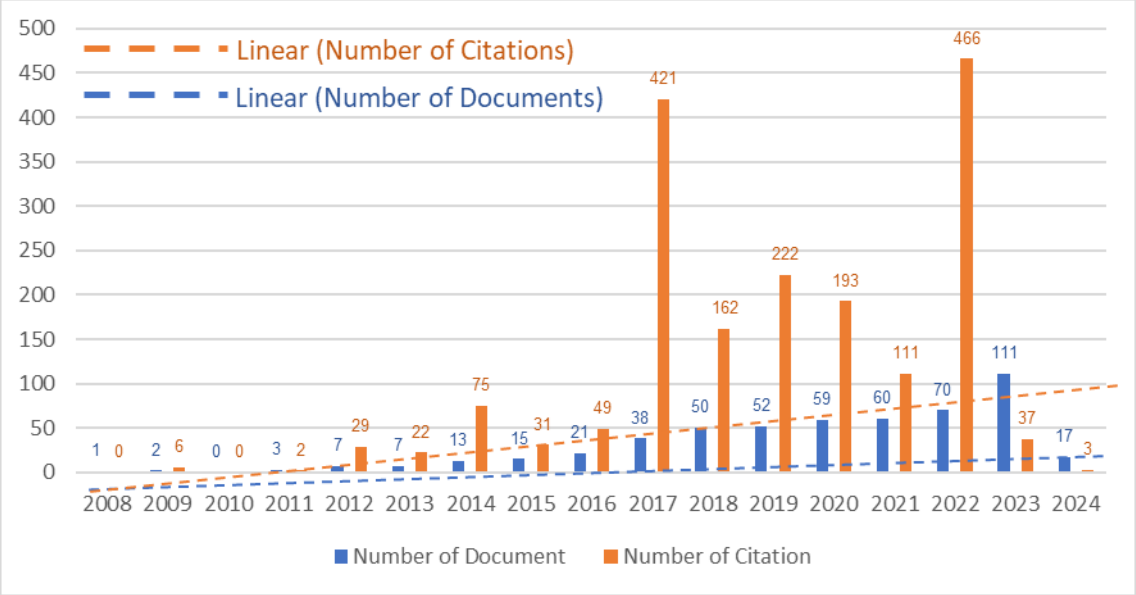

Figure 1. Annual growth of publications by number of documents and citations

This graph of the results of the bibliometric analysis illustrates the annual growth of publications by number of documents and citations from 2008 to 2024. In general, the number of documents published each year shows a gradual increase. From 2008 to 2013, the number of publications was relatively low, with less than 10 documents per year. However, in 2014 onwards, there was a more significant increase, with the number of documents peaking in 2023 with 111 documents. This increase reflects an increase in research interest or activity in a particular field during this period.

On the other hand, the trend in the number of citations shows a different pattern. Although the number of citations was very low until 2014, there were two significant peaks in 2017 and 2022, with 421 and 466 citations, respectively. This shows that in those years, there were publications that specifically received tremendous attention from the scientific community. The sharp fluctuation in the number of citations, especially after 2014, indicates that despite the increase in the number of publications, not all documents get the same level of citations.

This difference between the trend in the number of documents and the number of citations highlights that the quality or relevance of the research plays a more important role in determining the impact of a publication than simply the number of publications published. For example, although 2023 recorded the highest number of documents, the number of citations was much lower compared to 2017 and 2022. This suggests that relevant and influential publications are more likely to get higher citations, while an increase in the number of documents is not necessarily directly proportional to an increase in citations.

The results of the analysis obtained by the researcher were 526 articles, then the researcher made a visualization of 526 articles that had been obtained through VOSViewer software. Changes and shifts in science can be measured through bibliometrics. In bibliometrics, science mapping is a method of visualizing a field of science (Royani et al., 2019).

The next stage was an analysis of microcontroller-based learning media using the binner calculation method on VOSViewer, 3097 terms/words were obtained

with a minimum limit that appeared on each word, which was set 4 times, so that 64 words were obtained that were within the threshold limit, then filtered out terms/words that were relevant to the development of microcontroller-based learning media and obtained 16 terms classified in 4 clusters.

Based on the results of the analysis with binner calculations, it produces a very plural grouping. In cluster 1, which is marked with purple, the terms that belong to this group are terms that tend to discuss Science and Technology Learning Media, the group has terms such as, Arduino, *Media Pembelajaran Fisika*, Motor, *Pengembangan*, and Research. For cluster 2, which is marked in green, the terms that belong to this group are terms that tend to discuss Interactive Learning Media, the group has terms such as, Learning Media, Interactive Learning Media, Learning, and Design. In cluster 3, which is marked by the color red, terms that belong to this group are terms that tend to discuss Internet-Based Learning Media and Technology, the group has terms such as, Internet, IoT, and *Teknologi*. In the last cluster, namely cluster 4 is marked in yellow, the terms belonging to this group are terms that tend to discuss Microcontroller Learning Media, the group has terms such as *Media Pembelajaran Mikrokontroler*, *Mikrokontroler*, and Trainer.

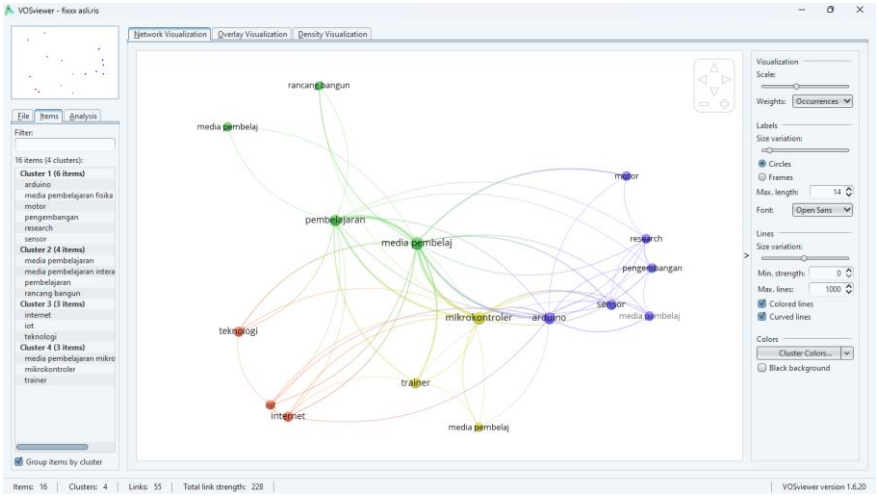

Figure 2. Network Visualization

In the first cluster, the terms found show that the learning media in the cluster is intended to make physics experiments interactively, while motors and also development can be used to create physical models. Research shows that effective learning media must be based on solid research. In the second cluster, the terms found in the cluster show that the learning media included in the cluster is intended to increase the interaction between students and learning materials. The third cluster shows that the terms found that learning media utilize Internet of Things technology to improve learning effectively, and provide access to various learning resources, and the Internet of Things allows students to interact with the world in real and real-time. The fourth cluster shows that the terms contained in the cluster are intended to assist educators in the development of learning media that can use microcontrollers so that students can learn learning media in real or real form so that students can experience meaningful learning through learning media integrated with microcontrollers. The result of the Network Visualization can be seen in Figure 2.

Figure 3. Overlay Visualization

In addition to being able to see the relationship of words in each cluster, the VOSViewer software is also able to identify terms that are frequently used in recent years or that are currently trending. Based on the results of the resulting overlay visualization, it is found that terms such as "Technology", "Internet", "Arduino", and "IoT" are widely used in the latest researches today. Trend visualizations from previous years to the present are characterized by color changes, ranging from blue to yellow. The more yellow the color, the more it indicates that the term is trending and widely used in current research.

With this capability, VOSViewer helps researchers not only to understand how certain topics relate to each other within clusters, but also to track the development of important terms that emerge and evolve over time. This is very beneficial for researchers in identifying the latest research trends and adjusting their research topics to stay relevant and impactful in the scientific community. Through trend analysis based on color changes in overlay visualizations, researchers can easily recognize popular terms and understand how the focus of research shifts over time. The results of the overlay visualization research trend can be seen in Figure 3

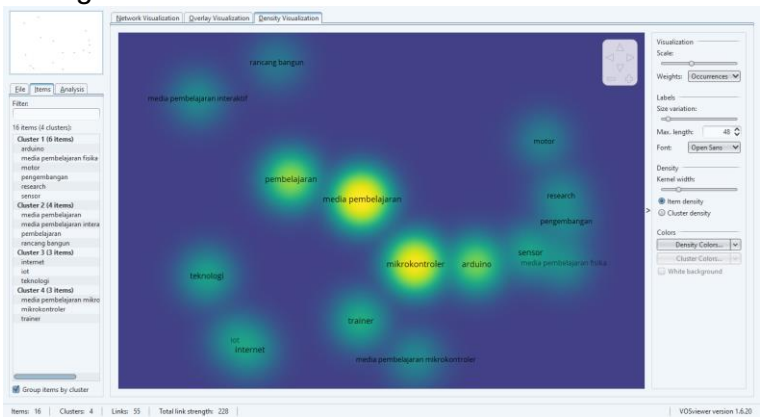

Figure 4. Density Visualization.

In addition to performing visualizations as described above, the VOSViewer software also has the ability to see the density of terms used in research. The density of this term is indicated through the intensity of the colors in the visualizations generated by the software. The more intense or darker the color, the greater the density of the term. In the context of this study, the terms that have a

higher density or darker color intensity are “Mikrokontroler”, “Arduino”, “Trainer” and “Pembelajaran”.

This term density can be used to see what terms are often used in the studies that have been conducted. In other words, the denser the term, the more often it appears in various studies, suggesting that the topic is gaining more attention in the scientific community. This allows researchers to understand current research trends and areas that may be a major focus in the future. By understanding the terms that are often used, researchers can identify topics that are relevant and have the potential to be further developed in their research. To see a visualization of the term density over the research span can be seen in Figure 4.

CONCLUSION

This study shows that the mapping of research topics related to the development of microcontroller-based learning media is current, with data obtained from 2008 to 2024, apart from that, this study also maps the visualization results of the network with terms divided into several clusters so that it is easy to see the trend of each cluster, and this study also shows the density and research trends based on the terms that found in the results of obtaining a database from Google Scholar through Harzing's Publish or Perish.

Through this study, it was found that publications related to microcontroller-based learning media have produced as many as 526 articles from 2008 to 2024 in May, the largest increase was found in the transition from 2022 to 2023 which jumped by 41 articles, and the highest point of publication lies in 2023 which is 111 articles. This study also shows that there is a grouping based on clusters divided into four, namely the first cluster on "Science and Technology Learning Media", the second cluster on "Physics Learning Media", the third cluster on "Internet and Technology-Based Learning Media" and the fourth cluster discussing "Microcontroller Learning Media".

The direction of current research trends tends to focus on the integration of advanced technology into the field of learning and education. Popular trends identified include the use of technologies such as the Internet, Arduino, and the Internet of Things (IoT). The popularity of these terms suggests that research is currently exploring how such technologies can be applied to improve learning experiences and educational efficiency. This technology can provide new tools and platforms for more interactive and adaptive learning, so it can help meet the individual needs of students and improve learning outcomes.

On the other hand, the density of terms such as Learning Media, Microcontrollers, Arduino, and Learning shows that these topics are often used in research publications and have high relevance in the scientific and educational communities. This indicates that there is a strong focus on the development and application of technology-based learning tools, such as microcontrollers and Arduino, in the context of education. The use of this technology in learning allows for the creation of a more dynamic and engaging learning environment, where students can actively participate through the use of innovative hardware and software.

Overall, the trend direction of this research is leading to the development of innovative methods and tools for education that use the latest technology. This research also serves as a map for future researchers in developing better research based on existing topic trends, with the aim of continuing to innovate and utilize technology to improve the effectiveness of learning. By looking at trend data and

topic density, researchers can select topics that are relevant and have a significant impact for their future research. This provides an opportunity for researchers in the field of education to create new technology-based solutions that can improve the quality of learning, both in the classroom and outside the classroom, as well as enrich the overall educational experience.

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