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The Effect of Using Electronic Teaching Materials to Improve Student's 4C Skills in Physic Material: Bibliometric Analysis

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ABSTRACT

In today's digital era, 4C skills (Critical Thinking, Communication, Collaboration, and Creativity) are essential competencies that students must master to face the challenges of the 21st century. However, complex and abstract physics learning often makes it difficult for students to develop their 4C skills. The use of electronic teaching materials can be an effective solution in facilitating the formation of students' 4C skills through more interactive and contextual learning. This study aims to determine the trends and focus of research related to electronic open materials to see students' 4C skills in physics material. The method used is bibliometric analysis. The population of this study was 1000 articles whose data were searched using the Publish or Perish (PoP) application from 2018-2023, so that 124 articles were obtained as samples that met the keyword criteria. The data is stored in Microsoft Excel as data processing material and stored in RIS form for use in VOSviewer software to obtain mapping in searching for publication trends.

INTRODUCTION

Education plays a very important role in developing human resources (AKILAH, 2018; Lestari & Nuryanti, 2022; Scheneider & Bowen, 1993). Quality human resources are produced by quality education (Iqbal et al., 2023; Siregar et al., 2017). Education has a very important contribution in improving the quality of a nation (Muhardi, 2004). In essence, education is a process of self-development in facing obstacles and challenges that a nation will face to achieve progress. In the era of the industrial revolution 4.0, the demand for quality human resources is increasing along with rapid technological developments. Based on the World Economic Forum report (2020), 85 million jobs will be replaced by technology by 2025, and 97 million new technology-based jobs will emerge. This condition requires the education system to adapt to prepare a generation that is able to compete globally. UNESCO data (2023) shows that countries with education systems that are oriented towards developing 21st century skills have a higher level of economic competitiveness. Therefore, educational transformation through the integration of technology and the development of critical skills is an urgent need in preparing future generations (Pare & Sihotang, 2023)

Responding to these global challenges, improving the quality of education requires various methods, both in learning innovation, curriculum development, and educational facilities and infrastructure (Crosling et al., 2015). Meanwhile, to improve student learning achievement, teachers are required to make the learning process more innovative so that students can learn optimally both in independent learning and in class (Bakar, 2018; Brophy, 1986). In line with the predictions of the World Economic Forum, the industrial revolution 4.0 has presented significant technological disruption, making advances in science and technology both a challenge and an opportunity in transforming the world of education. The OECD report (2023) revealed that countries that have successfully integrated technology into their education systems have shown significant improvements in student learning outcomes, especially in terms of digital literacy and problem-solving skills.

In line with the demands of educational transformation, technological advances in the 21st century not only act as a means of learning, but also as a catalyst in developing the competencies needed to face the industrial revolution 4.0. Based on Dinni's research (2018) , students must be able to develop the ability and skills to solve increasingly complex problems in everyday life. The 21st century education framework identifies four essential skills known as the 4Cs: Critical Thinking, Creativity, Collaboration, and Communication (Redhana, 2019) . Mastery of these 4C skills is key for students in facing global challenges, where Warli et al., (2019) .Emphasized that critical thinking and contextual problem solving skills are fundamental competencies that must be mastered. A recent study by the Partnership for 21st Century Learning (2023) showed that graduates who mastered the 4C skills had a 60% higher level of adaptability in facing technological changes and job market demands.

The implementation of 4C skills in the context of learning does not only focus on academic aspects, but also on the development of soft skills that are applicable in everyday life (Sari et al., 2023). According to the results of a World Bank study (2023), individuals with good 4C skills are 45% more likely to succeed in their professional careers. In the critical thinking dimension, participants are trained to analyze various complex phenomena and design innovative solutions through a systematic approach. The communication aspect allows students to articulate their thoughts, ideas, and knowledge effectively, both verbally and in writing, which according to a Harvard Business Review study (2023) is the most sought-after skill by 80% of global companies. Meanwhile, collaboration skills facilitate the development of teamwork skills, build synergy, and foster a sense of collective responsibility in achieving common goals. The creativity dimension encourages students to develop innovative ideas and produce original real work, in line with McKinsey's findings (2023) which show that 70% of companies consider creativity as one of the key factors in developing quality products and services.

To optimize the development of these 4C skills, the transformation of the learning paradigm in the 21st century is inevitable, marked by the rapid development of Science and Technology (IPTEK) which drives fundamental changes in the curriculum, media, and learning technology (Rahayu et al., 2022) . The 2023 International Society for Technology in Education (ISTE) survey revealed that 85% of teachers who effectively integrated technology into learning succeeded in increasing student engagement and learning outcomes. This confirms the demands of teachers not only to master learning content but also to be able to adapt and integrate new technologies into their pedagogical practices. The creative and innovative use of technology has been proven to be able to create a more dynamic and

attractive learning environment, as shown in the research of Sriwahyuni et al (2019) which emphasizes the strategic role of technology in transforming the learning process.

Although technology has advanced rapidly, significant challenges are still encountered in its implementation, especially in physics learning. A recent study by the American Association of Physics Teachers (2023) revealed that 67% of students have difficulty understanding abstract physics concepts. This problem is further complicated when educators still rely on conventional learning methods without integrating laboratory practicums and Information and Communication Technology (ICT)-based learning media. According to an analysis by the National Science Teaching Association (2023), schools that integrate virtual simulations and practicums in physics learning show an increase in students' conceptual understanding of up to 75% compared to conventional learning. This is in line with the findings of Swandi et al (2015) which states that the quality of physics learning is largely determined by the availability of adequate laboratory facilities, tools and materials, and learning media.

In today's world of education, education is closely related to the development of information and communication technology. The use of technology in learning has become a basic need to improve the effectiveness and efficiency of the teaching and learning process, especially in science subjects. Physics is one of the sciences that studies the properties and phenomena of nature and all its internal interactions that can be observed by humans. In the learning process, students' curiosity needs to be stimulated, nurtured, and maintained through interactive and innovative learning approaches. This is in line with the characteristics of 21st century learning which emphasizes critical thinking skills, creativity, and problem solving. Physics is an experimental science, so that by conducting experiments students can not only understand and master the concepts, theories, principles, and laws of physics, but can also apply scientific methods and develop scientific attitudes (Risdianto, 2008) . The integration of technology in physics learning is very important to help students visualize abstract concepts and improve their understanding of complex physical phenomena.

Furthermore, physics is one of the sciences that plays an important role in the development of science and technology. This can be seen in the development of technology that widely applies physics (Karisma, 2016). In line with this, the development of electronic teaching materials is a strategic solution in explaining material that cannot be done directly. Through the integration of images and videos in learning, it is expected to motivate and increase the effectiveness of learning. Learning videos are especially useful for clarifying material so that it can be visualized more concretely (Sriwahyuni et al., 2019) . n this context, the development of teaching materials can be an alternative in providing more effective, efficient and interactive learning resources. With this more modern and interactive learning approach, students will be more interested in learning, so that their analytical skills will be trained and learning outcomes can improve optimally.

METHODS

In this study, the author uses the bibliometric analysis method, which is a study of bibliographic analysis of scientific activities. This bibliometric or scientometric analysis is part of the research evaluation methodology that allows researchers to analyze various literatures with systematic methods (Ellegaard & Wallin, 2015) . This method was chosen because it can

help understand the intensity of current research on a topic from various research fields explored by researchers (Comarú et al., 2021) .

The criteria for articles used in this study include documents indexed by Google Scholar in the 2018-2023 period, with a focus on research on the Effect of the Use of Electronic Teaching Materials on Students' 4C Skills in Physics Materials. The selected articles must meet the criteria in the form of original research articles, in Indonesian or English, can be accessed in full (full text), and have gone through a peer review process. The total number of articles that meet the criteria and are analyzed in this study is 124 documents.

The variables marketed in this study include annual publication trends, collaboration patterns between researchers, geographic distribution of research, methodology used, and research impact through site analysis. Specifically, this study also analyzes the relationship between the use of electronic teaching materials and the development of 4C skills (Critical Thinking, Creative Thinking, Communication, and Collaboration) in physics learning. Mapping of keywords and co-occurrence terms was also carried out to identify the main themes in the study.

The research steps were carried out systematically starting from data collection using the Publish or Perish application to collect documents from the Google Scholar database. Furthermore, the collected data was analyzed using VOSViewer software to visualize the relationship between research variables. The analysis techniques used include co-citation analysis to identify interrelated research groups, bibliographic coupling to determine the similarity of references between articles, co-word analysis to map keywords that often appear together, and temporal trend analysis to see the development of research topics from year to year. The results of the analysis are then visualized in the form of bibliometric maps, graphs, and tables to facilitate data interpretation.

RESULTS AND DISCUSSION

Results

The article search process was carried out using the Publish or Perish software by entering keywords related to "Electronic Teaching Materials" and "4C Skills". The search was limited to publications in 2018-2023 with a maximum limit of 1000 articles from the Crossref database. then the author selected articles that were in accordance with the topic and separated articles that did not contain keywords.

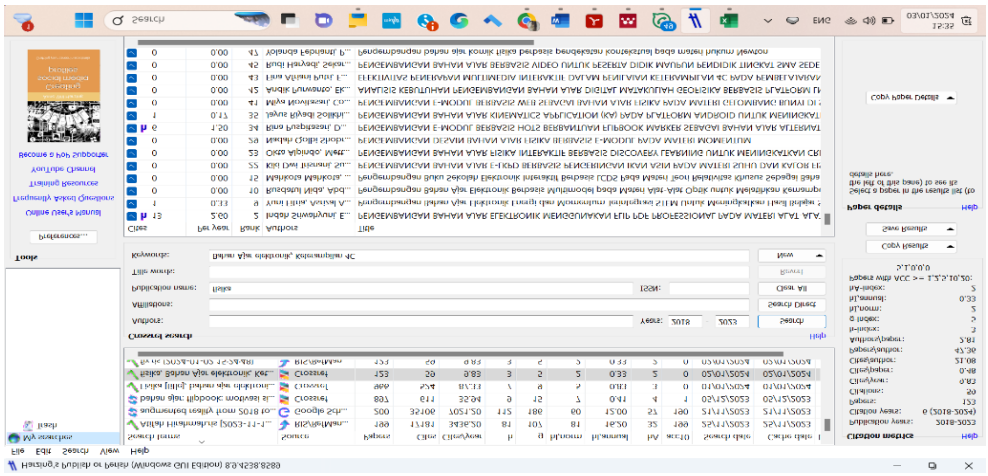

Figure 1. Determine Keywords and Conduct a Search

From the search results, around 124 articles were found to be analyzed, the distribution of articles based on the year of publication showed an increasing trend. A significant increase was seen especially in 2020-2021, which may have been influenced by the increasing need for e-learning during the COVID-19 pandemic. After that, the author saved it in xlsx format for Microsoft Excel and RIS format for VOSViewer software. From files xlsx The researcher filtered and processed the search results data using Microsoft Excel. The researcher processed the data with the initial step, namely sorting the lowest year to the largest year. The lowest year the researchers found was 2023. In this case the author decided to carry out a bibliometric analysis of the use of electronic teaching materials on students' 4C skills in physics material.

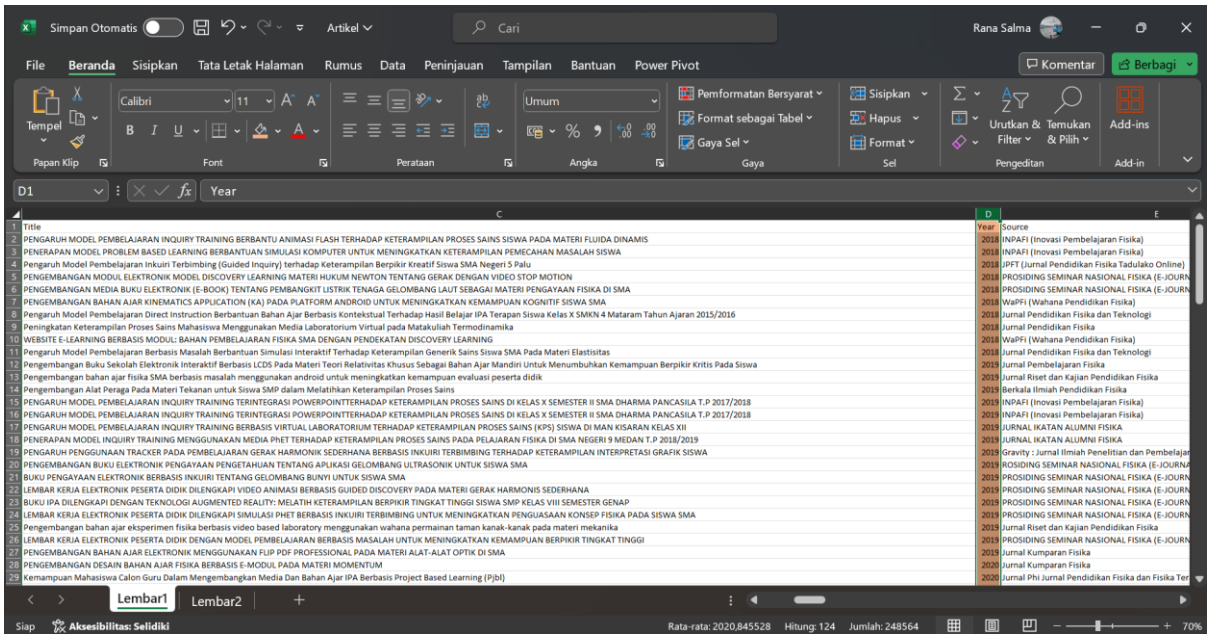

Figure 2. Filtering and Processing Search Results Data

After that, the researcher also included the analysis results that the researcher selected from the Crossef database based on author citations, article authors, article titles, article years, article sources, and article publications. can be seen in Table 1.

Table 1. List of Search Result Articles

Cites	Authors	Title	Year	Source	Publisher
13	Indah Sriwahyuni, Eko Risdianto, Henny Johan	Development of electronic teaching materials using professional flip pdf on optical equipment materials in high school	2019	Journal of Coil Physics	UNIB Press
6	Rina Puspitasari, Dedy Hamdani, Eko Risdianto	Development of hots-based e-modules assisted with flipbook markers as an alternative teaching material for high school students	2020	Journal of Coil Physics	UNIB Press
4	Amaliyah Tazkiyah,	Development of Electronic Modules with Android-Based Feedback on	2020	Journal of Physics and	Mataram University

	Sulur Sulur , Sahal Fawaiz	Temperature and Heat Materials for SMA/MA Students		Technology Education	
3	Cut Awwali Rahmatina, Misbahul Jannah, Fera Annisa	Development of stem-based teaching materials (science, technology, engineering, and mathematics) in SMA/MA	2020	Phi Journal ; Journal of Physics Education and Applied Physics	Raniry State Islamic University
3	Gelby Pradina Paramitha, Ida Sriyanti, Melly Ariska, Leni Marlina	Electronic module analysis of junior high school students' critical thinking skills on physics material	2021	Journal of Physics Innovation and Learning	Sriwijaya University - Unsri Learning Innovation Center
3	Mazetha Ramadayanty , Sutarno Sutarno , Eko Risdianto	Development of a physics e-module based on multiple representation to train students' problem solving skills	2021	Journal of Coil Physics	UNIB Press
2	Fauzi Bakri, Dewi Muliyati, Inas Nurazizah	Module based e-learning website: high school physics learning materials using a discovery learning approach	2018	Wapfi (Physics Education Platform)	Indonesian University of Education (UPI)
2	Fahmi Yahya, Syarif Fitriyanto	The Influence of Problem-Based Learning Models Assisted by Interactive Simulations on High School Students' Generic Science Skills in Elasticity Material	2018	Journal of Physics and Technology Education	Mataram University
2	Eliyarti Eliyarti , Chichi Rahayu, Zakirman Zakirman	Application of physics teaching materials with various forms of web-based assignments to improve engineering students' learning outcomes	2020	Undiksha Journal of Physics Education	Ganesha University of Education
2	Liza Septiaahmad , Indra Sakti, Iwan Setiawan	Development of ethnoscience-based physics student worksheets using the discovery learning model to improve high school students' critical thinking skills	2020	Journal of Coil Physics	UNIB Press

From the results of the analysis that the researchers searched for, namely 124 articles, the next stage was to determine the visualization of the 93 articles that the researchers found

using *VOSViewer* software. Changes or shifts in knowledge can be measured using bibliometric science. In relation to bibliometrics , science mapping is a method of visualizing a field of science (Royani et al., 2019) . Below, researchers present several steps for creating visualizations with *VOSViewer*.

Analysis using VOSviewer software produces a network visualization that illustrates the relationship between keywords in research on electronic teaching materials and 4C skills. The visualization of the relationship between terms can be seen in Figure 5. Each cluster is distinguished by a different color.

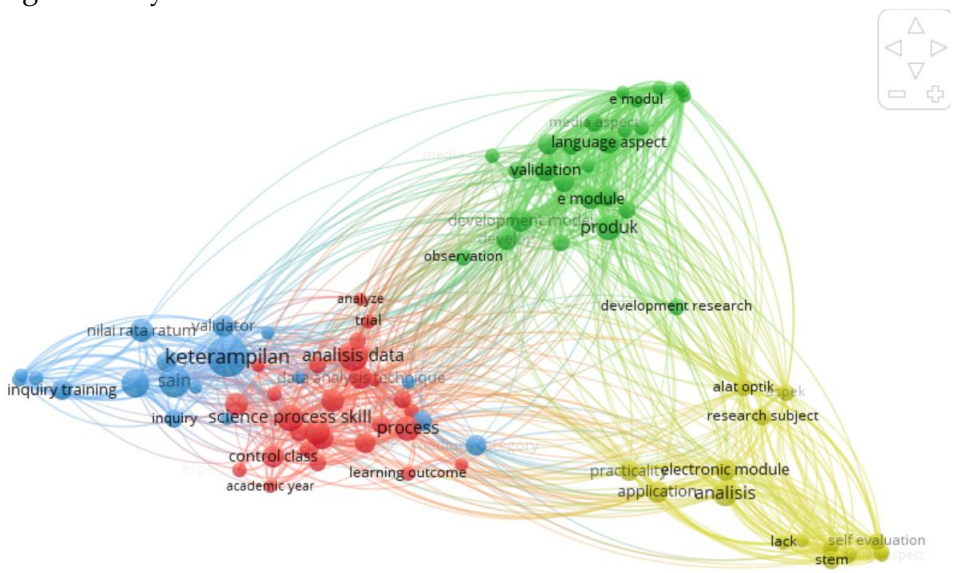

Figure 3. Visualization Network

Based on picture there is three terms that have circle big that is skills (blue), data analysis (red), and e-module (green). Analysis results This show more grouping compound, In cluster 1, it is marked with color red, included words to in group this is like achievement, effect indicates that cluster This represent group from research influence. In cluster 2, marked in green, several specific words appear such as characteristics, development model, etc. In cluster 3 which is marked in blue, the words included in group 1 tend to be general and non-specific words, such as skills, methods, etc. In cluster 4, marked in yellow is the cluster that represents electronic teaching materials marked with the words/terms application, design aspect, etc.

The VOSviewer visualization also shows a strong relationship between clusters, especially between the influence of cluster research (red) and learning methods and skills (blue). This indicates that research on the effectiveness of electronic learning materials is often associated with the development of certain skills. Meanwhile, the characteristics of cluster development (green) have a close relationship with the implementation of electronic learning materials cluster (yellow), indicating the relationship between aspects of development and implementation in learning practices.

Further analysis is shown through density visualization in Figure 7, which displays the distribution of research intensity in the form of a heat map. This visualization uses color gradation to depict item density and item weight in the e-learning materials and 4C skills research network. The brighter or more illuminated an area is, the higher the keyword density

in that area, indicating the most researched topics and having a significant influence in this field.

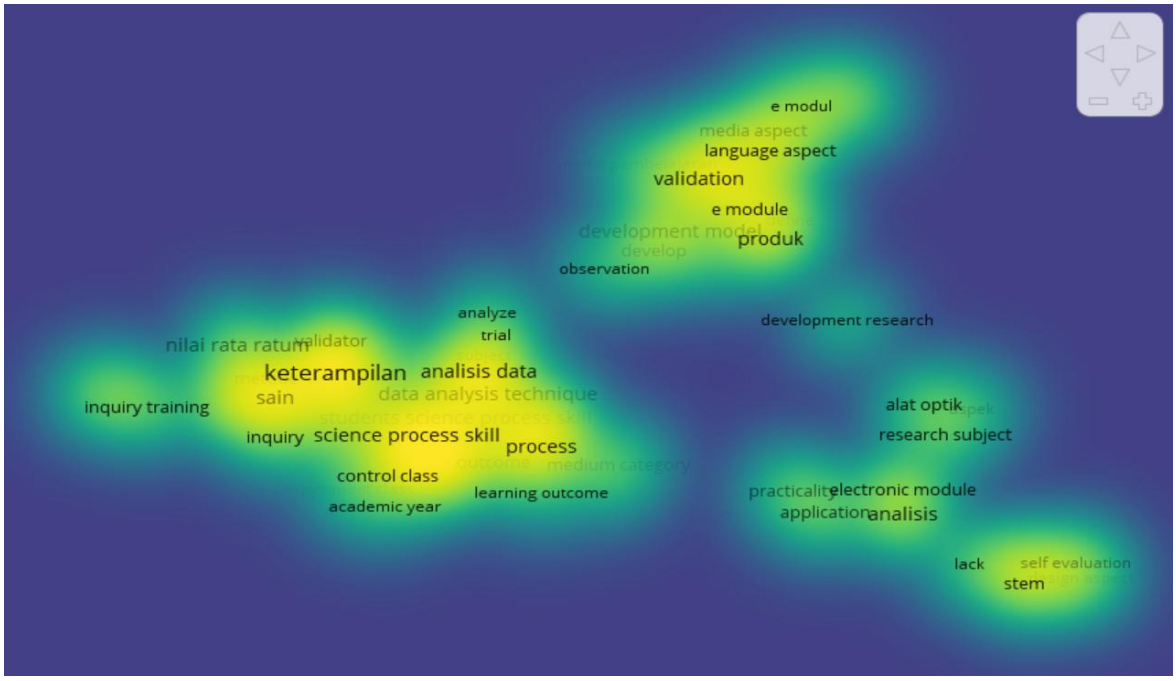

Figure 4. Density Visualization

The clusters density view, is an item (label) marked equal to visible items. Each *item point* has a color depending on *item* density at that time (Tupan, 2016) . This can identify a very bright spot, meaning that there has been a lot of research on the topic of Electronic Teaching Materials related to 4C skills in physics material, but we can see a very dim spot, namely the words development model and students' science process skills are still very rare to find. This shows that research uses the keywords development model and students science process skills for electronic teaching materials have the opportunity to be researched in the future.

Based on the visualization density analysis, several research opportunities that can be developed in the future include: Development of a more specific learning model for electronic teaching materials, Integration of science process skills in electronic teaching materials, and Exploration of the relationship between the electronic teaching material development model and 4C skills. Therefore, further research is needed to optimize the development of electronic teaching materials that support students' science process skills.

CONCLUSION

This study was conducted to obtain a comprehensive picture of Electronic Teaching Materials and their influence on improving students' 4C skills in physics material through bibliometric analysis. The research findings analyzed from 124 primary articles between 2018-2023 showed a significant increase in research publications on electronic teaching materials. In addition, the results of the visualization density analysis revealed that although there are many studies on the use of electronic teaching materials in physics learning, there are still research gaps, especially on topics related to the development model and students' science process skills. This gap opens up significant opportunities for future research, especially in the development of learning models that integrate science process skills with electronic open materials. Based on these findings, it can be concluded that the development of electronic

teaching materials has great potential in improving students' 4C skills in physics learning, but still requires further exploration, especially in the aspects of the development model and integration of science process skills. The research gaps identified in this analysis can be the basis for future research development, focusing on learning model innovation and optimization of science process skills integration in electronic teaching materials for physics learning

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