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Development of Modern Physics Learning Media Based on Interactive Web Using the PJBL Model to Improve Critical Thinking Skills: A Systematic Review

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© 2025 The Authors. This open access article is distributed under a (CC-BY License) Abstract: Critical thinking skills are the ability to analyze and evaluate information used to draw valid conclusions. Critical thinking skills can be facilitated through learning with a interactive web-based learning media with project based learning (PjBL) model. This research aims to identify and analyze research trends of development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. This research method is descriptive and analytical. The data used in this research was obtained from documents indexed by Google Scholar from 2015-2024 using Publish or Perish and Dimension.ai. Research procedures use PRISMA guidelines. The data identified and analyzed are the type of publication, publication source, and the title of research that is widely cited. The data analysis method uses bibliometric analysis assisted by VOS viewer software. The results of the analysis show that research trend indexed by Google Scholar from 2015 to 2024 has experienced a fluctuating increase. However, in 2024 there will be a decline in the research trend on it. There are many documents in the form of articles, proceedings, chapters, preprints, edited books and monograph that discuss research about development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. Key words that are often used in research about it are collaboratin, communication, creativity, technology etc.

Keywords: Critical thinking; Interactive web; Modern physics; Project based learning

Introduction

Some of the challenges in the 21st century include critical thinking skills, problem solving, communication and collaboration skills and the ability to use information and communication technology for daily activities (González-Pérez & Ramírez-Montoya, 2022; Stehle & Peters-Burton, 2019). Critical thinking skills are key skills for students to adapt to the external challenges of the 21st century (Thornhill-Miller et al., 2023). This is in line with the fourth goal of the SDGs, namely trying to make quality education. Quality education can be obtained by mastering one of the 21st century skills, namely critical thinking. Students' critical thinking skills in science material are relatively low with an average of 40.62%. Science teachers must provide instructions first so that students can provide answers to questions from teachers. Students' difficulty in understanding the concept of science is also supported by the lecture method used by teachers and learning media that still refer to textbooks, so that science subjects are considered less interesting.

Students' critical thinking skills are important to analyze problems in the real world (Connerade, 2023;

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Lestari & Setyarsih, 2021; Muhammad et al., 2023);. The low critical thinking skills are caused by several factors, one of which is that learning is still teacher-centered, including in the Modern Physics course. Modern physics is one of the important courses in physics because it underlies several other advanced courses, including quantum physics, solid state physics, statistical physics and nuclear physics. In general, the concept of modern physics includes the special theory of relativity, quantum theory for electromagnetic radiation and matter, hydrogen-like atoms, multielectron atoms, nuclear physics, and atomic systems (Nanni, 2023). Another factor is the still rare use of learning media in the Modern Physics course that can provide a better understanding of abstract materials.

Based on the description above, one of the efforts that can be done is by developing interactive web-based media using a model that can facilitate the improvement of critical thinking skills of students. The learning model used is Project Based Learning (PjBL). Project-Based Learning (PjBL) is a form of learning that focuses on students. Students are actively involved in the learning process. Students' thinking skills in dealing with problems will be trained through PjBL. Students work together with others and reflect on what they have learned. In addition, students can be active in the search and decision-making process by improving their practical thinking skills (Golden, 2023; Sellars et al., 2018). Learning using ethno-STEM-PjBL can improve high-level abilities such as critical thinking skills (Bramastia et al., 2023; Hikmah et al., 2023). People who think critically are people who can reflect on their knowledge, think rationally and factually, and use relevant information to solve a problem (O'Reilly et al., 2022).

PjBL contributes to students' academic achievement by creating a more equal learning environment. PjBL Project Work is given to individuals or groups of students. Then, project work begins with the selection of a specific topic by students with direction from the teacher. The general topic is a problem that can be solved through experiments or observations. Project work provides an opportunity for students to promote their achievements. In addition, this work allows students to work together in a real-world environment by collaborating on a task (Yu, 2024; Zhang & Ma, 2023). The use of learning models is very good when combined with the use of learning media (Risnawati et al., 2018). This is closely related to the use of information and communication technology which is increasingly developing rapidly as an effort to digitize education in the implementation of the independent curriculum. Information and Communication Technology (ICT)based learning in the world of education cannot be separated from the needs of 21st century learning,

especially in science learning (Chai et al., 2014; Hinostroza et al., 2024; Kwangmuang et al., 2021).

One alternative that can be done is that learning media is integrated with technology, such as interactive web-based media. The use of web-based media has various benefits such as the speed of obtaining information, through websites various information in the world can be obtained in seconds. The benefits of the website are supported by the increasing ease of operating computer devices, ease of getting internet access, and increasingly affordable internet usage costs. Another advantage in using website-based learning media will be felt by teachers or lecturers.

Through interactive website-based learning media, lecturers can monitor the learning process and development of students. This will help the learning evaluation process in Modern Physics courses (Dewi Muliani & Citra Wibawa, 2019). Therefore, this research wants to know the research trend of the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. It is hoped that this research can become a reference in developing further research related to critical thinking in students' learning.

Method

This research method is descriptive and analytical, which aims to understand and describe research trends in the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. The data used in this study was obtained from information sources indexed by Google Scholar using analytical tools such as Publish or Perish and Dimension.ai. To carry out a search on Google Scholar, keywords related to research trends on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills.

In this research, an analysis was carried out on 1,000 documents that had been indexed by Google Scholar between 2015 and 2024. The Google Scholar database was chosen as a place to search for documents because Google Scholar applies consistent standards in selecting documents to be included in its index, and Google Scholar displays more documents than the top databases. Others, especially research in the field of education (Hallinger & Chatpinyakoop, 2019; Hallinger & Nguyen, 2020; Zawacki-Richter et al., 2019). To filter data that has been collected via Publish or Perish, researchers used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Result and Discussion

This research aims to describe research trends on development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills conducted from 2015 to 2024. Research documents are taken from documents from 2015 to 2024. Figure 1 is presented below regarding research trends on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills.

Figure 1 shows that the trend in research on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills from 2015 to 2024 has increased. Where the research trend is with an increase in the number of publications every year, namely from 2015 to 2020. However, in 2021 the research trend on the development of modern physics learning media based

on interactive web using the PjBL model to improve critical thinking skills has decreased. The increasing trend in research on the problem-based learning model to improve critical thinking skills caused by 21st century education has focused on improving critical thinking competence.

In 2015 there were 4 publications related to the trend, then this will continue to increase to 83 publications in 2020 and keep increased until 143 publications in 2023. This increasing research trend provides a deeper understanding the problem which is low of critical thinking skills in physics learning and ways to solve that problem. Research is able to improve critical thinking skills through various methods, one of them is problem-based learning model. Below are also table 1 presented research of development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills based on the type of publication.



Figure 1. Research trends in development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills

Table 1. Trends in physics learning media based oninteractive web using the PjBL model to improve criticalthinking Skills Research Based on Publication Types

Publication Type	Publications
Article	178
Edited Book	127
Chapter	127
Monograph	13
Proceeding	6
Preprint	4

Based on Table 1, it is known that research development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills from 2015 to 2024 contained in 6 types of publications. In the form of articles there were 178 documents, chapters as many as 127 documents, proceedings as many as 6 documents, edited books as many as 127 documents, monographs 13 document, and preprints as many as 4 documents. Research trends development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills in article form is the type of publication that contains the most research about it. Meanwhile, the type of publication contains the least amount of research results development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills is a preprint. Research conducted by Oltarzhevskyi (2019) states that an article is a complete factual essay of a certain length created for publication in online or print media (via newspapers, magazines or bulletins) and aims to convey ideas and facts that can convince and educate. These articles are usually published in scientific journals both in print and online (Suseno & Fauziah, 2020).

Below are also table 2 presented top ten (10) sources title trends in research on development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills which are often cited by other researchers related to this matter. Table 2 shows that the most widely published source of research trends on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills is the Jurnal Penelitian Pendidikan IPA, namely 18 publications with 18 citations and an average citation of 1.00. Jurnal Penelitian Pendidikan IPA contains scientific articles form of research results that include science, technology, and teaching in the field of science. The first edition were published in 2015. All edition in this journal are open access, i.e. the articles published in them are immediately and permanently free to read, download, copy & distribute. Below are also table 3 presented top ten (10) article title trends in research on development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills which are often cited by other researchers related to this matter.

Table 2. Top 10 Sources Title Trend of development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills Research in 2015-2024

Name	Publications	Citations	Citations Mean
Jurnal Penelitian Pendidikan IPA	18	18	1.00
Advances in Social Science, Education and Humanities Research	55	52	0.95
Lecture Notes in Networks and Systems	13	11	0.85
Lecture Notes in Computer Science	8	7	0.88
Education Sciences	5	50	10.00
Communications in Computer and Information Science	5	17	3.40
Cogent Education	4	13	10.75
Advances in Intelligent Systems and Computing	4	43	0.83
International Journal of Information and Education Technology	3	1	0.33
Applied Sciences	3	2	0.67

Table 3 shows that research on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills that is widely cited by other researchers is about " Improving Students' Critical Thinking Skills: Is Interactive Video and Interactive Web Module Beneficial?" which is 14.00 (Febliza et al., 2023). Then the research entitled "Integrating Ethnoscience on Critical-Thinking Oriented Web-Based E-Module of Secondary School Science" was cited 8.00 times (Hsu et al., 2022). Research by Jiang et al. (2020); Solla et al. (2019), entitled "Sustainable Design with BIM Facilitation in Projectbased Learning" is also widely cited by other researchers, namely 7.50 per year. Karnando et al. (2024), in their research entitled "From Engagement to Empowerment: Project-Based Learning in Python Coding Courses" was cited 2.40 per year.

This research data is comparable to data on the increasing trend of research on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking

skills from 2015 to 2024. This means that in that year, research related to it was continuously cited by other researchers. In the articles researched and written by these researchers, there are many terms/keywords related to development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. Below are presented ten (10) popular keywords related to the topic.

Table 4 shows that the keywords that often appear related to research on the the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills are interactive web page, 5 times with a level of 1.81. Many studies discuss learning media using interactive web. (Bada, 2022; Maslakhah et al., 2024; Wahyudi et al., 2023). Table 4 also shows that creativity is also a keyword that appears frequently in research trends on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills, namely 10 times with a relevance of 0.35. Several articles discuss the use of interactive web-based learning media to increase creativity (Huang et al., 2020; Raimundo & Rosário, 2024; Ramdinawati Syam et al., 2024).

Table 3. Top 10 Citations on Trend of development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills Research in 2015-2024

Cites/year	Year	Author	Title
14.00	2023	Febliza, Asyti; Afdal, Zul;	Improving Students' Critical Thinking Skills: Is Interactive Video and
		Copriady, Jimmi	Interactive Web Module Beneficial?
8.00	2024	Monica Prima Sari , Arief	Integrating Ethnoscience on Critical-Thinking Oriented Web-Based E-
		Muttaqiin , Rahmah Evita Putri , Rani Oktavia	Module of Secondary School Science
7.50	2015	Vivien Luo, Wei Wu	Sustainable Design with BIM Facilitation in Project-based Learning
2.40	2020	Mark Frydenberg, Kevin Mentzer	From Engagement to Empowerment: Project-Based Learning in Python Coding Courses
1.00	2024	Feni Eka Wulandari;	The relationship between students' creative thinking skills and
		Murni Sapta Sari;	cognitive achievement through project based learning integrated by
		Dwi Listyorini;	interactive web
		Racy Rizky Abdillah	
0.33	2016	Neo Mai,	Enhancing Malaysian Students' Learning with Interactive Multimedia
		Heidi Tan Yeen-Ju &	and the Web: The MILE Project
		Nordiana Ludin	,
0.25	2021	Karmila Suryani; Jalius	STEM-MEA (Science Technology Engineering Mathematics - Means
		Jama; Sukardi; Khairudin	End Analysis) Model for Improving the Creativity and Critical
		-	Thinking of University Students
0.13	2017	MY Anuar.	Integrating interactive, edutainment technology with project-based
			learning: A pedagogical model for inclusive classrooms
0.00	2023	Nor Idalaila binti Aziz,	Adopting an Active Learning Approach for Teaching and Learning of
		Abdul Aziz bin Ab Nasir	Web Design Technology: A Guide for Effective Learning
0.00	2016	Shaimaa Alkhuly	The Effect of Webquest on Enhancing EFL Student Teachers'
		5	Argumentative Writing and Critical Thinking

Below are the visualization is accomplished by generating a landscape map, which offers a visual representation of subjects related to scientific studies. The outcomes of bibliometric mapping for the co-word network in articles related to the topic development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills are illustrated in Figure 2. Figure 2 shows the results of bibliometric keyword mapping on research trends on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. In Figure 2 there are 31 keyword items that are often used in research on development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills from 2015 to 2024. Figure 2 also contains 4 clusters, where the first cluster is colored red and consists of 12 keyword items, namely collaboration, communication, creativity, engineering, etc. The second cluster in green consists of 9 keyword items, namely critical thinking, education, interactive web application, etc. The third cluster in blue consists of 7 keyword items, namely course, interactive web page, etc. And the fourth

yellow cluster consists of 3 keyword items, namely outcome, PBL and study.

Table 4. Keywords on Trend development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills Research in 2015-2024

Terms	Occurrences	Relevance
Interactive Web Page	5	1.81
Collaboration	5	1.81
Communication	5	1.42
Engineering	4	1.15
Interactive Web	4	0.84
Application		
Education	17	0.76
PBL	4	0.72
Creativity	10	0.35
Innovation	5	1.04
Course	10	0.60

Figure 2 shows that network visualization shows the network between the terms being visualized. Keywords classified into seven clusters are arranged in a color chart showing the divisions/clusters that are connected to each other. The results of this analysis can be used to determine keyword research trends in the last

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year. This analysis shows several keywords that are often used in research on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. The more keywords that appear, the wider the visualization displayed. Below are also presented keywords regarding the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills based on overlay visualization (Luh Gede Sutaryani et al., 2024; Wang & Tahir, 2020).



Figure 2. Network visualization on trend development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills research

Figure 3 shows the trend of keywords related to research development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills in Google Scholar indexed journals from 2015 to 2024. Trends in the themes of writing articles related to development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills from the oldest to the newest year are marked with purple, blue themes, turquoise, dark green, light green and yellow. In the picture below you can see that the PBL, activity, web, etc. This shows that these keywords were widely used by researchers in 2019. In 2022, the keywords that frequently appeared were education, interactive web page, development, etc.



Figure 3. Overlay visualization on development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills research

Research on development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills is one area of research that has developed rapidly in recent years. The following also presents keywords for development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills research based on density visualization. Figure 4 shows density visualization. The density of research themes is shown in bright yellow. The brighter the colors of a theme, the more research is done. The fainter the color means the theme is rarely researched (Kaur et al., 2022; Liao et al., 2018). Faintly colored themes such as interactive web page, PBL, technology, are dimly colored keywords. This shows that these keywords can be used as a reference for further research. (Bahtiar et al. (2023); Dong et al. (2023); Doyan et al. (2023); Ruiz-Rojas et al. (2024), stated that yellow indicates keywords that are currently and frequently used in research, like critical thinking, project, etc.



Figure 4. Density visualization on trend development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills research

Overall, research on development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills is important because it can attract students' attention to learn through learning media in the form of interactive websites that are easy to access and are able to explain abstract concepts in modern physics courses, and also able to facilitate critical thinking skills (Kurniawan et al., 2024; Topano et al., 2021; Yani & Rosana, 2024). Critical thinking is part of 4C skills that students must have. Critical thinking skills are very important so that students are able to process information to solve problems both in learning and in real life (Ananda et al., 2023; De Klerk et al., 2024; Desiana et al., 2022). The research trend in development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills is expected to continue to develop in the next few years. This can be done by developing new combination of PjBL model with technology or other things to facilitate students' critical thinking thinking skills, especially in modern physics course (Bayani et al., 2025).

Conclusion

Research on trends in the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills has urgency high because of its potential to provide various benefits to 21st century education. The research trend on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills indexed by Google Scholar from 2015 to 2024 has experienced a fluctuating increase. However, in 2024 there will be a decline in the research trend on the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. There are many documents in the form of articles, proceedings, chapters, preprints, edited books and monograph that discuss research into the development of modern physics learning media based on interactive web using the PjBL model to improve critical thinking skills. Key words that are often used in research about it are collaboratin, communication, creativity, technology, etc.

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Author Contributions

Conceptualization, A. D.; methodology, S. ; validation, A. H.; formal analysis, S. A.; investigation, M. I.; resources, N. R. A.; data curation, S. H.: writing – original draft preparation, A. D.; writing – review and editing, S., A. H.: visualization, M. I., N. R. A., S. H. All authors have read and agreed to the published version of the manuscript. All authors contributed to writing this article.

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Conflicts of Interest

No conflict interest.

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