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Mapping Research Trends on Physics Learning Media Based on PJBL Model to Improve Critical Thinking Skills: A Review

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Abstract: The Project-Based Learning (PjBL) model is a learning approach that emphasizes active student involvement through project-based activities. In the context of physics learning, the use of PjBL-based media has proven effective in encouraging students to think critically, as they are required not only to understand concepts but also to apply them to solve real-world problems. This research aims to identify and analyze research trends of physics learning media based on PjBL model to improve critical thinking. 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 physics learning media based pn PjBL model to improve critical thinking. Key words that are often used in research about it are collaboratin, communication, creativity, technology etc.

Keywords: Critical thinking; Learning Media; Physics; Project based learning

Introduction

The modern physics course plays a fundamental role as a prerequisite for advanced topics such as quantum mechanics, solid state physics, statistics, and nuclear physics. The core concepts of modern physics include the theory of special relativity, quantum aspects of electromagnetic radiation and atomic structure, such as hydrogen-like atoms, multielectron atoms, and nuclear physics (Safronova et al., 2018). The use of learning media, especially the textbook, is still limited. This traditional method often results in the teaching and learning activities being teacher-centered, which may lead to low critical thinking skills (Leibovitch et al., 2025). The average critical thinking skills in the science subject is only 40.62%, suggesting that understanding the material is limited, leading to difficulty in grasping the core of the topics, such as close learning (Bouchée et al., 2022; Lodge et al., 2018). The legacy of development for quality education is important for critical thinking, which is included in the fourth Sustainable Development Goal (SDG) in the 21st-century skills.

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Critical thinking helps students focus on real-world applications. To ensure quality education and critical thinking, students are encouraged to develop essential skills that help close real-world problems. Approaches such as using technology for daily learning activities (Van Laar et al., 2020; Stehle & Peters-Burton, 2019; González-Pérez & Ramírez-Montoya, 2022).

These 21st-century skills, which include critical thinking and problem-solving, focus on quality education. The reason for low critical thinking is the still-heavy reliance on teacher-centered learning, which limits close real-world critical thinking. Improving critical thinking skills through relevant materials can help reduce achievement in critical thinking for science topics (Mahdian et al., 2024; De Los Santos et al., 2025). One of the things that can be done is to create interactive web-based media using a model that helps improve students' critical thinking skills. The model used is called Project Based Learning, or PjBL. PjBL is a learning approach that puts students at the center. Students are actively involved in their learning. Through PjBL, their ability to think critically and solve problems is developed. They work together with their classmates and reflect on what they have learned. Also, they get to take part in searching for information and making decisions, which helps them improve their practical thinking skills (Kwangmuang et al., 2021; Dawson et al., 2024). Using ethno-STEM-PjBL learning can help students develop high-level skills like critical thinking (Lestari et al., 2024; Sumarni et al., 2021).

Critical thinkers are those who can reflect on what they know, think logically and based on facts, and use the right information to solve problems (Retno et al., 2025). PjBL helps students do better in school by making the learning process more fairs. In PjBL, students are given a project to work on either individually or in groups. The project starts with students choosing a topic, with guidance from the teacher. The topic is usually a problem that can be studied through experiments or observations. These projects give students a chance to show what they have learned. Also, they allow students to work together in real-life situations by solving tasks as a team (Nainggolan & Purwaningsih, 2024; Dias-Oliveira et al., 2024). Using a learning model works well when it is paired with good learning materials (Almulla, 2020). This is especially important as information and communication technology (ICT) continues to grow rapidly, helping to modernize education. ICT-based learning is very important in today's education system, especially for science subjects (Buzzell et al., 2025; Bangsawan et al., 2023).

The integration of interactive web-based media in learning processes offers benefits such as quick access to information, leveraging the ease of internet usage, and cost-effective internet access. All of which can be achieved through web-based media (Ningrum et al., 2024; (Masruri et al., 2024). This allows for faster access to online learning materials. Environmental and energy-efficient technology and cost-effective internet use enable efficient learning environments. These tools give teachers the ability to track student performance and learning progress. Benefits include promotions of interactive methods through various media, which dent the use of online learning platforms that offer quick access to information, affordable internet, and effective education. This media integration allows lecturers to monitor student progress and optimize online learning. The impact can be seen in courses like Modern Physics (Arbabifar & Nazerdeylamin, 2024; Halim et al., 2020).

Therefore, this research wants to know the research trend on physics learning media based pn PjBL model to improve critical thinking. 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 (Doyan et al., 2025; Selano et al., 2024; Hallinger & Chatpinyakoop, 2019).

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. 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.

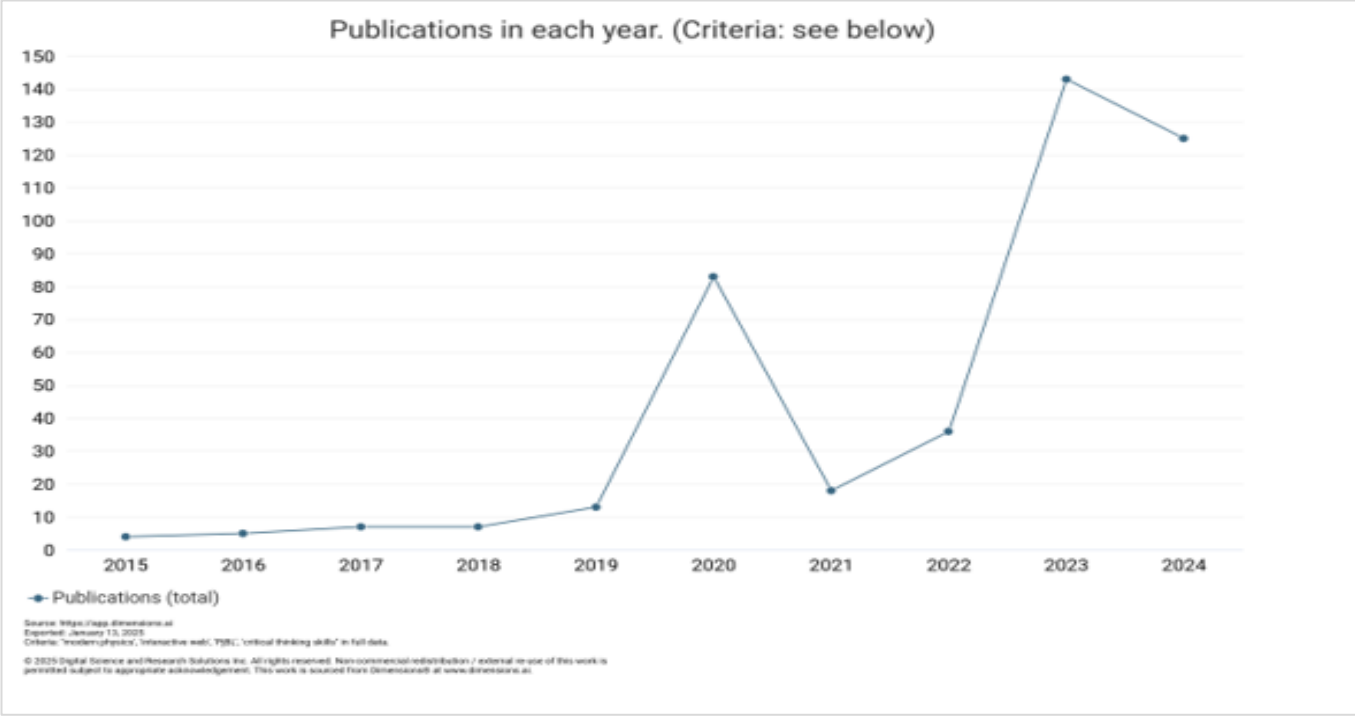

Figure 1. Research trends in physics learning media based on PjBL model to improve critical thinking

Table 1. Trends in Physics Learning Media Based on PjBL Model to Improve Critical Thinking 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 Physics Learning Media Based on PjBL Model to Improve Critical Thinking 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 (Ramadani et al., 2025). Research by Liao et al. (2018), entitled "Sustainable Design with BIM Facilitation in Project-based Learning" is also widely cited by other researchers, namely 7.50 per year. Acerra et al. (2022), 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 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 3. Top 10 Citations on Trend of Physics Learning Media Based on PjBL Model to Improve Critical Thinking Research in 2015-2024

Cites/year	Year	Author	Title
14.00	2023	Febliza, Asyti; Afdal, Zul; Copriady, Jimmi	Improving Students' Critical Thinking Skills: Is Interactive Video and Interactive Web Module Beneficial?
8.00	2024	Monica Prima Sari , Arief Muttaqiin , Rahmah Evita Putri , Rani Oktavia	Integrating Ethnoscience on Critical-Thinking Oriented Web-Based E-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

Cites/year	Year	Author	Title
1.00	2024	Feni Eka Wulandari; Murni Sapta Sari; Dwi Listyorini; Racy Rizky Abdillah	The relationship between students' creative thinking skills and cognitive achievement through project based learning integrated by interactive web
0.33	2016	Neo Mai, Heidi Tan Yeen-Ju & Nordiana Ludin	Enhancing Malaysian Students' Learning with Interactive Multimedia and the Web: The MILE Project
0.25	2021	Karmila Suryani; Jalius Jama; Sukardi; Khairudin	STEM-MEA (Science Technology Engineering Mathematics - Means 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, Abdul Aziz bin Ab Nasir	Adopting an Active Learning Approach for Teaching and Learning of Web Design Technology: A Guide for Effective Learning
0.00	2016	Shaimaa Alkhuly	The Effect of Webquest on Enhancing EFL Student Teachers' Argumentative Writing and Critical Thinking

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 (Daryanes 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 (Suharti et al., 2024; Yulianti et al., 2025).

Table 4. Keywords on Trend Physics Learning Media Based on PjBL Model to Improve Critical Thinking 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 Application	4	0.84
Education	17	0.76
PBL	4	0.72
Creativity	10	0.35
Innovation	5	1.04
Course	10	0.60

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.

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

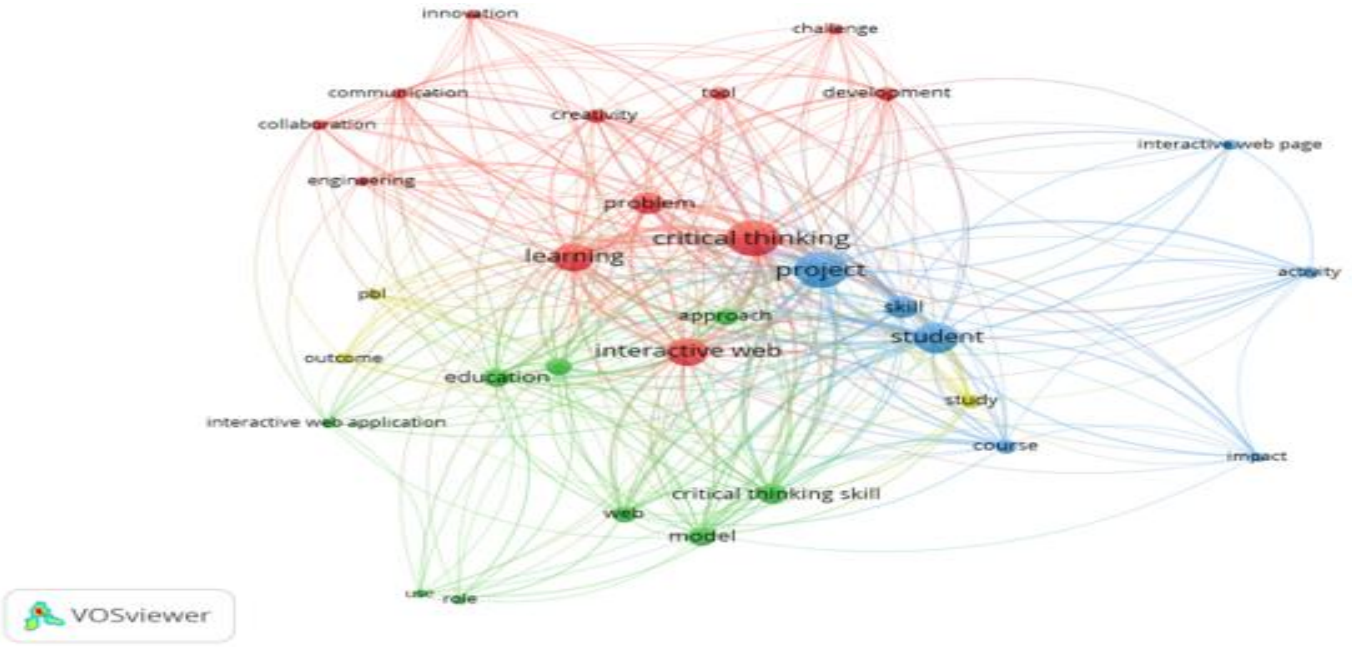

Figure 2. Network visualization on trend physics learning media based on PjBL model to improve critical thinking research

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.

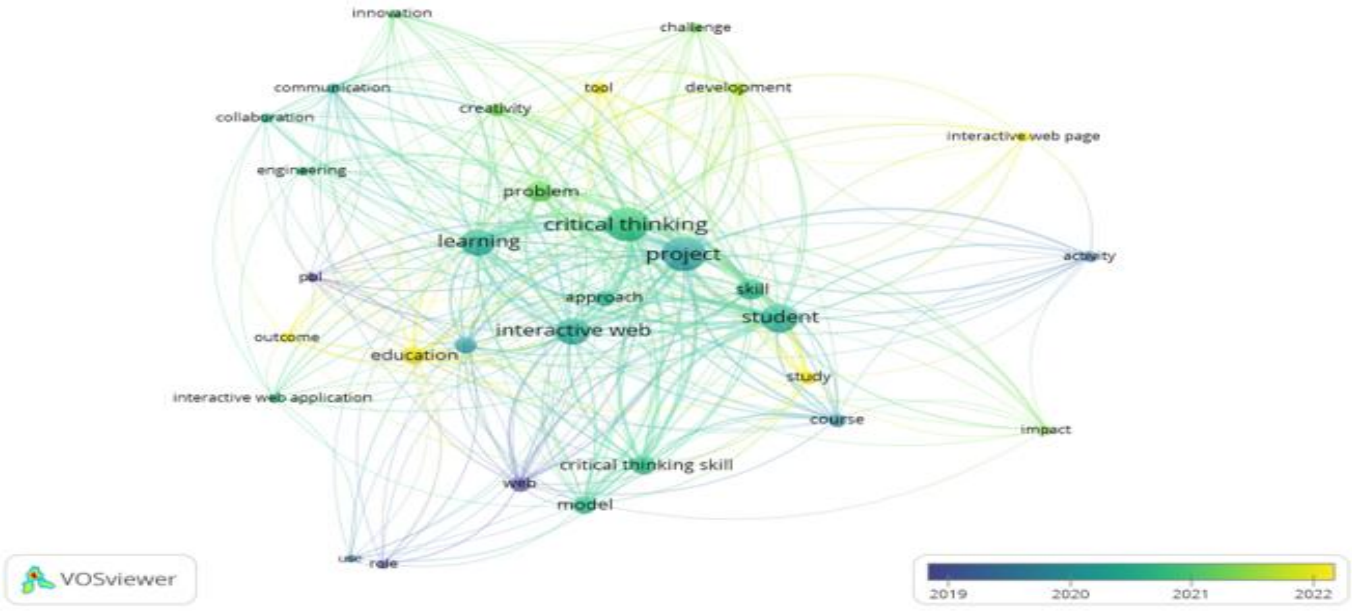

Figure 3. Overlay visualization on physics learning media based on PjBL model to improve critical thinking research

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. Doyan et al. (2023) and Bahtiar et al. (2023) stated that yellow indicates keywords that are currently and frequently used in research, like critical thinking, project, etc.

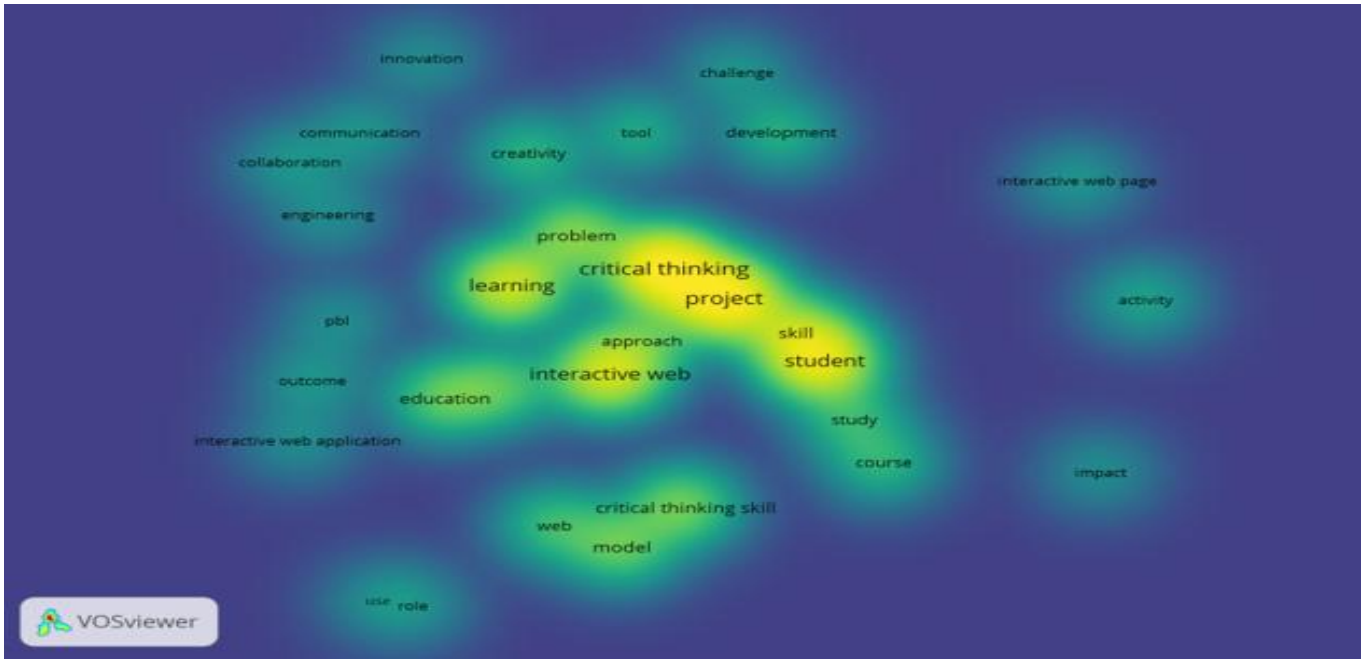

Figure 4. Density visualization on trend physics learning media based on PjBL model to improve critical thinking research

The Project-Based Learning (PjBL) model is a learning approach that emphasizes active student involvement through project-based activities. In the context of physics learning, the use of PjBL-based media has proven effective in encouraging students to think critically, as they are required not only to understand concepts but also to apply them to solve real-world problems (Bell, 2010; De Klerk et al., 2025). PjBL-based learning media serves as an interactive tool that helps students connect physics theory to everyday phenomena. Through media such as digital simulations, virtual laboratory-based experiments, or even the use of instructional videos, students gain a more contextual learning experience. This process allows students to explore problems, ask questions, and formulate hypotheses, significantly developing critical thinking skills (Pratiwi et al., 2025). According to Afikah et al. (2022), PjBL is effective in increasing conceptual understanding while honing higher-order thinking skills. This aligns with the findings of Sutaryani et al. (2024) and Novitra et al. (2021), which showed that the application of project-based media in physics learning can improve students' analytical, evaluation, and reflection skills. Students are trained to identify problems, develop problem-solving strategies, and evaluate results, which are the essence of critical thinking. Furthermore, PjBL-based media also facilitates collaboration between students. During projects, students often discuss, exchange ideas, and defend their arguments. This interaction fosters critical thinking skills because students must present logical reasons and receive feedback to improve their ideas (Ekalia et al., 2025; Zeng & Ravindran, 2025). Thus, PjBL media not only serves as a conduit for information but also as a facilitator of social and cognitive interaction. However, the implementation of PjBL-based media in physics learning also faces challenges (Aprinaldi et al., 2023; Sinaga et al., 2023).

Some teachers still struggle to design media that suits the characteristics of the project, while students sometimes struggle with time management when completing projects (Adams & Blair, 2019; Wolters et al., 2025). Therefore, teacher training support and appropriate technology utilization are essential for optimal implementation of PjBL media. Overall, PjBL-based physics learning media has great potential for improving critical thinking skills. This happens because the media provides meaningful learning experiences, encourages contextual problem solving, and trains students in managing information and constructing logical arguments.

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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Conceptualization, A. D; methodology, S.; formal analysis, A. H.; investigation, S. A.; resources, M. I.; writing—preparation of original draft, I.K.N.; writing—reviewing and editing, N. R. A.; visualization, A. D; supervision, S.; project administration, A. H; obtaining funding, S. A. All authors have read and approved the published version of the manuscript.

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