

Analysis of the Development of Electronic Teaching Materials Integrated with Problem Based Learning to Promote Critical Thinking Skills: Systematic Literature Review

Azifa Feziyasti^{1*}, Michelly Fathimatuzzahra Suhengki², Aulianisa Dina Pratiwi³, Asrizal⁴, Festiyed⁵

^{1,2,3} Magister of Physic Education, Department of Physic, Universitas Negeri Padang, Padang, Indonesia.

^{4,5} Department of Physic, Faculty of Mathematic and Science, Universitas Negeri Padang, Padang, Indonesia

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ABSTRACT

This article aims to analyze the development of electronic teaching materials based on the Problem-Based Learning (PBL) model to promote student's critical thinking skills. Ideally, education should facilitate students in thinking critically, creatively, and independently when facing various problems. However, challenges in achieving this ideal condition often arise due to the lack of effective learning models. Using the Systematic Literature Review (SLR) method, this study examines various previous studies related to develop of electronic teaching materials based on Problem Based Learning. Based on the literature analysis conducted, it was found that research on the development of electronic teaching materials using the Problem-Based Learning model has been discussed in 20 journal articles analyzed. These articles indicate that the Problem-Based model in electronic teaching materials has great potential in facilitating the improvement of critical thinking skills, especially in the context of interactive and structured learning. These findings are expected to provide insights for curriculum developers and educators in designing more effective and innovative teaching materials, as well as to encourage further research in this field.



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*Correspondence:

Azifa Feziyasti, Magister of Physics Education, Department of Physic, Universitas Negeri Padang, Padang, Indonesia.

• email : Azifa.feziyasti2001@gmail.com , Phone: 081257800989

INTRODUCTION

In the era of globalization and the industrial revolution 4.0, the world of education is faced with demands to produce individuals who not only master knowledge, but also have essential 21st century skills (Nesri & Kristanto, 2020). These skills consist of critical thinking, communication, collaboration and creative thinking skills (Fonna & Nufus, 2024). However, (Masruroh et al., 2023) in their research revealed that students' 21st century skills are still in weak category, one which is critical thinking. Meanwhile, critical thinking skill are essential to help students succeed in academics and their daily lives. Therefore, education must be able to respond to these changes with relevant and innovative approaches. One approach

that can improve critical thinking skills for students is through active application and problem-solving-based learning, such as problem-based learning (PBL).

However, in implementing problem-based learning (PBL), one of the biggest challenges faced is the availability of effective and relevant teaching materials. Research by (Roshid & Haider, 2024) shows that many schools still using conventional teaching materials that do not support the development of 21st century skills, especially critical thinking skills. This deficiency can hinder students in developing their maximum potential in tune with the needs of the times. Most educators have not fully integrated critical thinking skills into the teaching materials used, both in terms of content and learning methods (Ilana & Cintamulya, 2022). This shows that many educators are still limited to traditional approaches, so students do not have access to innovative teaching materials that can stimulate critical thinking skills. As a result, critical thinking skills in students tend to be low and not optimally developed. This condition also indicates a gap in the utilization of educational technology which should be the main tool to support problem-based learning (PBL). The limitations in the application of learning methods integrated with modern technology indicate the need for more attention to the development of teaching material that is relevant, interactive, and suitable with current educational needs.

To solve this problem, it is needs to develop electronic teaching materials that are not only integrated on text and images, but it can equipped with interactive features to help increase the critical thinking skill. Electronic teaching materials based on the problem based learning (PBL) model can be a more effective solution to answer this need because the PBL model allows students to learn through direct experience in solving real problems. This model can encourage students to think critically, work together in groups, communicate effectively, and produce creative solutions. Using electronic teaching materials integrated with local values and problem-based learning (PBL) approach has significant potential to promote students' critical and creative thinking skills (Ramadhani et al., 2021). The integration of local values not only provides a relevant context for students, but also increases their awareness of their local wisdom and cultural uniqueness. Thus, electronic teaching materials designed with this approach not only meet the needs of 21st century learning but also contribute to the preservation of cultural values in the learning process. This approach is believed to be an effective way to overcome the limitations of conventional teaching materials in helps the increase of critical thinking skills for students in this digital era.

This research has advantages in the design approach of electronic teaching materials that are not only problem-based learning (PBL), but focus on promote critical thinking skills through technology. Although problem-based learning (PBL) model is widely known in education, the utilization of electronic teaching materials that are optimally integrated with problem-based learning (PBL) to increase students' critical thinking skills is still very limited. Through a Systematic Literature Review (SLR), this research analyzes, classifies, and evaluates the development of problem-based learning (PBL) electronic teaching materials to promote critical thinking skills in students. In accordance with the opinion of (Richter et al., 2019) a systematic literature review is a structured examination of existing studies, conducted using established research methodologies. that are rigorous and structured, so as to answer research questions. The research sources used in this study are journal articles that are relevant to the topic of problem-based learning (PBL) models to improve critical thinking skills in students.

The application of problem-based learning (PBL) models in learning has been widely proven effective in developing critical thinking skills (Fitriani et al., 2020). The learning process using the problem-based learning (PBL) model can involve students individually and in groups for problem solving activities that have been designed by the teacher

(Fatmawati & Sujatmika, 2018). Problem-based learning (PBL) facilitates students to engage in problem-solving activities, so as to encourage the use of critical thinking skills. In this case, electronic teaching materials designed with problem based learning (PBL) principles must have interactive elements, such as group assignments, problem simulations, and resources that can be accessed online to facilitate collaboration between students. Meanwhile, according to (Boholano et al., 2020), technology and electronic teaching materials have great potential in supporting 21st century learning, especially in developing critical thinking skills. Technology can enrich the learning experience by providing tools and platforms that allow students to collaborate, discuss and solve problems creatively. Problem-based learning (PBL) electronic teaching materials are expected to create a more dynamic learning environment that is responsive to students' needs.

Based on the description above, this research was conducted to address the lack of studies that systematically integrate problem-based learning (PBL) electronic teaching materials in improving critical thinking skills in students. Although various studies have examined problem-based learning (PBL) and critical thinking skills separately, few have explicitly explored the needs and challenges in developing electronic teaching materials that fit this learning model. This study aims to provide deeper insights into the design of problem-based learning (PBL) electronic teaching materials that are effective and relevant in improving critical thinking skills in students. The results of this study are expected to make a significant contribution to the development of curricula and educational practices that are more adaptive to the demands of technological developments and 21st century skills need. Therefore, by analyzing the needs of electronic teaching materials integrated with the problem-based learning (PBL) model, this research is expected to be able to offer practical recommendations for the development of teaching materials that are more effective in contextualizing modern learning.

METHODS

This study was conducted based on the concept of a literature review, utilizing the systematic literature review (SLR) method that applies PRISMA (Preferred Reporting Items For Systematic Literature Reviews) guidelines (Dewi & Dasari, 2023). This method is implemented by analyzing and identifying relevant journals or articles that align with the research question's topic are analyzed. The review process is conducted systematically and structured at each stage, following predetermined procedures (Triandini et al., 2019). This method is useful for understanding the development of previous research, identifying research gaps, and strengthening the theoretical foundation and methodology used in the study.

The articles used were selected based on inclusion criteria, such as topic relevance, year of publication, language, and accessibility, as well as exclusion criteria, such as duplication or lack of appropriate data. The selected articles for this study must meet the criteria of having a relevant research type, variables, and results. The research steps included formulation of research objectives and protocols, literature search using keywords on selected databases, selection of articles based on criteria, extraction of essential data, assessment of study quality, analysis of results, and reporting of findings. The review process was conducted by reading the articles in depth, evaluating the methodology and results, and identifying patterns, contributions, and research gaps to develop a systematic and targeted conclusion. Articles used This study applies four stages, namely search strategy (identification), selection criteria (screening), quality assessment (eligibility), and data extraction (included) (Alannawa & Hidayati, 2021).



Figure 1. Stages of Systematic Literature Review

The first stage is to choose a theme or title to be studied, then formulate the problem in the form of a question or what is called a research question. The research question (RQ) in this research is how the development of electronic teaching materials integrated with problem-based learning can promote student's critical thinking skills. The next stage is to make inclusion and exclusion criteria. The inclusion criteria (special criteria) used in this study are: Journals or articles published in 2020 - 2024, journals or articles relevant to the theme of the need for material teaching integrated electronic based on problem-based learning (PBL) models or critical thinking skills, Research samples in journals or articles are junior high school and high school students, and journal or article indexed by google scholar, Sinta, or repository. Exclusion criteria in this study were journals or articles published before 2020. Inclusion criteria were selected based on relevance and year of publication (2020-2024) to ensure the data were up-to-date and relevant. Exclusion criteria were used to eliminate articles that were outdated and less relevant to the latest developments in science education

The next step is to create a database and keywords. The database used in the process of searching for journals or reference articles is google scholar and semantic scholar through the help of publish or perish. The keywords used are "Electronic Teaching Materials", "Problem-Based Learning Model" and "Critical thinking skills". After following these stages, the results of this research will be described in the PRISMA diagram for further data analysis by combining data that has met the inclusion criteria and descriptive research quality assessment to provide an overview according to the problems in the research question (Research Question). After entering the keywords "Problem Based Learning," "Electronic Teaching Materials," and "Critical Thinking," several articles will appear featuring various types of electronic teaching materials, such as e-modules, e-books, and e-learning software, across different branches of science subjects and the critical thinking variable. The process of reviewing each journal involves identifying 20 selected journals by examining the author's identity, the branch of science, the type of teaching material, the combinations used in the teaching material, and the subject matter. Additionally, an analysis is conducted on these 20 selected articles to assess the validity and practicality of developing electronic teaching materials integrated with the Problem-Based Learning model to enhance critical thinking skills.

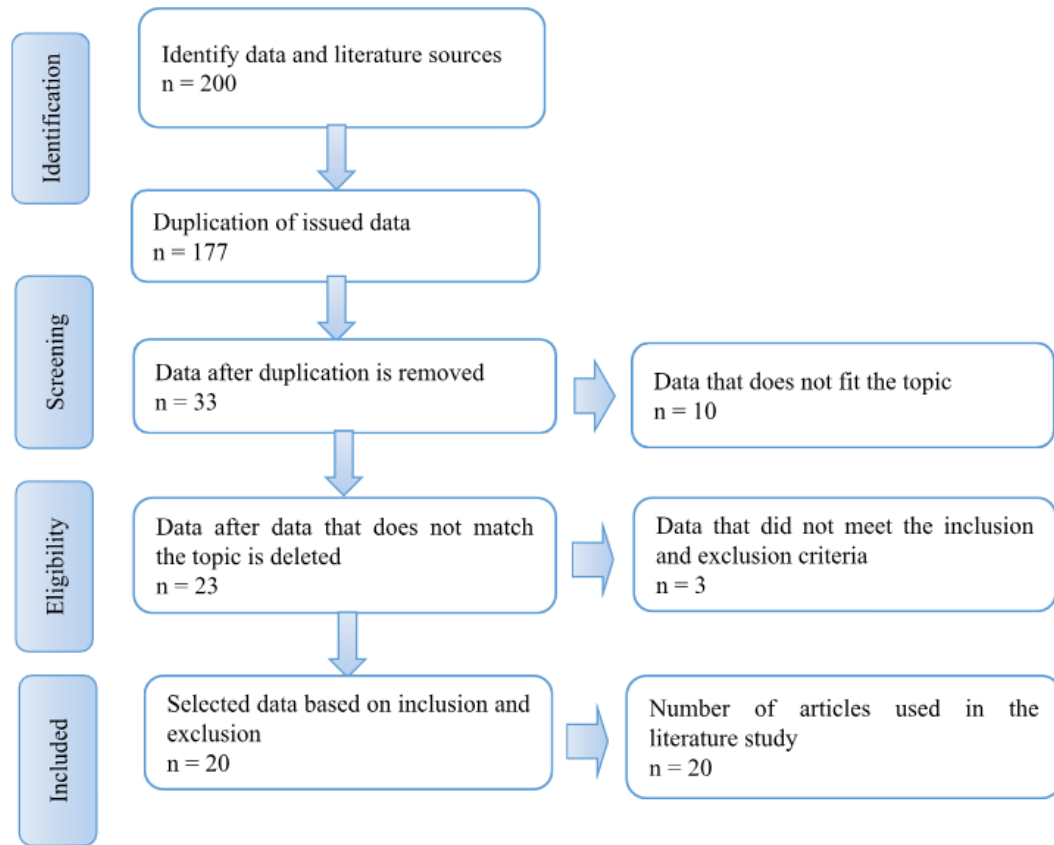


Figure 2. Flowchart of Article Selection

Based on figure 2, the article selection process in this study followed the PRISMA flow which consists of 4 stages, namely identification, screening, eligibility, and inclusion. At the identification steps, 200 articles were obtained from various sources, but 177 of them were duplicates, leaving 33 articles for the screening stage. Of the 33 articles, 10 articles were eliminated because they did not match the research topic. Furthermore, at the eligibility step, 3 articles did not meet the predetermined inclusion and exclusion criteria. In the last step, 20 articles were declared eligible and used in the analysis of this literature study.

RESULTS AND DISCUSSION

Results

The results concerning the research findings included in this systematic literature review include an analysis and summary of various scientific articles relevant to the development of electronic materials teaching integrated with the problem-based learning (PBL) model on critical thinking skills. This research uses a systematic approach to identify and review articles related to the theme. Based on the research method applied, 20 articles were selected as the main source for further analysis. These articles were selected by considering the quality of the journal, the relevance of the topic, and its contribution to the development of electronic materials teaching based on the problem-based learning (PBL) model towards critical thinking skills for students. The insights gained from analyzing these articles include analysis according to the year of publication, analysis based on the type of teaching materials, analysis according to subjects and analysis according to subject matter. The following presents a complete analysis of the general grouping of articles from sources used as references for this study:

Table 1. General Article Analysis Grouping

No.	Identity	Field	Types of Electronic Teaching Materials	Model	Teaching Material Combination	Material
1	Hati & Setaji, (2024)	Physics	E-Modules	PBL	Google Sites	Harmonic Motion
2	Ajri & Diyana, (2023)	Physics	E-Modules	PBL	Live worksheet	Dynamic Fluid
3	Tsurayya Zhafirah et al., (2021)	Chemistry	E-Modules	PBL	-	Hydrocarbons
4	Gita et al., (2022)	Physics	E-Modules	PBL	-	Rotational Balance and Dynamics
5	Wiranti et al., (2023)	Chemistry	E-Modules	PBL	ISPRING	Redox Reactions
6	Ridlo et al., (2024)	Physics	E-Modules	PBL	Google Collaboration	Motion and force
7	Sartika (2024)	Biology	E-Modules	PBL	-	Human Digestive System
8	Nurjanah & Trimulyono, (2022)	Biology	E-SW	PBL	-	Human Heredity
9	Nisak et al (2023)	Biology	E-SW	PBL	-	Environmental Change
10	Dwi Rahmawati & Mahanani Tri Asri (2023)	Biology	E-SW	PBL	-	Virus
11	Zuhrotun Nisa & Fitrihidajati, (2024)	Biology	E-SW	PBL	-	Environmental Pollution
12	Duri et al., (2024)	Physics	E-SW	PBL	-	Sound Wave
13	Jati & Winarno, (2024)	Physics	E-SW	PBL	Liveworksheet	Thermodynamics
14	Novitasari, (2023)	Chemistry	E-SW	PBL	-	Chemical Equilibrium
15	Milatti & Fitrihidajati, (2024)	Biology	E-SW	PBL	-	Environmental Change
16	Nahriyah & Rachmadiarti, (2023)	Biology	E-Book	PBL	-	Environmental Change
17	Suyanti & Silaban (2024)	Chemistry	E-Book	PBL	CTL	Acids and Bases
18	Andini (2022)	Biology	E-book	PBL	-	Human Digestive System
19	Agustina & Fitrihidajati, (2020)	Biology	E-Book	PBL	-	Environmental Pollution
	Umami &	Physics	E-Book	PBL	-	Temperature and Heat

According to the outcomes of the analysis of grouping articles in general, there are 20 articles with each category of field, type of electronic teaching materials, subject matter, and a combination using problem-based learning (PBL) approaches to promote students' critical thinking abilities. Studies from different sources were utilized, it can be interpreted that the development of electronic materials teaching integrated with the problem-based learning (PBL) model is needed to promote critical thinking skills in students. Various studies have shown that E-modules, E-SW (Electronic Student Worksheet), and E-books integrated on problem-based learning (PBL) model can help students understand the material better, increase active involvement, and hone critical thinking and problem solving skills. Therefore, the development of electronic materials teaching integrated on problem-based learning (PBL) model is a research that is widely carried out and is an effective solution to promote the standard of education, particularly in improving critical thinking skills in students. The articles analyzed were between 2020-2024, from the 20 articles obtained there was only 1 article on the development of electronic teaching materials integrated with the problem-based learning (PBL) model published in 2020 and 2021.

In Figure 3, the data represent the number of articles on the development of electronic teaching materials integrated with the problem-based learning (PBL) model from 2020 to 2024. The result of development electronic materials teaching has increased significantly in each year. This indicates that many studies have been conducted on the development of electronic teaching materials integrated with the problem-based learning (PBL) model.

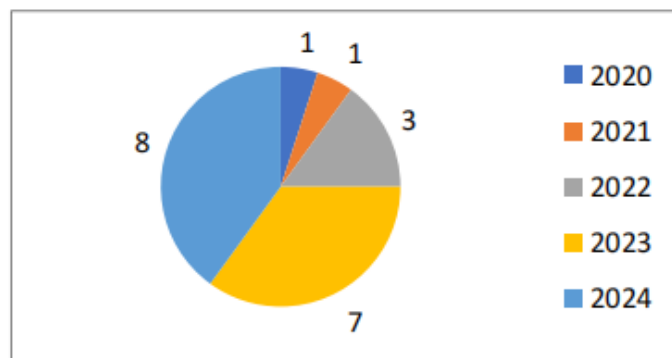


Figure 3. Number of Articles Based on Year of Publication

The increase in research on the development of electronic materials teaching integrated with the PBL model to promote critical thinking skills shows the importance of these skills to be improved at this time. A Critical thinking skills are one of the skills required for students in the current era. Critical thinking skills are also very important for students to have in learning learning materials in the field of science. This is because natural science is closely related to research and investigation activities so that students will be trained to think critically in learning.

The following result in this study is the analyze of electronic materials teaching integrated with the problem-based learning (PBL) model to promote critical thinking skills for students. Based on the analysis, there are various types of electronic materials teaching developed to measure the validity and practicality of these materials teaching so that they can be used during class learning. The variety of materials teaching developed is adjusted based on each needs analysis at the electronic teaching material development step.

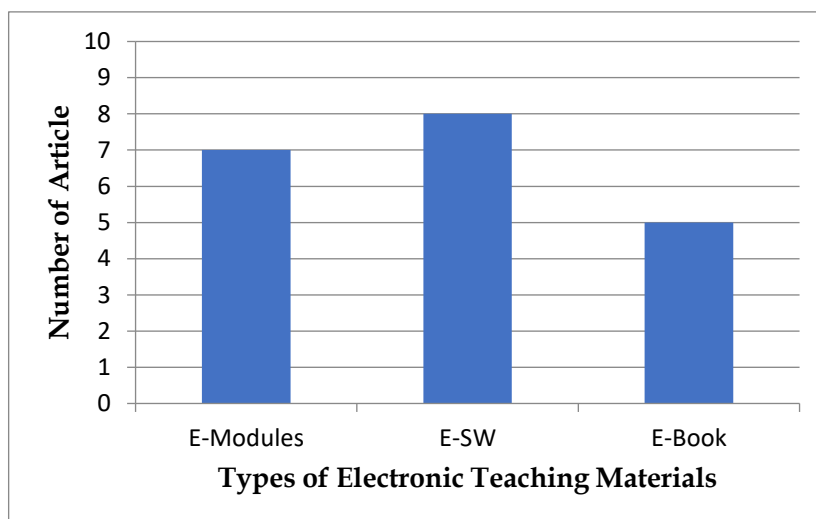


Figure 4. Number of Articles by Type of Electronic Teaching Materials

Based on Figure 4, developed electronic teaching materials have various interesting features that can be utilized by students, including videos, animations, virtual laboratories, and others. The provision of these features is an advantage of electronic teaching materials and is a feature that is of interest to students to promote motivation while study according to the needs analysis of electronic teaching materials obtained through a needs analysis questionnaire. In addition, the integration of the problem-based learning (PBL) model in electronic materials teaching allows students to learn independently so that students can build their own knowledge. This can certainly improve creative and critical thinking skills in students.

Furthermore, the outcomes obtained are an analysis of the development of electronic materials teaching integrated the problem-based learning (PBL) model to promote critical thinking skills based on subjects. Physics, biology, and chemistry subjects are natural science families that allow the use of electronic materials teaching integrated problem-based learning (PBL) model in the classroom. Critical thinking skills are closely related to practicum and research activities in the subject areas of physics, biology, and chemistry. Therefore, there are many studies on the development of electronic materials teaching in these subjects.

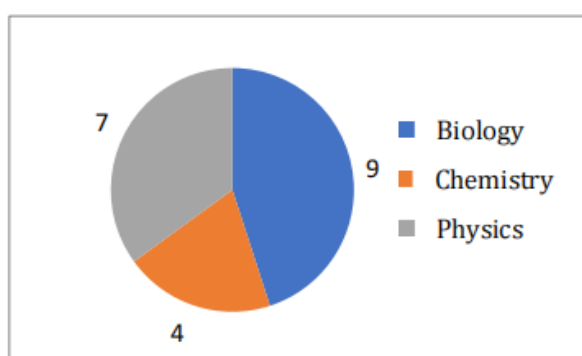


Figure 5. Number of Articles Based on Subject Area Analysis

According to Figure 5, the outcomes when analyze article about development of electronic materials teaching integrated with the problem-based learning (PBL) model to promote critical thinking skills in students show a significant amount. This explains that it is important to develop electronic materials teaching in the subject areas of physics, biology, and chemistry. According to the needs analysis, that need for electronic materials teaching in these subject areas is because students and teacher need materials teaching that can helps the

increase critical thinking skills. In addition, students also feel that if the electronic teaching materials used are interesting, it will promote students' curiosity and enthusiasm for learning. Therefore, the application of learning using electronic materials teaching integrated with the problem-based learning (PBL) model can certainly promote students' cognitive learning outcomes as well as students's critical thinking ability.

The next analysis is the development of electronic materials teaching integrated with the problem-based learning (PBL) model to promote critical thinking skills based on subject matter. The analysis results show that several articles have the same subject matter based on the needs analysis of critical thinking ability in students, learning outcomes, and according to the criteria of the subject matter. The results of the development of electronic materials teaching integrated using learning models based on subject matter shown in table 2.

Table 2. Research Results of Electronic Teaching Material Development Integrated Problem-Based Learning (PBL) Model

Course Content	Article Code	Research Results			
		Validity Value	Ket	Practicality Score	Ket
Environmental Change	9	3.77		95%	
	15	98.96%	Very Valid	95.71%	Very Practical
	16	93.75%		94%	
Environmental Pollution	11	4.00	Very Valid	96.67%	Very Practical
	19	3.99		99.65%	
Harmonic Motion	1	3.90	Very Valid	4.34	Very Practical
Dynamic Fluid	2	81.5 %	Very Valid	-	-
Rotational Balance and Dynamics	4	3.57	Very Valid	3.50	Very Practical
Redox Reactions	5	98.09%	Very Valid	4.56	Very Practical
Motion and force	6	88%	Very Valid	90%	Very Practical
Human Digestive System	7	86%	Very Valid	81.06%	Very Practical
Human Heredity	8	97.8%	Very Valid	93.09%	Very Practical
Virus	10	89.25%	Very Valid	99%	Very Practical
Sound Wave	12	84.1%	Very Valid	93.95%	Very Practical
Thermodynamics	13	0.90	Very Valid	96.5%	Very Practical
Chemical Equilibrium	14		Valid	88%	Very Practical
Acids and Bases	17	4.59	Very Valid	4.45	Very Practical
Human Digestive System	18	89.85%	Very Valid	88.86%	Very Practical
Temperature and Heat	20	87%	Very Valid	85%	Very Practical

According to table 2, the outcome when analyze article about the development of electronic materials teaching integrated problem-based learning (PBL) learning model to promote students' critical thinking skills as a whole based on the validity and practicality values is in the very valid and very practical category. This is because at each step of development an assessment is carried out by experts or validators, revisions or improvements are made to obtain a high score. In addition, the practicality scores by teachers and students also obtained high scores. The factor that influences this is that before the practicality test activities are carried out, the electronic materials teaching integrated problem-based learning (PBL) model are carried out a validity test first so that it allows the quality of the electronic teaching materials developed to be used in learning. Therefore, based on the research results found regarding the development of electronic materials teaching integrated problem-based learning (PBL) model, it is expected can be promote critical thinking skills in students.

Discussion

The development of electronic materials teaching integrated with problem-based learning (PBL) model shows that the types of teaching materials need to be designed by considering elements of interactivity and relevance to the learning context. problem-based learning (PBL) model has the power to motivate students to participate actively in the learning process. In problem-based learning (PBL), students are faced with real problems relevant to everyday life, which requires them to not only understand the subject matter but also apply it in a broader and practical context (Rusman, 2012). This approach is very effective in promote students' critical and creative thinking ability, because they are required to analyze problems in depth, find innovative solutions, and work together with a group of friends to achieve better understanding. In addition, problem-based learning (PBL) also facilitates collaboration and communication among students, which is crucial in improving social skills and teamwork. The group discussion process that occurs in problem-based learning (PBL) provides opportunities for students to exchange ideas, criticize each other's thinking, and enrich their views on the problem at hand (Lutfiah sya'bani choirunisa et al., 2023).

The advantage of electronic materials teaching lies in their ability to provide easy and flexible access to information, allowing students to learn independently and at their own pace (Padwa & Erdi, 2021). With electronic teaching materials, students are not limited by time and space, allowing them to access materials anytime and anywhere as needed. This is very supportive of a more individualistic learning style, where students can adjust the tempo of learning to their level of understanding, as well as provide opportunities to repeat material that has not been mastered.

According to results described, various studies show that e-modules, E-SW, and E-books integrated problem-based learning (PBL) model can help students understand the material better, increase active involvement, and hone students' critical thinking skills. The three electronic teaching materials are the most widely used in problem-based learning (PBL) learning. According to (Titin Priyantini et al., 2015) , E-modules have several advantages, namely in the presentation can be equipped with video, audio, and animation. In addition, E-modules can make the learning process more interesting, interactive, can be used anywhere, and can improve the quality of learning (Prasetya et al., 2017) . (Daryanto, 2013) state, that e-modules have the characteristics of self contained, self instruction, user friendly, and adaptive. E-modules can stimulate students to actively engage in the learning process so

that electronic materials teaching integrated problem-based learning (PBL) models in the form of e-modules are most widely used by students. In addition, most students find it difficult to understand the material from existing books, so the development of e-modules is needed (Malina et al., 2021).

The development of E-SW can also promote student involvement and help them participate actively in learning (Ardhini & Hamimi, 2023). Students obtained empirical data through observation and investigation (Sukaesih et al., 2022). Accordingly, as shown in the research by (Sukmawati & Ghofur, 2023), stated that the use of E-SW received a positive response by students when learning was carried out. So it is concluded that the development of E-SW is effective in promotes students' critical thinking ability. E-SW can be systematically designed to help students engage in learning activities more easily, independently and practice critical thinking skills (Azizah & Kuswanti, 2022). The advantages of E-SW are that it can present text, animation, images, and videos that are interesting and interactive. So that this media will have an impact on student activities to be more active and fun. One of them can also increase student confidence in solving critical thinking problems (Maulana & Sopandi, 2022).

Meanwhile, e-books are also used to develop students' critical thinking skills. A graduate in education should possess 21st-century skills (Asrizal & Festiyed, 2020). Electronic teaching materials can include sound elements and dynamic images such as videos (Smagulova et al., 2021). According to (Liana et al., 2021), e-books supported by the problem-based learning (PBL) are characterized by problems and generate curiosity. Problem-based learning (PBL) will transform traditional learning into a new learning approach designed in the form of soft files so that it can be operated using electronic devices owned by students and can support students in learning independently by using questions that are designed in an interesting and meaningful way.

According to (Mayasari et al., 2022), along with technological developments, different learning strategies implemented to develop better human resources, including the use of ICT in education. The development of information technology 4.0 requires the provision of not only paper-based materials teaching, but also interactive materials teaching that include text, figures, video, and audio with electronics (Krisnajaya et al., 2024). PBL-based electronic teaching materials by utilizing digital tools can make students actively involved in analyzing and solving problems, besides that PBL-based electronic materials teaching are also expected to make students more independent and able to understand the material well (Anggraeni, 2022).

The results also show that the materials teaching developed had good validity and practicality values. Assessments from experts and students show that teaching materials are not only theoretical but also ready to be applied in practical classrooms. The validity value of materials teaching is an indicator that materials teaching are suitable for use or not. The validity value of materials teaching also determines the quality of the teaching materials themselves. In addition to validity, practicality is also a measure of the feasibility or quality of a teaching material developed (Yulinda et al., 2022).

Overall, the development of electronic materials teaching integrated with problem-based learning (PBL) contributed significantly to the increase of students' critical thinking ability. This approach not only facilitates more interactive and engaging learning, but also enables students to develop skills needed in real life. By utilizing technology and innovative learning methods, education can be more responsive to 21st century skills needs. The majority of students like attractive features such as images, animations, and videos to fulfill their learning needs (Feziyasti et al., 2024). Therefore, the development of electronic materials teaching integrated with the problem-based learning (PBL) model is really needed

to promote students' critical thinking skills and can be a guide for educators in developing and applying materials teaching to students.

CONCLUSION

Based on the analysis conducted through systematic literature review, this study shows that the development of electronic teaching materials integrated with problem-based learning (PBL) has significant potential in improving critical thinking skills. From the 20 articles analyzed, it was found that the application of PBL in an interactive and structured learning context is capable of motivating students to actively participate in the learning process, as well as improve their understanding of the subject matter. These results underscore the importance of integrating educational technology in the modern learning process. The implication of these findings is the need for the development of more innovative curricula and teaching materials, which not only focus on the delivery of information, but also on the formation of students' critical thinking ability. Thus, the development of electronic materials teaching integrated with problem-based learning (PBL) approach will contribute significantly to improving the quality of education in today's digital era.

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