



Study of Science Learning Based on Scientific Literacy in Improving Critical Thinking: A Scoping Review

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Received: June 13, 2023

Revised: July 30, 2023

Accepted: August 25, 2023

Published: August 31, 2023

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DOI: [10.29303/jppipa.v9i8.5667](https://doi.org/10.29303/jppipa.v9i8.5667)

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Abstract: Facing and following increasingly sophisticated technological developments in science learning studies, both pupils and students must increase scientific literacy to improve critical thinking. Critical thinking skills will encourage students to understand problems and create alternative problem solutions with problem solving stages, namely clarification, assessment, inference and strategy. This research aims to explore the Study of Science Learning Based on Scientific Literacy in Improving Critical Thinking. The research was conducted using a scoping review approach. A scoping review is typically used to map the existing literature on a defined topic in terms of the volume, nature, and characteristics of key studies. The results of the scoping review analysis found several problems such as the low level of science learning regarding scientific literature so that pupils and students are unable to identify problematic issues and scientific evidence due to a lack of practicing skills in conducting scientific literature. The impact that occurs is that the ability to think critically decreases. Therefore, various efforts are being made, one of which is that pupils and students must have concepts to connect science, science learning websites, focus on specific knowledge, be able to design relevant indicators, have the ability to translate into critical, systematic and anticipatory actions, students' critical thinking skills, school location, and problem-based learning model.

Keywords: Critical Thinking; Natural Sciences; Scientific Literacy.

Pendahuluan

Education is an important element in the development of knowledge and human resources (HR) so that they are reliable, high quality and competitive. In this era of Industry 4.0 and Industrial Evolution 4.0, it is very important to prepare competitive human resources in the global industry (Syamsuar & Reflianto, 2019). As is the ease of accessing information in the digital era, this must be accompanied by competencies, such as skills, attitudes, values and good knowledge (Napal Fraile, et al., 2020). These competencies are expected to be able to anticipate some of the negative impacts of the increasing spread of fake news circulating through social networking sites, such as Facebook, Twitter, YouTube and WhatsApp. Fake news that is deliberately created and manipulated to make it look like a credible

journalistic report to deceive readers. So this news will make the public, especially students, confused and lost in digesting it.

In the study of natural science (science) learning, to face and keep up with increasingly sophisticated technological developments, scientific literacy must be used (Okada, 2013). Science has become one of the subjects found in the world of education in Indonesia. Science refers to a family of sciences whose objects are natural objects with definite and general laws, valid whenever and wherever. Natural science is related to the way of finding out about nature systematically, so that it is not only mastery of a collection of knowledge in the form of facts, concepts or principles but also a process of discovery (Nasional, 2006). Apart from that, natural science is also an empirical science and discusses natural facts and phenomena. . These natural facts and

How to Cite:

Bramastia, B., & Rahayu, S. . (2023). Study of Science Learning Based on Scientific Literacy in Improving Critical Thinking: A Scoping Review. *Jurnal Penelitian Pendidikan IPA*, 9(8), 499-510. <https://doi.org/10.29303/jppipa.v9i8.5667>

phenomena make learning not only verbal but also factual. This shows that the nature of science is a process that is needed to create science learning that is empirical and factual.

Based on scientific literacy in the study of science learning, it has many definitions because it is a broad subject with a very long history. The Organization for Economic Co-operation and Development (OECD) in 2013 defined scientific literacy as a person's ability to engage with scientific issues and ideas as a reflective citizen (PISA, 2015). Scientific literacy is also defined as understanding scientific concepts meaningfully, explaining scientific phenomena, describing them based on scientific evidence, and applying them in everyday life (Fives, et al., 2014). Scientific literacy emphasizes scientific concepts, the nature of science, and the interaction between science and society (Archer-Bradshaw, 2014). Scientific concepts are needed because they function to understand science and are the main capital in solving problems. The essence of science as scientific epistemology, which is conceptualized as values and beliefs towards science, which allows students to understand that evidence can build knowledge scientifically. Interaction between science & society can be achieved best if students are taught from a social perspective, learn science based on what they see, and apply it in social life. These three components enable a person to face scientific situations, and participate actively in a society where science and technology are very important (Kahler, et al., 2020).

The basis of scientific literacy will actually train a person's skills for critical thinking. Because skills in critical thinking are the basis of other skills, including communication, collaboration, global awareness, technology, life and career skills, as well as the ability to learn and innovate (Friedel, et al., 2008). Critical thinking skills can be improved through education, including the application of learning models (Marjan, et al., 2014). Critical thinking contributes to the development of a person's skills in exploring, producing, using and testing information independently and increases their enjoyment in exploring (Mahardini, et al., 2018). Critical thinking is very important to improve a person's ability to think and reason, and is important for a person to meet personal demands (Ramdani, et al., 2021). So critical thinking becomes one of the initial parts of scientific thinking and is very important for cognitive skills in science education in understanding knowledge and making connections by analyzing knowledge and producing new knowledge from knowledge existing (Che, 2002; Ali, 2010).

The importance of improving critical thinking in natural sciences, one of which must be based on scientific literacy. Therefore, researchers want to explore the

Study of Science Learning Based on Scientific Literacy in Improving Critical Thinking.

Method

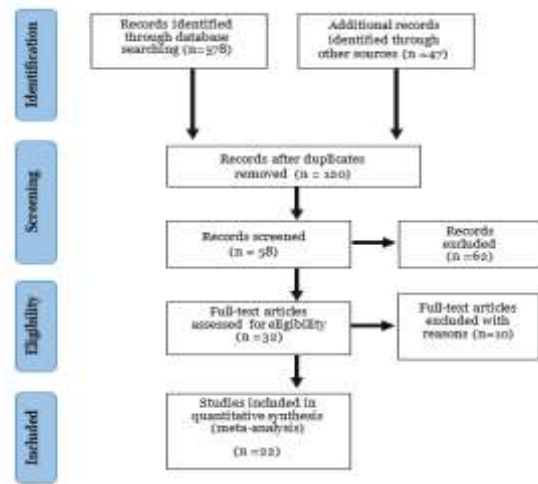


Figure 1. Journal selection flowchart

The research was conducted using a scoping review approach. A scoping review is usually used to map the existing literature on a specified topic in terms of volume, nature, and characteristics of the main studies (Arksey & O'Malley, 2005). This can be especially useful when the topic is complex or has not been comprehensively reviewed (Pham, et al., 2014). Therefore, the research carried out is in line with the objectives of this research. The main stages of our research methodology include: (1) identifying research questions, (2) identifying relevant research, (3) selecting research, (4) mapping data, and (5) compiling, summarizing, and reporting the results (Mays, 2004).

Literature search

The search for journal articles was set in the time period 2012 to 2022. We first conducted a search in the following databases and search engines: Education Resources Information Center (ERIC), Scopus, Crossref, and Google Scholar, with a combination of key terms: study Natural Science learning, based on scientific literacy, and critical thinking. "scientific literacy" is used to enhance "critical thinking" in science learning, but so far there has been little research on the issue of critical thinking using scientific literacy in science learning. Our initial investigation showed that "scientific literacy" is frequently mentioned in several research journals to refer to skills or competencies related to improving critical thinking. We also applied a backward snowballing technique to articles found by reviewing reference lists to identify potentially relevant studies.

Literature selection

These documents were selected by the researchers involved based on a series of selection criteria as follows:

Inclusion criteria:

Research published in peer-reviewed journals and book chapters from 1991 to 2021. Research related to the study of scientific literacy-based science learning, in improving critical thinking both in English and Indonesian, the results of which will be generalized to English

Exclusion criteria:

Master's and doctoral theses Studies that focus on learning outside of science. The decision to focus on studying science literacy-based science learning in improving critical thinking ensured that the included literature had undergone rigorous peer review, only articles published in peer-reviewed journals, while book chapters were included, master's and doctoral theses were not included. Taking these selection criteria into account, the researchers read the title, abstract, and keywords of each article to select relevant studies. We skimmed some articles when necessary to ensure there were no relevant studies. We also discuss if there are any discrepancies in the relevant journal selection results.

Therefore, the selection results are based on mutual agreement of the researchers. A total of 22 research journals (see figure 1 for a PRISMA chart illustrating the literature search and selection process for this review).

Data analysis

To get an overview of the selected articles, general information about the articles, such as type of article, author's name, year of publication, research design, and findings, was recorded and summarized using Excel (Fereday & Muir-Cochrane, 2006).

Result and Discussion

To provide an overview of the research, we present an overview of the general information of the selected articles. As shown in Table 1, there are 22 empirical studies, including theoretical articles and reviews. Among empirical studies, material analysis is the research method used: mixed methods design, quantitative research, pre-experimental, qualitative research, and research and development (R&D). The research period found was 2017 to 2022. Most related research was found in Indonesia.

Table 1. Geography of research, year, and research methods

Year	Amount	Research Design	Amount	Geography	Amount
2017	3	quantitative research	3	Indonesia	21
2018	1	mixed methods design	6	Turki	1
2019	3	pre-experiment	4		
2020	9	a qualitative design	4		
2021	3	Research and Development (R&D)	5		
2022	3				

A summary of the findings from 22 journal articles can be seen in Table 2 which contains the title, researcher's name, year of publication of the journal, and findings from the research that has been conducted. Comparatively, the research found discusses how to improve critical thinking in terms of attitude, behavior and motivation by using scientific literacy in science learning. This research also discusses the objectives and findings of research conducted by researchers.

In our conceptual framework, we explain several objectives of assessment, as this helps answer one key question: why should improving critical thinking be based on scientific literacy in the study of science learning? These answers will be explained further below, more in line with assessment for/for/as learning. However, we must admit that the studies reviewed do use different terms in their discussion.

In the industrial era 4.0, any information, especially related to science, can be accessed via social media. Because social media is a very attractive medium for

everyone because of its short and attractive packaging with free features, so people easily create news without any scientific basis and many people easily believe things they have read and seen without looking at the scientific basis. In reality, mass media or social media has great power that can influence its audience. In fact, on the other hand, the information conveyed by the mass media often contradicts or is biased with the existing understanding of the audience (Carrascosa, et al., 2015). In fact, when the facts are selected by the information maker, the information can quickly influence the audience's perception in making decisions to act. The effects of mass media in reality can occur in a short time, quickly, instantly and strongly influence a person or society (McQuail, 2012). This is very dangerous, especially in science learning studies which must be based on research and natural truth.

Therefore, this research will highlight three important findings, namely that science learning studies

must be based on scientific literature and scientific literature is one way to improve critical thinking.

Table 2. Findings Related to the Study of Science Learning Based on Scientific Literacy in Improving Critical Thinking

Title	Author's Name	Year	Findings
Enhancement of Students' Biological Literacy and Critical Thinking of Biology Through Socio-Biological Case-Based Learning	H. Suwono, H. E. Pratiwi, H. Susanto, H. Susilo1	2017	The results of the data analysis showed that SocBioCBL improved students' critical thinking skills and biological literacy.
The Effectiveness of Natural Science Learning Based on Contextual Teaching and Learning in Improving The Critical Thinking Skills of Elementary School Students	N. Hariyati, Tarma	2017	The average score is 146.64. The ability of student information literacy is at level 66,67% from ideal. On a scale of 1-5, the literacy capability of new information reached 3.33. It shows that the ability of information literacy is still low.
The Development of Scientific Literacy through Nature of Science (NoS) within Inquiry Based Learning Approach	A. Widowati, E. Widodo, P. Anjarsari, Setuju	2017	The low science literacy of Indonesian students is believed to be due to a lack of learning involving the process of science, for example in terms of formulating scientific questions, using the knowledge it possesses to explain natural phenomena, and drawing conclusions based on facts obtained through inquiry. It shows that learning with inquiry is important to do so that science literacy develops.
Improved Critical Thinking Skills on Science Learning By Appling the Predict, Observe, Explain (Poe) Model	Larasati, Jenny Indrastoeti Siti Poerwanti, Anesa Surya	2018	that students' critical thinking skills on science learning can be improved by implementation of POE model. It can be seen from students' classical mastery from pre-action to cycle III meeting II, and the result is 85%. The conclusion of this research revealed that through Predict, Observe, Explain (POE) model can improve the critical thinking skills in science throuhgt in the fifth grade students of State Primary School of Makahaji 03 in the academic year 2017/2018.
Developing Scientific Literacy-Based Teaching Materials to Improve Students' Computational Thinking Skills	F. Fakhriyah, S. Masfuah, D. Mardapi	2019	At count of 2,215 and ttableof 1.99. Thus, it could be concluded that the teaching materials of the developed scientific literacy concepts were effective in improving the students' computational thinking skills.
Prospective Teachers' Scientific Literacy through Ethnoscience Learning Integrated with the Indigenous Knowledge of the People in the Frontier, Outermost, and Least Developed Regions	Parmin Parmin1*, Fidia Fibriana2	2019	According to the results of this research, scientific literacy indicators data indicated that the use of indigenous knowledge is a crucial key as the strategy of concept mastery, analytical thinking, problem-solving, and communication skills improvement.
Science Literacy-based Scientific Method: A Study to Improve Science Process Skill of the Middle School Students	Nurlina, Riskawati, Khaeruddin, Nurfadilah	2019	the average score of science process skills obtained by students before the application of scientific literacy-based scientific methods is lower than the scores obtained by students after treatment
Science literacy, critical thinking skill, and motivation: A correlational study	Rosita Primasari, Mieke Miarsyah, R. Rusdi	2020	(1) there was a positive correlation between the critical thinking skill and scientific literacy (11.83%), (2) there was no significant correlation between motivation and scientific literacy, and (3) both predictors (i.e. critical thinking skill and motivation) were able to predict the criterion (scientific literacy) (22.56%). It is suggested to optimize students' critical thinking skill and motivation to sharpen students' scientific literacy
Implementation of an Inquiry Learning Model with Science Literacy to Improve Student Critical Thinking Skills	Ani Sutiani, Manihar Situmorang, Albinus Silalahi	2020	that a standard inquiry learning model with science literacy has been developed for Chemical kinetics topic, where the feasibility is categorized to be very good (M = 3.60±0.06). Implementation of the developed learning

Title	Author's Name	Year	Findings
Improving students' critical thinking skills through natural science learning website	V A S Utami, Djukri2	2020	model in the teaching and learning activities has proven to be able to improve students' critical thinking skills. Students' thinking abilities are classified as very good, where the achievements are obtained in the range of 72-97%.
Science process skills and critical thinking in science: Urban and rural disparity	Tanti, D. A. Kurniawan, Kuswanto, W. Utami, I. Wardhana	2020	The independent sample t-test shows that students' science process skills in learning science in urban tend to be higher than in rural schools ($p < 0.01$). Students' critical thinking in learning science for urban areas is high but for rural areas is a fair category, with significance $p < 0.001$. The regression showed the level of contribution of students' science process skill influence as much as 51.5% for critical thinking. The other research result was found that students' science process skill affects critical thinking in learning science. Moreover, a comparison between students' science process skills and critical thinking based on their school location showed that urban is higher than rural.
The Effects of Problem-Based Learning on Critical Thinking Skills and Student Science Literacy Analysis on Students' Scientific Literacy of Newton's Law and Motion System in Living Things	Suhriman, Husnul Khotimah Indah Slamet Budiarti, Tanta	2020	the Problem-based Learning model significantly effect on students' critical thinking and science literacy
Students' Critical Thinking: A Study on Science Teaching Material Based on the Scientific Approach	Lisa Ariyanti Pohan, Julia Maulina, Tuti Hardianti	2020	The results of this study indicate that problems are found in the ability of scientific literacy, especially in the aspect of identifying scientific issues in the aspect of knowledge, especially the concept of the human movement system, which gets the lowest result, namely 18.18%
Scientific Approach to Improve the Critical Thinking Skills	Karlina Wong Lieung, Dewi Puji Rahayu, Fredy	2020	the teaching materials developed were feasible to use with a score of 4.28 in the very good category. Student responses to teaching materials based on a scientific approach were in the high response category. Based on testing with the has an effect on independent sample t-test, the P-value obtained was $0.0437 < 0.05$. Therefore, it can be concluded that the use of scientific approach-based teaching materials improving students' critical thinking skills
Learning Bryophyta: Improving students' scientific literacy through problem-based learning	Vitri Anugrah Nainggolan, Risya Pramana Situmorang, Susanti Pudji Hastuti	2021	The procedure was colaborative classroom-based research. The result of research is shows critical thinking students on the first cycle 43,6% with the average score 39,24. Second cycle shows at least 60,97% with average score 54,88. And the third cycle achieve 81,48% with average score at 73,33. The conclusion is, critical thinking skills students had increased after carried out class action research
An Exploration of Scientific Literacy on Physics Subjects within	Prima Warta Santhalia and Lia Yuliati	2021	The results of the students' scientific literacy abilities show that the indicators of identifying scientific problems and explaining scientific phenomena have almost the same average value. It showed a gap in the N- Gain score on the indicators using scientific evidence.
			the students' scientific literacy increases after applying phenomenon-based experiential learning in the learning process. The Wilcoxon Signed-Rank Test also

Title	Author's Name	Year	Findings
Phenomenon-based Experiential Learning			supports this with Asymp.Sig. (2-tailed) 0.000, which shows that phenomenon-based experiential learning affects increasing the students' scientific literacy. In addition, an increase in students' scientific literacy can also be seen from the N-gain and effect size obtained, namely 0.53 in the medium category and 0.86 in the strong category, respectively.
Integration of Critical Thinking Skills in Science Learning Using Blended Learning System	Ferrinda Prafitasari, Sukarno, Muzzazinah	2021	Integrating critical thinking skills with blended learning system in elementary school in science learning is still necessary. This is an open access article under the CC BY-SA license. considered because there are still obstacles in its implementation. The results of this study have implications for finding solutions to improve critical thinking skills in science learning. science learning with blended learning system to be more effective. The recommendation in this study is that teachers are more creative in implementing blended learning system learning strategies so that the success of critical thinking skills in students' science learning can be achieved well.
Development of Scientific Literacy-Based English Teaching Materials for Biology Students	1Syahreni Siregar, 2Eka Yuniasih	2022	English materials must be based on scientific literacy. This is intended to train their English skills in accordance with their majors so that they are able to understand the biology term in English. English learning process is one of the subjects that is difficult to understand because the English material is too general and abstract so it is difficult to practice.
The Effect of the Critical Thinking Based 4 MAT Instruction Applied in Science Education on Critical Thinking Dispositions	Sirin Ilkorucu, Menekse Seden Tapan Broutin, Mestan Boyaci	2022	showed a significant difference in favor of the experiment group students in terms of the scores of critical thinking disposition. The experiment group evaluated themselves as more part of nature in their responses and dealt with biodiversity, the basis of sustainable living in critically. The control group's responses showed individuals do not solve problems concerning biodiversity and do not seek solutions unless the problems are affecting them. This study shows that the CT- 4MAT instruction helped to promote students' Critical thinking dispositions.
Relationship between Scientific Literacy and Critical Thinking of Prospective Teachers	Ivayuni Listiani, Herawati Susilo, Sueb	2022	a relationship between scientific literacy and the critical thinking of prospective teacher students. This result indicated that understanding science requires good thinking, especially critical thinking.

Science learning studies must be based on scientific literature Weak scientific literacy

In studies of science learning, obstacles were still found related to weak science literature for both pupils and students. This problem was found in several studies conducted by researchers. For example, research conducted by Haryati and Tarma (2017) showed that students' scientific literacy abilities were still at a low level. Likewise, research conducted by Budiarti and Tanta in 2021 showed that problems were found with scientific literacy abilities, especially in the aspect of identifying scientific issues. These scientific issues are mainly in the knowledge aspect, especially the concept of the human movement system, which gets the lowest

results (Budiarti & Tanta, 2021). Supported by research by Nainggolan et al in 2021, it shows that the indicators for identifying scientific problems and explaining scientific phenomena have almost the same average value. This shows that there is a gap in the N-Gain value in the indicator using scientific evidence (Nainggolan, et al., 2021). In its application, Nurlina et al in 2019 stated that the average score of science process skills obtained by students before implementing scientific methods based on scientific literacy was lower than the score obtained by students after treatment.

The low level of scientific literacy in science learning is found to be a sign that the generation in a nation is weak and vulnerable to a decline in the quality

of human resources (HR) in the development of the nation's progress. Scientific literacy should be considered a key competency for social inclusion and active participation for a better world. With rapid advances in technology and science as well as in the area of science communication, the meaning of scientific literacy becomes more relevant for government agencies and non-governmental organizations in a country (Brown, 2016). Currently, scientific literacy has been defined not only as the ability to read and understand articles related to science, but also the ability to understand and apply scientific principles in everyday life (Okada, 2013). Scientific literacy also has an important role in decision-making on daily life issues such as health, interactions with the environment, as well as determining the products used and their impact on the environment. Of course, making decisions in everyday life using scientific processes, scientific knowledge and values will be better and more precise.

Therefore, in the literature related to Responsible Research and Innovation (RRI), actors namely society and innovative scientists must be mutually responsive to each other to develop a better and more precise understanding related to scientific and ethical issues (including risks, benefits, and obstacles) (Ozgelen, 2012). Thus, it will enable proper inculcation of scientific and technological progress in their society (Okada, 2013).

Causes of low scientific literacy

The cause of this low scientific literacy was revealed by Widowati et al in 2017 that students in Indonesia still have low scientific literacy because it is believed to be due to a lack of learning that involves scientific processes, for example in formulating scientific questions, using the knowledge they have to explain natural phenomena, and draw conclusions based on facts obtained through inquiry. This shows that learning by inquiry is important so that scientific literacy develops (Widowati, et al., 2017). Lack of scientific literacy makes students feel bored and confused, this statement is in accordance with research by Siregar and Yuniasih (2022) showing that students lack scientific literacy because they feel bored and confused regarding the material content of science literacy presented, especially related to English literacy.

Even though students actually have fairly good content knowledge, their procedural and epistemic knowledge is inadequate, resulting in them not being able to use it in problem solving activities. One way to overcome this is that teachers are recommended to focus their pedagogical attention on methods of gaining knowledge and understanding of problem solving in a broader context (qualitative knowledge, understanding of science, scientific explanations of phenomena with appropriate interpretations) (Bellova, et al., 2018).

Scientific literature is one way to improve critical thinking.

Literacy as a strategy for mastering concepts

Scientific literacy is very important in science learning according to the results of research conducted by Parmin and Fibriana (2019) showing that scientific literacy indicator data indicates that the use of indigenous knowledge is an important key as a strategy for mastering concepts, analytical thinking, problem solving, and improving communication skills.³⁰ Scientific literacy can increase supported by the application of phenomenon-based learning in the learning process. As stated by Santalia and Yuliaty (2020), students' scientific literacy increased after implementing phenomenon-based learning in the learning process.

Science learning builds students' way of thinking to understand natural phenomena or events using scientific methods as used by scientists. The main goal of science education is to teach scientific concepts and processes, thereby helping students develop a strong understanding of scientific findings as well as the skills and processes used in science. Science education aims to increase students' competence in an effort to meet life's needs in various situations (Sadler, et al., 2009). Many studies related to science education have been developed, one of which is through the Program for Intercount Student Assessment (PISA) carried out by the Organization for Economic Co-operation and Development (OECD) (Hadisaputra, et al., 2019). Science education develops various abilities in the field of science, one of which is scientific literacy.

Scientific literacy is internationally recognized as one of the benchmarks for the quality of education (Ardianto & Rubini, 2016). Scientific literacy is one of the scopes of PISA (Program for International Student Assessment) studies which focuses on students' ability to use scientific knowledge and skills (Ardianto & Rubini, 2016). Scientific literacy has become a widespread concern for students scientists, lecturers and public policy holders (Impey, 2013), because it is very necessary for modern society to overcome science and technology problems (Turiman, et al., 2012), as well as to support sustainable development (Undompong & Wongwanich, 2014). Scientific literacy is a person's capacity to use scientific knowledge, identify questions and draw factual conclusions to understand the universe and make decisions about changes that occur due to human activities (OECD, 2006). Scientific literacy is an element of life skills that must be the main result of the education process until children are 15 years old. Therefore, children aged 15 years (at the end of compulsory education) are considered to need to have an adequate level of scientific literacy, both to pursue science and non-science fields (Wardhani & Rumiati, 2011). Scientific literacy is classified into four categories,

namely science as a collection of knowledge, science as a way of thinking, science as a way of investigating, and the interaction between science, technology and society. The development of scientific literacy is needed to prepare students who are literate in the field of science (Undompong & Wongwanich, 2014).

The relationship between scientific literacy can improve critical thinking

Research conducted by Listyani et al (2022) revealed that to understand science requires good thinking, especially critical thinking. This was clarified by research by Primasari et al in 2020 which revealed that there is a positive correlation between critical thinking skills and scientific literacy. So students are advised to optimize students' critical thinking skills and motivation to sharpen scientific literacy. Sutiani et al (2021) showed that the standard inquiry learning model which has been developed with scientific literacy is able to improve students' critical thinking abilities.

Efforts to build students' scientific literacy can be done through training students' critical thinking skills. Because students' critical thinking skills can help students to solve problems related to scientific literacy. Critical thinking is a self-regulated assessment that results in interpretation, analysis, evaluation, and inference as well as explanation of evidence, conceptual, methodological, or contextual (White, et al., 2011). Critical thinking can also raise important questions and problems to formulate them clearly, collect and assessing relevant information to think openly (Duron, et al., 2006). So, it can be concluded that critical thinking skills will encourage students to understand problems and create alternative problem solutions with the problem solving stages, namely clarification, assessment, inference, and strategy (Gotoh, 2016). Students' critical thinking skills in solving Scientific literacy can be measured using metacognitive assessment instruments based on scientific literacy. Because critical thinking has become a set of skills that make it possible to solve problems logically and reflect on them autonomously through metacognitive regulation (Yantim et al., 2017). This means that it refers to ways of increasing awareness about the thinking and learning process (Suwono, et al., 2017).

Supporting factors for critical thinking

A supporting factor in improving critical thinking is learning biological social case studies. This is in accordance with research by Suwono et al in 2017 showing that learning Social Biology cases can improve students' critical thinking skills and biological literacy (Suwono, et al., 2017). To improve critical thinking, a person must have concepts to connect science. In accordance with research conducted by Fakhriyah et al

(2017), it shows that 66.2% of students already have concepts for connecting science with other scientific disciplines, can write scientific terms, but students still have misconceptions, while 33.8% of students think that theories and concepts are has been explained correctly, but has limited understanding and finds it difficult to connect with the concept in his own opinion (Fakhriyah, et al., 2017). Supported by the existence of a science learning website as expressed by Utami and Djukri in 2020, it shows that the science learning website has a significant effect on students' critical thinking skills (Utami, 2020).

Ilkorucu et al in 2022 showed that in a literature study before conducting experimental research, Burford, et al (2016) showed that the Sustainable Development Goals (SDG) and within it focused on thinking or modeling knowledge specifically and could design relevant indicators for various ways of knowing such as critical thinking or "learning to learn". Apart from that, Rieckmann (2012) also highlighted that the ability to translate knowledge into systematic and anticipatory critical thinking actions is a need that needs to be developed by students (Ilkorucu, et al., 2022).

Another factor also shows that conducting research by Lieung et al (2020) shows that students' critical thinking skills have increased after conducting classroom action research (CAR). Larasati et al in 2018 also revealed that students' critical thinking skills in science learning can be improved by implementing the model. The Predict, Observe, Explain (POE) model can improve critical thinking skills in science learning for elementary school students (Larasati, et al., 2018).

Prafitasari et al in 2021 of 19 participants also showed that integrating critical thinking skills with a blended learning system in elementary schools for science learning still needs to be considered because there are still obstacles in implementing it so that it is more effective. The recommendation in this research is that teachers are more creative in implementing blended learning system learning strategies so that the success of critical thinking skills in students' science learning can be achieved well. Kurniawan et al (2020) showed that students' science process skills influence critical thinking in learning science. In addition, a comparison between students' science process skills and critical thinking based on school location shows that students in urban areas are higher than students in rural areas. Critical thinking is also influenced by the problem-based learning model, in accordance with research by Suhirman and Khotimah in 2020 showing that the learning model Problem Based has a significant effect on students' critical thinking skills and scientific literacy (Suhirman & Khotimah, 2020).

At the level of critical thinking assessed through critical writing prompts, students showed poor critical

thinking reflection. Their level is still at the basic level because the quality of students' arguments regarding the given topics is mostly on a basic scale that is not supported by adequate reasons. Students' writing is also at a basic level in terms of the quality of topic exploration because they are weak in the ability to synthesize ideas from several references needed to complete their writing. The ability to support their ideas using evidence is mostly at the pre-intermediate level. Lack of reference exploration or careful reading can be pointed out as a supporting reason for this finding. Regarding organizational ideas, most of the students were at the pre-intermediate scale. Their writing is not supported by adequate rhetorical skills. Meanwhile, in the last aspect observed, namely conclusions, the majority of students were at the basic scale. However, their writing still needs to be improved on the element of unity. Because the thesis statement is not always presented explicitly, the conclusions made also do not represent the content of their critical thinking shown in their writing.

The results of this research also reveal that an important factor that influences the ease of expressing critical thinking is language ability. A critical thinker can express his thoughts well through the use of good language both in spoken and written form. The students clearly had difficulty developing their critical thinking skills due to language acquisition. Only a few students can reflect their arguments well through written English write well-organized English. These findings indicate that language ability is an important factor which is significant in influencing critical thinking. Language limitations make the arguments in students' writing unclear. Meanwhile, the ease of presenting arguments depends on a person's knowledge of good language and how to apply this knowledge to a discourse. This knowledge into a discourse so that critical thinking can be understood by others.

Because this research examines critical thinking and the factors that influence it, future researchers can develop other variations of critical thinking assessment, for example by linking critical writing in one subject with others such as critical reading or critical listening. The relationship between other possible factors such as learning style, self-efficacy and learning motivation also needs to be further investigated.

Conclusion

Several important things found in this research are that problems related to the study of science learning based on scientific literature for both pupils and students are still relatively low. The problems that arise are in the aspect of identifying problematic issues and scientific evidence and scientific skills. This is because they lack learning that involves the scientific process, for

example in formulating scientific questions, using the knowledge they have to explain natural phenomena, and drawing conclusions based on facts obtained through inquiry. Apart from that, they felt bored and confused about the content of the science literacy material presented, especially related to English literacy. The reason why the problem of lack of scientific literacy arises is a lack of learning that involves scientific processes.

We know that scientific literacy is one way to improve critical thinking by being able to master concepts, critical thinking, problem solving and communication skills with indigenous knowledge. This means that building science learning can build students' way of thinking to understand phenomena using scientific methods like scientists do. This is of course by training students' abilities and skills in improving scientific literature properly and appropriately. So that students' critical thinking abilities in science learning.

Of course there must be supporting factors such as students must have concepts to connect science, science learning websites, focus on specific knowledge, be able to design relevant indicators, have the ability to translate into critical, systematic and anticipatory actions students' critical thinking skills, school location, and problem-based learning model. If these factors can be implemented well, science learning based on scientific literacy can improve well so that the thinking abilities of pupils and students will also improve.

Acknowledgements

We would like to express our gratitude to God Almighty and our parents who have supported this research until completion. Apart from that, we would also like to thank those who helped in completing this article.

Author Contributions

Bramista preparation of the original text, results, discussion, methodology, conclusions; Satutik Rahayu did analysis, proofreading, reviewing and editing.

Funding

No funding.

Conflicts of Interest

We have no conflict of interest.

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