

Scientific Literacy in Science Instruction: Media and Teaching Approach Employed

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Abstract: Students must receive optimal training in science learning to ensure the development of competitive future generations with scientific literacy. This research can be an illustration or source of innovation for educators related to learning media, learning strategies, and learning models that can be applied to train students' scientific literacy. This article presents a description of media and learning strategies implemented in an effort to train students' science literacy skills. Twenty articles published from 2013 to 2022 were obtained from several Q2-Q3 indexed journals such as *Journal of University Teaching and Learning Practice*; *International Journal of Instruction*; *Bioscene*; *Journal of Turkish Science*; *Journal of Mathematics, Science and Technology Education*; *Journal of Geoscience Education*; *Journal of Biological Education*, *Journal of Education and e-Learning Research*; *European Journal of Education Research*; and *Eurasian Journal of Educational Research*. The review results show that science literacy is widely practiced in science learning at primary, secondary and tertiary levels. Learning strategies and models that are widely used in scientific literacy-based learning such as inquiry models, POGIL, contextual learning, structured project tasks and others. The learning media that are often used are textbook development, web media, Augmented Reality and others. The learning model with great potential to improve scientific literacy is the inquiry model because it has been widely applied. The most recommended learning media are web media and Augmented Reality (AR).

Keywords: Learning Model, Learning Strategy, Learning Media, Scientific Literacy, Science Instruction

Abstrak: Literasi sains perlu dilatihkan kepada siswa secara optimal melalui pembelajaran sains untuk mempersiapkan generasi masa depan yang kompetitif. Penelitian ini dapat menjadi gambaran atau sumber inovasi bagi para pendidik terkait media pembelajaran serta strategi dan model pembelajaran yang dapat diterapkan untuk melatih literasi sains peserta didik. Artikel ini menyajikan uraian tentang media dan strategi pembelajaran yang diterapkan dalam upaya melatih kemampuan literasi sains siswa. Dua puluh artikel yang diterbitkan dari tahun 2013 hingga 2022 diperoleh dari beberapa jurnal terindeks Q2-Q3 seperti *Journal of University Teaching and Learning Practice*; *International Journal of Instruction*; *Bioscene*; *Journal of Turkish Science*; *Journal of Mathematics, Science and Technology Education*; *Journal of Geoscience Education*; *Journal of Biological Education*, *Journal of Education and e-Learning Research*; *European Journal of Education Research*; dan *Eurasian Journal of Educational Research*. Menurut hasil review, praktik literasi sains melibatkan berbagai jenjang pendidikan, termasuk sekolah dasar, sekolah menengah, dan sekolah tinggi. Strategi dan model pembelajaran yang banyak digunakan dalam pembelajaran berbasis literasi sains seperti model inkuiri, POGIL, pembelajaran kontekstual, tugas proyek terstruktur dan lain-lain. Media pembelajaran yang sering digunakan adalah pengembangan buku ajar, media web, Augmented Reality dan lain-lain. Model pembelajaran yang berpotensi besar untuk meningkatkan literasi sains adalah model inkuiri karena telah banyak diterapkan. Media pembelajaran yang paling direkomendasikan adalah media web dan Augmented Reality (AR).

Kata kunci: Model Pembelajaran, Strategi Pembelajaran, Media Pembelajaran, Literasi Sains, Pembelajaran sains.

INTRODUCTION

One of the aims of education is to cultivate students' critical thinking, problem-solving, and research skills (Temel, 2014). Besides that, education is also enabling student to effectively address both the positive and negative effects of the continuous advancements in science and technology on human life. This necessitates the development of students' abilities to think critically and creatively, respond to current issues, and solve problems in a comprehensive manner (Dewi et al., 2021). Quality science education significantly impacts development and is crucial for students' success in the 21st century (Pertiwi et al., 2022).

Scientific literacy is the capacity to think across different scientific disciplines and incorporate multiple scientific concepts into scientific practice. It also involves a deep understanding of science and the ability to apply it to everyday life (Cahyana et al., 2019). Increased scientific literacy is important because it impacts economic life, especially social life, and enhances the decision-making capacity of individuals and communities. Wen et al. (2020) also found that people with good scientific skills are able to apply scientific concepts to solve problems and recognize technological products and their positive effects. The individual is familiar with how to use and maintain the product, has innovation in creating simplified product technology and is able to make decisions based on local values and customs.

With ethical, moral, and global issues on the rise, students need to develop problem-solving skills as well as critical problem-solving skills through scientific literacy learning (Dewi et al., 2021). People who possess a good level of scientific literacy have the ability to apply scientific methods to comprehend problems and utilize scientific knowledge to solve them (Zhang et al., 2020).

The level of scientific literacy in Indonesia is still low, as evidenced by Indonesia's ranking of 64th out of 72 countries based on the results of PISA 2015. The average score for scientific literacy in Indonesia is 403 points, which is much lower than the international average score of 500 points (Balitbang, 2016). One of the competencies that science teachers and students preparing to teach in schools must possess is the ability to apply learned topics to solve relevant problems. Science concepts are aligned with real-life situations and then communicated in classroom learning well.

To align with educational reform, science materials need to be created or updated to tackle scientific literacy problems. To enhance scientific literacy, various materials and approaches can be employed that address themes such as scientific knowledge, the nature of scientific inquiry, the interaction of science, technology, and society, and science as a way of thinking. (Upahi et al., 2017). Explicit scientific processes should be incorporated to help students achieve learning objectives related to science literacy. Teaching and learning activities should include explicit discussions that provide opportunities for individual reflection so that students can build a more complete understanding of the science process.

The process of learning science must encompass various elements such as attitudes, knowledge, and skills (Irmita & Atun, 2018). In the 21st century, education should aim to cultivate students' scientific literacy skills. Collaborative learning is a successful approach to enhancing students' scientific literacy, as it involves students working together to solve problems, engage in scientific discourse, and develop critical thinking skills (Dewi et al., 2021). Textbooks and learning media also have a significant impact on science education. Quality teaching materials, especially textbooks, are considered the primary tools for advancing national education and national development. Science teachers rely heavily on available books and media. If media do not include scientific literacy components such as inquiry protocols, students are likely to be poorly informed about the scientific method (Sinaga et al., 2017).

Similar research related to scientific literacy using the literature review method has been conducted by Juniawan et al (2023). The study explored learning media that aims to improve scientific literacy in science learning at the elementary school level. The results of the study obtained several learning media which were grouped into video media, book media, digital media,

practical media, and game media. Video media such as animated videos; book media such as digital comics, pop up books, flipbooks; digital media such as ICT media, Linktree media, Augmented Reality media; practical media such as science media kits, smart word media; game media such as Si Pagar Air media, Kenali Aku circuit media.

Numerous studies have been conducted on enhancing scientific literacy through various learning models and media. This paper discusses the results of a search for learning models, learning strategies, and learning media that can be used to enhance students' scientific literacy in science learning. The study proposes suitable learning models and media based on the search results.

METHOD

This research was conducted using the Literature Systematic Review (LSR) method which consists of several stages, namely identifying, evaluating and interpreting the results of literature findings. The articles searched were articles on the topic of science literacy in science teaching contained in accredited national and reputable international journals. The article search used various journal search engines such as eric database, google scholar and taylor. The results of the article search were organized in a table and filtered based on several inclusion criteria. The first criterion is based on the year of publication of the article, which is from 2013 to 2022. The second criterion is the presence of the word scientific literacy both in the title, abstract and keywords. The third criterion is that the article is published in a reputable, accredited journal, and the text is available in full.

The search keyword used was "scientific literacy" in three databases. Next, article titles were selected that focused on learning models and teaching materials in science teaching. The search for articles with a focus on science literacy initially obtained 49352 articles but after sorting the articles based on the criteria, 20 articles were obtained. Some of the discarded articles focused on analyzing students' science literacy and science literacy profiles of teachers and prospective science teachers, developing science literacy assessment instruments and the emergence of science literacy in textbooks.

The researchers used a qualitative approach to analyze all the articles, focusing on the aspects related to the research objectives. Furthermore, the data obtained was paraphrased again. The article search process described above can be seen in the flowchart in Figure 1.

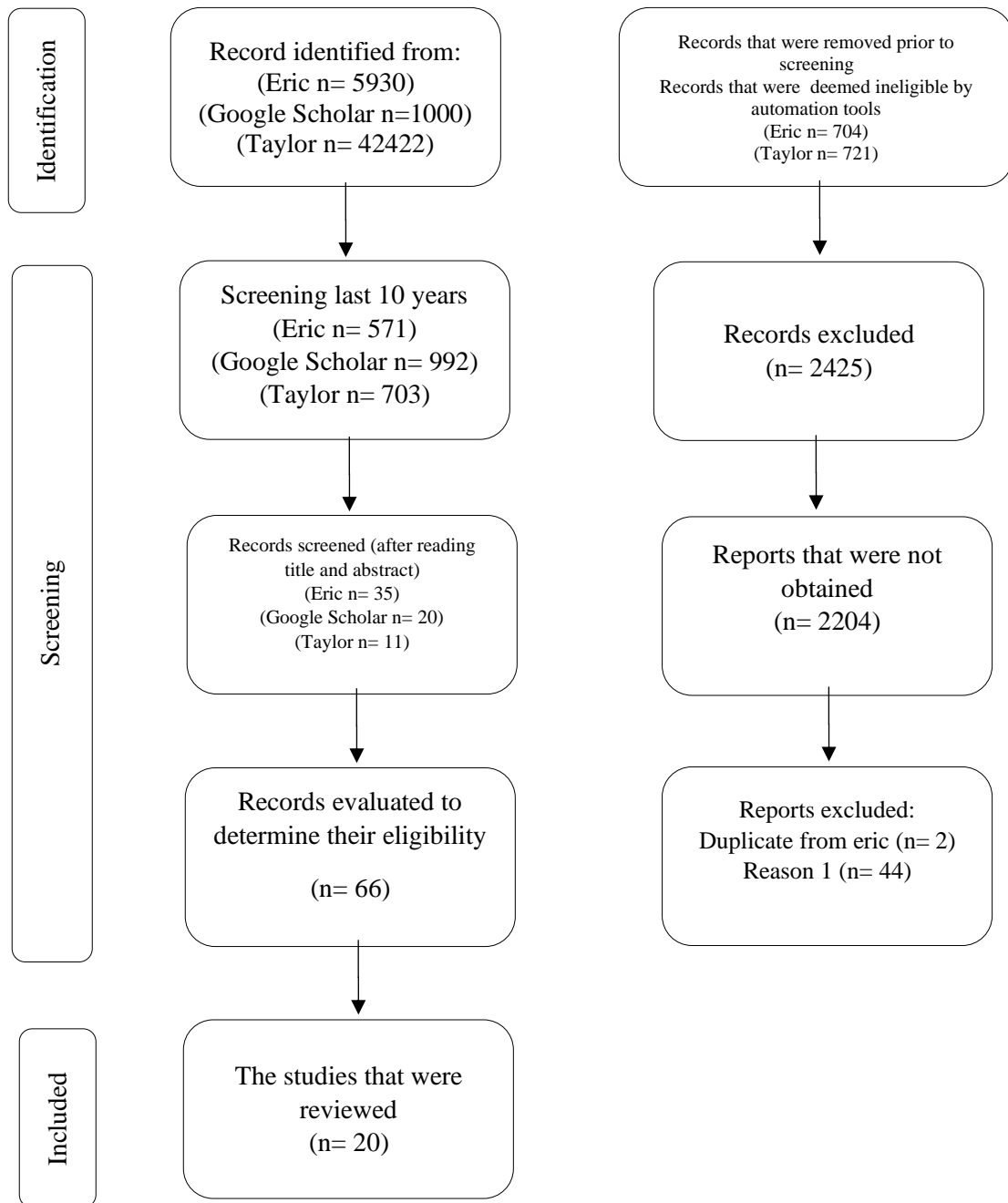


Figure 1. Article Search Process

RESULT AND DISCUSSION

Many studies related to scientific literacy have been conducted both abroad and domestically. Science literacy skills are also transferred in several learning materials and several school levels, be it elementary, junior high, high school or college. The learning material is certainly in the area of (Natural Sciences) such as chemistry, physics, biology, geology and so on.

The concept of scientific literacy encompasses various topics and discussion areas, such as science as a body of knowledge, science as a path of inquiry, science as a way of thinking, and the interaction of science with technology and society. The process of imparting scientific literacy to students involves several methods, including learning models, learning strategies, and teaching materials.

Scientific literacy competencies require an individual to think critically and analytically in order to explore problems, apply knowledge, formulate hypotheses, make and justify predictions according to scientific phenomena, identify and distinguish problems, analyze data, draw conclusions.

Learning Media in Scientific Literacy

The use of educational technology can engage students and inspire them to learn. The main function of learning media is to aid understanding and improve perception by visualizing and presenting clearly what is invisible or difficult to see (Winarni et al., 2020). The different methods of media used to educate people about science are outlined in Table 1.

Table 1. Media in Science Literacy-Based Learning

Researcher and Year	Learning Media	Subject Material	Impact
Parlindungan Sinaga, Ida Kaniawati, Andhy Setiawan (2017)	Science Literacy Based Textbook	Science	It can significantly improve science literacy.
Ivo Yuliana, Muhammad Edi Cahyono, Wahono Widodo, Irwanto (2021).	Ethnoscience-themed picture book	Science	High student posttest scores on all science literacy subscales.
Ucu Cahyana, Sri Supatmi, Erdawati, Yuli Rahmawati (2019)	Web Learning	Chemistry	A total of 60.3% of students scored in the range of 70 to 80, with only 1.9% of students scoring lower than 60.
Xiaoqing Gu, Chunli Wang, Lin Lin (2019)	Web Learning	General	The web helps students understand the material because a material component can be presented in a three-dimensional animation model.
Yuliana Wahyu, I Wayan Suastra, I Wayan Sadia, Ni Ketut Suarni (2020)	Augmented Reality	Science	Increasing the average score of students with a very good category.
Endang Widi Winarni, Endina Putri Purwandari (2019)	Augmented Reality	Science	The N-Gain value of 0.8 indicates that the app is very effective in improving students' science literacy.
Adi Pramuda, Mundilarto, Heru Kuswanto, Soka Hadiati (2019)	Smartphone Berbasis Real-Time Physics Organizer	Physic	Plays a major role in the advancement of worldwide scientific literacy, particularly in the aspect of developing habits of mind.

Researcher and Year	Learning Media	Subject Material	Impact
Endang Widi Winarni, Daimun Hambali, Endina Putri Purwandari (2020)	ICT Media	Science	Improving students' science literacy skills.
Christine M. Ambrosino & Malia Ana J. Rivera (2020)	Place-based Ethology Laboratory Module	Marine Science	Increase students' positive attitude towards marine science, confidence in scientific skills, and content understanding.

Many teaching materials or learning media with scientific literacy content have been developed in several subjects. Initially, science textbooks have been created to promote scientific literacy, align with the curriculum requirements and graduate competency standards, and enhance students' understanding of science. Textbooks are an integral part of a quality education; therefore, it is the teacher's responsibility to ensure that learning materials are aligned with curriculum objectives and to help achieve them.

The creation of science textbooks for primary school students also includes incorporating ethnoscience themes. Ethnoscience involves integrating local cultural knowledge into scientific learning, aiming to make the learning experience more meaningful for students. An innovative approach to this development is the creation of ethnoscience-themed picture books, which can help familiarize students with videos and texts related to phenomena in daily life. Learning is done by presenting scientific evidence about real phenomena then students discuss to investigate scientifically in groups.

The use of media such as websites and microbloggers can also train students' science literacy. This is because the media is an important source for certain scientific issues. The use of web media in chemistry courses can train scientific literacy. The unique attributes of online media can enhance the effectiveness and quality of learning. Online learning provides access to teaching materials that can be utilized over the internet, including slides, handouts, articles, and other resources. This mode of learning also supports collaboration, communication, and independent learning, making it an efficient means of delivering course materials. The existence of the web makes it easier to understand the material because a material component can be presented in a three-dimensional animation model.

Using Information and Communication Technology (ICT) for learning can make students more inclined to participate in discussions about science and technology. ICT and multimedia can be effective in learning because it can train media and information skills for 21st century needs, create an active and fun classroom atmosphere, deliver meaningful learning, give students access to exploration and high creativity, train communication skills, collaborate, work in groups and bring students to a higher level of thinking.

Other media that began to develop along with technological advances are Augmented Reality and Smartphone-based Real-time Physics Organizer. Augmented reality (AR)-assisted learning is more complex than traditional learning in terms of scientific literacy and student achievement. Augmented reality (AR) integrates virtual objects into the real environment, allowing for interactive operation in real time and the integration of objects in two or three dimensions. Smartphone-based Real-time Physics Organizer (RPO) is also developed in physics lessons. RPO can facilitate communication skills, student collaboration and systematic thinking/information management skills. By learning using RPO, students' ability to explore a physical phenomenon becomes better and can conduct scientific experiments using smartphone sensors and their applications well.

In Hawaii, a place-based laboratory module was developed on ecology. The module requires students to analyze animal behavior by facilitating the development of observation skills. The study focuses on teaching and learning through local phenomena, which is known as place-based education. The animals being studied are local, and the classroom is located on a small offshore

island in Hawaii, surrounded by a coral reef that is home to marine animals. The main objective of creating this module was to offer a distinct scientific inquiry experience rooted in local culture. Students tend to be more enthusiastic about using this module than standard textbooks.

The most recommended learning media or have great potential in improving science literacy are web learning and Augmented Reality (AR). Both media are widely used in science literacy-based learning both domestically and abroad. The target audience of the website can be designed for the general public but there are also websites that offer specialized scientific knowledge with a special target audience. Web media is much liked by people so that it can motivate the person and can even be used for self-learning. One thing that makes web media interesting is the presence of text accompanied by images and videos. The characteristics of web media support learning to be more effective so that it can be used to train science literacy.

Augmented Reality (AR) is a trendy application used by teachers these days. AR in science learning can develop students' creativity and looks very useful because it can visualize the concept of material in real terms. AR combines virtual things into three real dimensions and projects those virtual things in realtime so AR is considered as a technology-based media used to explain science concepts effectively.

Learning Strategy and Learning Model in Scientific Literacy

Classroom management using the right learning models and strategies can affect students' science literacy levels. Improving scientific literacy can be achieved by developing students' critical thinking skills in problem solving. Problem-solving skills are part of scientific literacy competencies. Critical thinking skills link content, process, and product knowledge to solve problems. Traditional learning, also known as teacher-centered learning, fails to fully involve students in the process of acquiring knowledge. This causes students to be less encouraged to solve problems, less proficient in using scientific skills and collecting scientific information and evidence. Table 2 presents various learning strategies and models to train scientific literacy.

Table 2. Learning Models For Practicing Science Literacy

Researcher and Year	Learning Model or Strategy	Subject Material	Impact
Citra Ayu Dewi, Maria Erna, Martini, Ikhfan Haris ⁴ , I Nengah Kundera (2021)	Learning Model Ethnoscience-based Contextual Collaborative	Chemistry	Improve students' science literacy in content, process and attitude.
Qing Zhang, Jingmin Wang, Ruihong Ji, Tairan Huang (2020)	Internationally collaborative research training workshop	General	Improving scientific literacy and self-efficacy of new graduate students.
Arif Sholahuddin, Eko Susilowati, Binar Kurnia Prahani, Erman Erman (2021)	Cognitive Style Based Learning Strategy or CBLS model	Environmental Pollution	Improving students' science literacy and environmental knowledge.
Melissa Eslinger, Ph.D. and Elizabeth Kent, M.S. (2018)	Structured Primary Literature Project	Biology	Improve students' ability to solve complex and unclear problems.
Harriet Whiley, Donald Houston, Anna Smith, Kirstin Ross (2018)	Use of Cultural Hooks and Authentic Challenge-Based Learning Strategies	Environmental Health	Improve the ability of both science and non-science students to understand and apply scientific concepts and knowledge.
Benjamin Surpluss, Michelle Bushey & Mark Halx (2014)	Laboratory courses by revi	Physical Geology	Enhance comprehension of science's characteristics, the

Researcher and Year	Learning Model or Strategy	Subject Material	Impact
Luthfia Irmita, Sri Atun (2018)	single eye physical geology lecture Technological Approach Pedagogical and Content Knowledge (TPACK)	Chemistry	process of science, the use of research in practical settings, and qualitative and quantitative approaches. Improving students' science literacy.
Ani Sutiani, Manihar Situmorang, Albinus Silalahi (2020)	Inquiry-based learning	Chemistry	Students' thinking skills are very good, with the percentage of achievement obtained ranging from 72-97%.
Bagus Endri Yanto, Bambang Subali, Slamet Suyanto (2019)	Inquiry-based learning	Biology	Enhance students' ability to think scientifically by improving their skills in analyzing, evaluating, and creating.
Ummu Aiman, Suryadin Hasyda, Usfan (2020)	Process Oriented Guided Inquiry Learning (POGIL)	Science	The utilization of media-supported Process Oriented Guided Inquiry Learning (POGIL) has an effect on the scientific literacy and critical thinking abilities of students.
Edward Nuhfer & Pam Mosbrucker (2018)	Interactive Method	Geology	The assessment results confirmed that the interactive engagement exercise yielded very high learning gains.

Collaborative learning is learning by combining several individuals or students who have different abilities. Contextual learning is learning to understand the cultural, social, and personal context of everyday life so that students have dynamic knowledge. The combination of contextual collaboration applies group learning to discuss phenomena in everyday life. The existence of contextual collaboration based on ethnoscience allows students to find local values. Students can explore facts and phenomena that occur in society and integrate them into science. Ethnoscience is the study of a person's knowledge of specific local norms and beliefs that influence their understanding of nature. It involves connecting students with scientific concepts based on their cultural background. This approach integrates indigenous knowledge with scientific knowledge and aims to bridge the gap between the two. For example, in a study on the development of an ethnoscience approach, it was found that the module enabled teachers to deliver a particular theme, and students felt happy and helped by its presence.

The scientific knowledge and confidence of new graduate students in China were improved through a collaborative workshop activity with international participation. This research utilized a case study approach that combined qualitative and quantitative data to contribute to the understanding of graduate education in China. The study identifies innovative forms of collaboration between Chinese universities and other universities.

Cognitive Style-Based Learning Strategy is also learning by forming groups to solve a problem through worksheet which contains stages of Cognitive Style-Based Learning. Cognitive Style-Based Learning has developmental effects on social skills and personality, and in the long run can improve students' scientific literacy.

The Technological Pedagogical and Content Knowledge (TPACK) approach is an amalgamation of content, pedagogy, and technology. The TPACK approach relies on a principle that learning is the basis for implementing effective learning, understanding scientific inquiry, expanding knowledge. A suitable model to integrate with Technological Pedagogical and Content Knowledge (TPACK) is discovery learning. In this approach, instead of simply presenting information, teachers facilitate students' exploration and construction of knowledge on their own. The combination of the two models encourages students to gather information and scientific evidence as problem solving, using their scientific abilities to explain scientific phenomena.

International collaborative postgraduate training on the Chinese campus is rare, so regular workshops are held six times in six weeks. Each workshop event is divided into two sessions: afternoon and evening. The workshops integrate seminar presentations and student interactive research activities. In the final week students are given practical opportunities to conduct presentations, discussions, and publications and gain experience as presenters. The report of the research project can be published in the SDUFE research journal as an option. By the end of the workshop, students had successfully completed several important activities, including gaining a clearer understanding of their research, identifying research questions, completing a literature review, and selecting relevant research methods.

Another strategy to train science literacy is by giving students assignments in the form of Structured Primary Literature Project. In the project, students are given the task of selecting articles, analyzing articles, making slides or power point and finally presenting the results of the discussion. This project is useful for improving science literacy and improving critical thinking skills. Students can apply what they've learned by using selected texts as a means to summarize, dissect, critique, or suggest clues for further exploration.

POGIL is a teaching and learning approach that is based on constructivist theory and focuses on process-oriented inquiry learning. In this model, the teacher acts as a mentor, guide, and evaluator, while the students are actively engaged in the learning process.

Not much different from POGIL, inquiry-based learning is constructivist learning that includes investigation and exploration activities so as to increase the knowledge of the students. Teaching and learning activities in this model are carried out through several stages, namely observing chemical phenomena, focusing on questions, planning and conducting investigations, analyzing data, forming new knowledge, epistemic knowledge, presenting new concepts, and finally implementing new concepts.

Strategies to improve students' scientific literacy were also implemented through a physical geology experimental program. Comprehensive learning objectives were achieved by significantly revising the curriculum and integrating research equipment into classroom activities. The curriculum was revised, an assessment framework was developed, and research equipment was integrated into project-based learning opportunities to enhance students' learning and scientific literacy. Another strategy used to improve scientific literacy among science and non-science students is authentic challenge-based learning through the use of the zombie apocalypse cultural hook. This approach uses the engaging platform of the zombie apocalypse to communicate important concepts in environmental health, such as microbes and toxins, and to connect students with science and improve their understanding of environmental health. By using this cultural connection, the relevance gap can be closed and students can be engaged in learning.

The above-mentioned learning models and learning strategies are definitely student-centered and allow students to work more actively in teams, solve problems, and develop critical thinking skills. The effectiveness of various learning experiences, such as visualization, writing, reflection, and discovery, in building and stabilizing synaptic connections has been well established. Two-way engagement has been shown to lead to higher quality learning.

The recommended learning model based on the explanation above is inquiry learning. The model is widely used and there are also many developments of learning models based on inquiry. Inquiry learning actually leads students to find their understanding or discovery independently

but still under the teacher's supervision. Even the inquiry model has three levels of inquiry, namely from the lowest structured inquiry, then the high level of guided inquiry and the third level of free inquiry. The importance of different methods of inquiry to respond to students' varying levels of readiness, interests, learning styles, and speeds of taking in and processing information. Inquiry learning can grow knowledge through the process of investigation and exploration. Introducing inquiry programming into learning materials can effectively engage students in the practice of science.

The results of this study are almost the same as previous research conducted by Juniawan et al (2023). This study explores learning media and learning models and strategies that have been applied with the aim of improving scientific literacy. Whereas the previous research focused on discussing learning media that are useful for improving scientific literacy. In addition, this research has a broader scope, namely learning media and learning models and strategies that are applied or developed in any subject and at the level of education ranging from elementary school to college. Whereas in previous studies only focus on learning media applied to science learning at elementary level schools. These two studies have similarities in the discussion of learning media to improve scientific literacy. There are learning media that are both found in this research and previous research such as ICT media, Augmented Reality media, and interactive media.

CONCLUSION AND SUGGESTIONS

The teaching of scientific literacy often involves various learning strategies and models. For instance, inquiry models, POGIL, collaborative learning, and cognitive style-based learning, structured project assignments, workshop seminars, laboratory courses, interactive methods, cultural linkages, and technological pedagogical and content knowledge approaches are commonly used to promote scientific literacy. The media that are widely used are textbook development, module development, ICT, web media, and Augmented Reality.

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