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Listen-search-read-discuss: an innovative lesson design to improve students' scientific literacy in higher education

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ABSTRACT

Scientific literacy enables prospective teachers to use science processes and products, allowing them to engage in scientific discussions about social issues. The listen-search-read-discuss (LISERED) learning model was developed by researchers to enhance scientific literacy. This study aimed to assess the implementation of the LISERED model in improving students' scientific literacy skills. The research followed a quasi-experimental design with pretest and post-test control groups. The study collected data on scientific literacy in chemistry education programs, involving 62 students as samples. The efficacy test utilized a written multiple-choice test, specifically the test of scientific literacy skills (TOSLS). The results indicated a high effect size (ES) for the LISERED model in enhancing scientific literacy mastery (ES Cohen=2.859; ES Hedges=2.824; and ES Glass=3.285). This model facilitates a more interactive and engaging learning environment, enabling students to develop a deeper understanding of science. Implementing the LISERED model empowers teachers to significantly enhance students' scientific literacy comprehension.

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1. INTRODUCTION

Scientific literacy is an important skill because it can increase good knowledge in order to achieve success in school and in community life later [1], [2]. Students who are able to think critically, deductively, and inductively in science learning are highly emphasized in 21st century learning where teacher-centered learning must be transformed into student-centered learning [3]. Scientific literacy is a very important thing that students need to develop their minds while at university [4], [5]. This is because, science literacy is one of the key skills that is very important for students in the 21st century [6]. This is because today's world is increasingly complex with rapid technological developments, urgent environmental issues, and global problems that require a deep understanding of science and critical thinking [7]. Scientific literacy is not just about mastering scientific facts, but also the ability to analyze information, understand the scientific method, and make decisions based on evidence [8]. Number of studies already stated that, students who have good scientific literacy will be better prepared to face future challenges, participate in technological developments, and contribute to finding solutions to complex problems faced by global society [9], [10]. Therefore, scientific literacy is one of the main competencies that needs to be embedded in education in the 21st century. It is important for an educated person to be able to make the right decisions, explain why, and be able to find solutions to a problem [11].

Scientific literacy is one of the abilities that every prospective teacher must possess in facing the 21st century [12]. Scientific and technological knowledge is used by every individual in accessing, reading, and understanding the global world [13], [14]. Scientific literacy makes it possible for each prospective teacher to be able to use science processes and products in making decisions so that they can participate in scientific discussions about science issues that affect social life [15].

Learning that leads to scientific literacy activities is important to carry out. This can improve student achievement. Students will also have a better scientific understanding with the skills of reading scientific reading texts [16]. Activities during integrated reading and writing can play an important role in achieving mind-on science learning. This activity will actively construct students' thoughts and assist in problem solving [17]. Students' reading skills greatly influence the assessment of scientific literacy because scientific literacy questions are presented in the form of reading (text) accompanied by several questions to be answered based on understanding the text. The results of previous research show that reading ability has a high correlation with the measurement of scientific achievement [18]. Good science learning to deal with changing times is important so that there is a need for science learning innovations that can lead students to individual scientific literacy [19]. Learning emphasizes that students as conscious beings understand the importance of their interactions with the environment.

Scientific literacy is widely acknowledged as an essential component of education on a global scale. Its significance lies in its ability to tackle global issues and foster comprehension of scientific principles. Numerous nations, including Indonesia, are actively striving to enhance scientific literacy through the implementation of innovative teaching methodologies and revisions to the curriculum [17], [20]. However, Indonesia faces distinctive challenges due to its diverse cultural landscape and its aspirations for scientific and technological advancement. Despite advancements in education, there persist barriers to cultivating a robust scientific literacy among Indonesian students. Factors such as curriculum design, teacher training, and access to resources all contribute to shaping students' grasp of scientific knowledge. Moreover, cultural attitudes towards science and technology can influence students' perception and engagement with scientific concepts.

A preliminary research was carried out in April 2019 at the Tanjungpura University on chemistry education study program through observation, questionnaires and interviews with several students and teachers. The pilot study was conducted to find the use of learning model to improve students' scientific literacy. Based on the learning questionnaire given to 80 students, 85% of students stated that lecturers used the lecture method more often in conducting classroom learning. As many as 15% of students answered questionnaires that the lecturers had used other methods, namely practicum and group discussions. As many as 100% both lecturers and students stated the need for a learning model that increased scientific literacy. They strongly agree with the changing patterns of education that provide 21st century skills. Lecturers need to conduct teaching and learning process that is able to improve students' scientific literacy. Furthermore, innovative lesson design as learning model in higher education to meet the challenge in improving students' scientific literacy is needed.

Implementing a learning model is a complex process that requires in-depth consideration of many factors [21]. This is because the learning model chosen will have a big impact on the success of learning activities [22]. Several factors that need to be considered include student characteristics, learning objectives, material taught, learning environment, and available tools [23]. Appropriate learning models must be designed to match the needs and preferences of learners and facilitate understanding and retention of the material [24]. Therefore, choosing the right learning model is very important in achieving learning goals and creating an effective learning experience. The development of a model suitable for information seeking activities already exists in the discovery and inquiry learning methods, but has not been integrated with other models that are suitable for 21st century skills [25]. This is the initial basis for consideration for integrating the main syntax of discovery and inquiry learning models, namely the process of searching, sorting, and selecting data or it can be summarized by the operational verb "search" [26]. Observing this description, it is necessary to find a way as an effort to make the learning process considered effective in training learning towards students, creating a learning atmosphere that is not boring and fun and changing the educational paradigm from being teacher centered to being student centered to improve student scientific literacy [27], [28]. Therefore, it is necessary to improve chemistry learning strategies in accordance with the objectives and nature of chemistry itself.

One learning model that has been empirically proven to improve scientific literacy skills is the listen-read-discuss (LRD) model that was first developed by Manzo and Casale [29]. The LRD model was developed because of the demands regarding discovery-based learning (heuristic) which made students learn comprehensively to understand a subject or material. LRD has been applied in the last decade to improve scientific literacy skills in students during learning [30]. Some of these shortcomings include that LRD has a long time to be completely applied in learning because of its long syntax LRD can be difficult to implement if the majority of students are in passive class [31], [32]. In addition, LRD has not been widely used in science learning. LRD is more widely used in language learning [29], [31], [33]. This is also a challenge in itself to develop LRD in science or science learning.

The learning model developed integrates the LRD learning model with the discovery and inquiry learning models in the operational verb "search" section to obtain comprehensive, long-term (lifelong learning), and meaningful learning objectives [29]. The development of an LRD learning model with a search process is predicted to minimize the impact or deficiency of LRD, discovery, and inquiry learning as well as improve scientific literacy skills and 21st century skills in students [34].

The authorial team behind the present paper developed the listen-search-read-discuss (LISERED) model as an effort to increase scientific literacy in basic chemistry courses. LISERED is an innovative lesson design combining discovery and LRD model. The researcher intended to examine an increase in scientific literacy skills in basic chemistry courses. The LISERED model has four syntaxes, namely "listen", "search", "read", and "discuss". The "listen" stage trains students to be able to find information appropriately and relevant to the subject matter. The "search" stage accustoms students to a literacy culture, especially reading as a basis for analyzing and understanding knowledge from correct reading sources. The "read" stage trains students to have basic language skills in the process of explaining their scientific findings. The "discuss" stage trains students to find solutions to a scientific problem by discussing. Given the context of the aforementioned issues, the problem statement in this research revolves around the application of the LISERED model to enhance students' scientific literacy. Consequently, the primary objective of this study is to assess the effectiveness of implementing the LISERED learning model in introductory chemistry courses at the university level.

2. METHOD

This type of research was quasi-experiment with pretest and post-test control group design [35]. The quasi-experimental research method was used in research to collect data on scientific literacy of students in chemistry education study programs. This study aims to determine the effectiveness of the LISERED learning model in physics learning as an experimental class. The learning model as a comparative treatment is direct instruction (DI) learning model as a control class.

Model testing at this stage is to determine the effectiveness of the LISERED model for students in basic chemistry courses. What is done is to compare the model developed with the conventional model in basic chemistry learning. The design used in this study was the randomized control group pre-test and post-test with one group design which is presented in Table 1.

This design comprises of two distinct groups, each of which selects a random subset of the population as a representative sample. The research study involved a total of 62 students as participants. The selection of these research participants was based on cluster sampling, considering that the study was conducted within the framework of specific course activities, making it impractical to include all classes or semesters. Apart from that, the number of samples selected for this research is considered to be quite representative of the population studied based on probability sampling theory [36]. Subsequently, the selected participants were divided into experimental classes, which received treatment using the LISERED learning model, and a control class, which received treatment using the DI learning model. The distribution of the sample size for each class is presented in Table 2.

Table 1. One group pre-test post-test study research design

Group	Pre-test	Treatment	Post-test
R_1	T_1	X	T_2
R_2	T_3	-	T_4

R1: experimental group, R2: control group, T: pre-test experimental group, T3: pre-test control group, X: treatment uses the LISERED, T2: post-test experimental group, T4: post-test control group.

Table 2. Distribution of student research samples

Class	Learning model	Group of samples	Samples
Experiment	LISERED	Reg A1 chemistry	32
Control	DI	Reg A2 chemistry	30

The treatment is only given to subjects in the experimental group within a certain period of time. After the treatment is complete then the dependent variable of the two groups is measured. The mean difference between the pre-test and the post-test for each subject in the two groups was calculated. The results of these calculations are compared to ascertain whether the treatment given to the experimental group has resulted in greater changes than the comparison group [37].

The instrument used at the product efficacy test stage was the test. The test method is a way of collecting data that exposes a number of questions to the research subject where student responses are categorized into correct responses or incorrect responses [38]. The test method is used to measure the scientific literacy of science teacher candidate students before and after using the developed products. The type of test used in this study is a written test in the form of a multiple-choice test which refers to a test to measure scientific literacy skills using test of scientific literacy skills (TOSLS) [39]. The research data were obtained through the pre-test and post-test using the TOSLS instrument consisting of 9 question indicators and 28 item items.

The aspect of scientific literacy as knowledge means that students understand the method of questions that lead to scientific knowledge. This aspect indicator refers to the category of scientific literacy skills, namely: i) identifying a valid scientific opinion; ii) conducting an effective literature search; iii) evaluating the use of scientific information; iv) understanding the elements of research design and how they impact findings scientific; v) making graphs that can present data; vi) reading and interpreting graphically from data; vii) solving problems using quantitative skills, including probability and statistics; viii) understanding and able to interpret basic statistics; and ix) presenting conclusions, predictions based on quantitative data [40]. The criteria for student scientific literacy are shown in Table 3.

The analysis used to determine the superiority of development products used data analysis on students' scientific literacy abilities as measured by using pre-test and post-test. The t-test is used to determine the advantages of using the model. The t-test conducted was to determine whether LISERED model has different outcome. Whereas before the t-test conducted, the data collected during the research must be tested the analysis prerequisites using the normality and homogeneity test [41]. The effect size (ES) test is calculated by comparing the results of calculations using the formula [16]. The ES criterion is used to determine the effect of the use of the development model on the scientific literacy of prospective science teacher candidates [42].

Table 3. Criteria of students' scientific literacy

Category	Score
Very high	86–100
High	76–85
Moderate	60–75
Low	55–59
Very low	≤54

3. RESULTS AND DISCUSSION

3.1. Description of students' scientific literacy

The data includes information on students' scientific literacy abilities, which were assessed through the combined results of various aspects of scientific literacy. To analyze the data, the pre-test and post-test results were examined to determine the mean, standard deviation, gain, and N-Gain. These statistical measures were evaluated using both classical methods and by categorizing the data based on the collected scientific literacy ability categories. Table 4 provides a comprehensive overview of the complete data on scientific literacy, which was obtained by distributing questionnaires to students in chemistry courses.

The data shows that the overall scientific literacy skills of students taught using the LISERED model (M=76.71; SD=6.03; gain=24.37) are higher than the scientific literacy abilities of students taught using the DI model (M=59.40; SD=5.78; gain=8.56). This certainly has an effect on the N-Gain achievement of students who are taught using the LISERED model (N=0.511) or are in the medium category are higher compared to the N-Gain of students taught using the DI model (N=0.174) or are in the low category. The findings show that students taught using LISERED model have better learning achievement than students taught using DI learning model. Figure 1 shows the comparison of pre-test and post-test results of treatments.

Table 4. Student scientific literacy ability data

Treatment	ESLS	Frequency	Pre-test		Post-test		Gain	N-Gain	Interpretation
			Mean	SD	Mean	SD			
LISERED	High	12	53.04	3.64	77.9	6.1	24.86	0.529	Medium
	Low	20	51.64	2.80	75.5	6.97	23.86	0.493	Medium
	Mean		52.34	3.22	76.71	6.03	24.37	0.511	Medium
DI	High	10	51.9	3.52	62.2	6.62	10.3	0.214	Low
	Low	20	49.78	2.62	56.6	4.95	6.82	0.136	Low
	Mean		50.84	3.07	59.40	5.78	8.56	0.174	Low

Another analysis was carried out based on ESLS, where Figure 2 explains the illustration of the analysis results based on ESLS. The data shows that the LISERED learning model has a slightly greater effect on high ESLS (g=24.86; N-Gain=0.529) than on low ESLS (g=23.86; N-Gain=0.493), the same thing is also true occurred in the DI learning model which had a slightly greater tendency to influence high ESLS (g=10.3; N-Gain=0.214) compared to low ESLS (g=6.82; N-Gain=0.136). In the LISERED model, the N-gain at the ESLS level is in the medium category, while in the DI model, the N-Gain at the ESLS level is in the low category (ESLS=KALS).

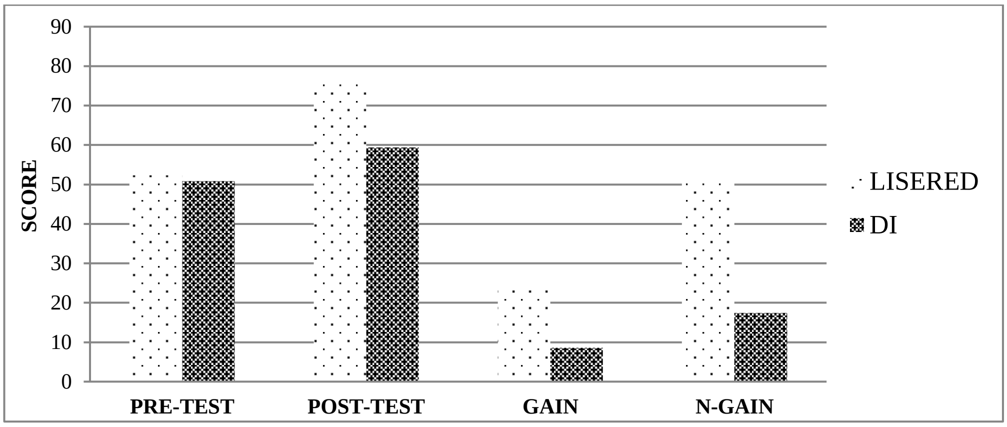

Figure 1. Comparison histogram of pre-test and post-test results of LISERED and DI

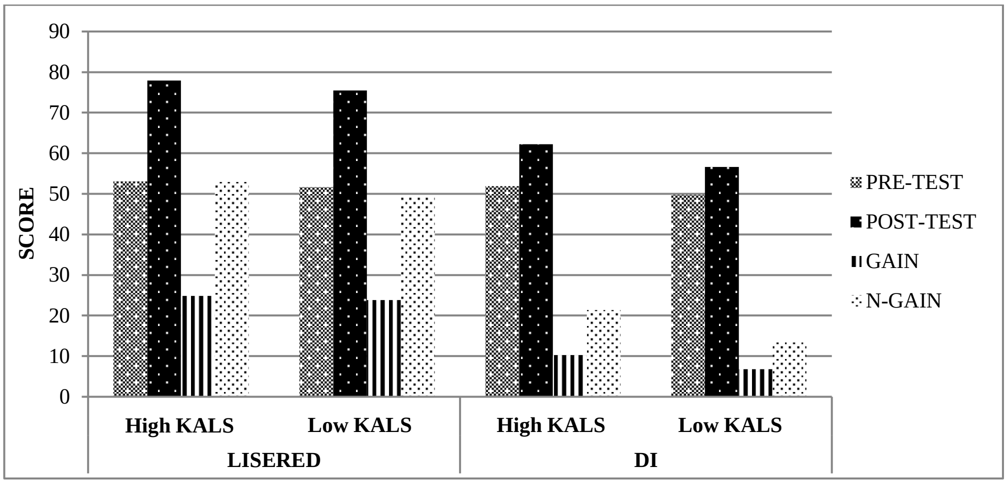

Figure 2. Histogram of pre-test and post-test results of science literacy

3.2. Histogram of pre-test and post-test results of science literacy

Based on the computational test results using SPSS 15, it is known that the overall test results state that the data is normally distributed (p value >0.05). Treatment in the form of LISERED learning model got p value 0.089, while treatment in the form of DI learning model got p value 0.096. It is said that the sample comes from a homogeneous population if the p value >0.05 using Kolmogorov-Smirnov test. The p value of calculated data is higher than fixed p value (0.096>0.05). The data were normally distributed. Levene’s test for equality of variances determined that the homogeneity of two group samples was 0.113. Based on the results of the Levene’s test of variance, it is known that the significance value of p value is >0.05 (0.113>0.05), so the data has a homogeneous distribution.

To compare the effect of treatments as learning models (LISERED and DI) on overall students’ scientific literacy achievement, a different test for the N-Gain mean score of LISERED and DI learning models was conducted. The test statistic used is the independent sample t-test. Provision for conclusion, namely significance <0.05, so there is a significant difference between LISERED and DI learning models. The results of statistical testing show that there is a difference in the acquisition of N-Gain scores of science literacy between students taught using LISERED and DI learning models (p value 0.000<0.005). The complete results are shown in Table 5.

Table 5. The result of the independent t-test

Gain	Mean	SD	T	df	Sig (2-tailed)
LISERED	50.91	12.85	2.592	12.593	0.000
DI	17.43	10.35			

3.3. The effect of using listen-search-read-discuss model to improve students' scientific literacy

To find out how much influence the LISERED learning model has on the achievement of student scientific literacy, the ES is calculated using the R stat ES for calculator t-test application. The results of ES calculations show that the effect of the LISERED learning model on each mastery of scientific literacy is in the high category (ES Cohen=2.859; ES Hedges=2.824; and ES Glass=3.285). In detail, the results of the ES test can be seen in Table 6.

Table 6. The ES LISERED test results based on the LISERED learning model

Learning model	Mean	SD	Cohen d	Hedges g	Glass	Interpretation
LISERED	50.91	12.85	2.859	12.593	3.285	High
DI	17.43	10.35				

3.4. Discussion

The testing implementation activity extends to the mole concept material. The final abilities expected from this course are: i) accuracy in explaining relative atomic masses; ii) accuracy in determining relative molecular mass; iii) accuracy in converting moles to number of particles; iv) accuracy in converting moles to mass of substances; v) accuracy in converting moles to molarity; and vi) accuracy in determining the molecular formula of compounds based on experimental data.

During the "listen" stage, the lecturer explains the concept of the reaction equation to the students and emphasizes the presentation of basic concepts. Stoichiometry is used to determine the mass in a balanced equation. The lecturer also provides a case study for the students to solve, aiming to develop their analytical skills and interest in further study. In the "search" stage, students explore their understanding and are encouraged to search for additional sources of information to strengthen their concepts. They have the freedom to choose various reading sources such as books, the internet, and other learning materials. The goal is for students to gather scientific information that can help them solve problems. Students show enthusiasm in finding the required information. During the "read" stage, students are asked to understand the reading sources independently. They focus on reading and concentrate to grasp the essence of the information. Students are engaged and take the learning resource seriously. In the "discuss" stage, students formulate appropriate answers and respond to problems raised by the lecturers and their peers.

The findings showed that LISERED learning model is more suitable for students with high ESLS. Students entered the classroom with apperceptive knowledge so that they have already scientific literacy before the lesson began. It is supported by the previous research related to LRD and discovery learning model [10], [43]. Just like the research conducted by Prastika *et al.* [17], where they applied problem-based learning, the learning model includes steps similar to LISERED, namely "search" and "discuss". Thanks to the implementation of this model, the students' scientific literacy skills significantly improved. Moreover, the research also mentioned that changes occurred in the students' attitudes as well [17], [44].

Students with better early scientific literacy will have better understanding in mastery learning of new concepts [45]. From the comparison of LISERED and DI learning model, students' achievement during LISERED is higher than students' achievement during DI in improving scientific literacy. It means that LISERED learning model is more suitable for the teaching and learning process of basic chemistry course than DI learnings model. The same result is found in the previous research regarding DI model [10], [46]. DI as learning model requires students to follow the direct steps given by the teacher. It means that the teacher controls the focus of classroom to engage in the explanation [46]. Students are not asked to join the interactive or two-way interaction [23]. According to Yaghmour and Obaidat [47], the implementation of the DI learning model in actual learning has the potential to enhance students' learning outcomes. However, the improvement or change is not significant enough to recommend this model when teachers aim for their students to achieve 21st-century skills [45], [47]. Meanwhile, scientific literacy requires students to be more active and engaging in the lesson. To sum up, LISERED model is suitable for chemistry learning.

The LISERED learning model is an approach that has been proven effective in increasing students' scientific literacy. This approach combines several important stages in learning scientific literacy [6]. The LISERED approach creates an active and collaborative learning environment, where students engage in a variety of activities that strengthen their understanding of science. Thus, this approach helps improve students' scientific literacy through an effective combination of listening, searching, reading, and discussion [1], [4]. Certainly, the learning model that includes steps of inquiry, discussion, and reading is considered more successful in enhancing students' scientific literacy, as proven by the research by Setiawan *et al*. [48]. The study successfully demonstrated that the implementation of a learning model that incorporates independent material search, reading, and discussion processes, such as the inquiry model, has a significant positive impact on improving students' scientific literacy [48], [49].

Based on the results, the advantages of the LISERED model are that this model is able to improve students' scientific literacy in basic chemistry courses, increase student activity during the learning process, create a new atmosphere and train 21st century learning skills, position teachers as facilitators in the learning process, position students as learning subjects where students are actively involved in the process of seeking information and conveying their findings, as well as changing teacher centered activities to student centered activities. It has been proven that the LISERED learning model is a very effective approach in increasing students' scientific literacy. This research contributes practically by introducing an innovative learning approach, namely LISERED, which has been proven effective in enhancing students' scientific literacy in higher education. LISERED not only integrates various sources of information but also develops students' critical and analytical skills in evaluating and synthesizing scientific information. Theoretically, this research contributes by developing a new learning model that can serve as a foundation for further research in the field of scientific literacy. By combining the approaches of listening, searching, reading, and discussing, LISERED creates a comprehensive framework to facilitate student-centered learning and the development of scientific literacy skills. Additionally, this research also provides methodological contributions by offering practical guidelines for educators in designing and implementing LISERED-based learning.

The LISERED model offers students the chance to engage in active learning, enhance their comprehension, and cultivate essential critical thinking abilities that are crucial for scientific literacy. However, the application process of this model in higher education exhibits certain weaknesses. These weaknesses encompass the search stage, which necessitates sufficient facilities and infrastructure like the internet. Additionally, the independent information-seeking and extraction by students becomes more challenging, and educators may not be fully proficient in effectively and efficiently managing class and time.

4. CONCLUSION

The LISERED model is effectively applied to basic chemistry learning in college students. This can be seen from the post-test score which is better than the pre-test value of scientific literacy and the calculation of the ES shows a relatively high value. The LISERED learning model can train students to have scientific literacy skills. The LISERED learning model can be applied more broadly by making modifications according to the needs and conditions for courses at universities or subjects in schools to improve students' scientific literacy. Modification of the LISERED learning model becomes an opportunity as a form of further research for other researchers. Based on the research results, several suggestions have been identified as it is recommended that this learning model can be applied to other subjects using more rigorous experimental methods and with a wider sample size.

REFERENCES

[1] C. A. Dewi, M. Erna, M. Martini, I. Haris, and I. N. Kundera, "The effect of contextual collaborative learning based ethnoscience to increase student's scientific literacy ability," *Turkish Journal of Science Education*, vol. 18, no. 3, pp. 525–541, Sep. 2021, doi: 10.36681/tused.2021.88.

[2] S. A. Vong and W. Kaewurai, "Instructional model development to enhance critical thinking and critical thinking teaching ability of trainee students at regional teaching training center in Takeo province, Cambodia," *Kasetsart Journal of Social Sciences*, vol. 38, no. 1, pp. 88–95, 2017.

[3] Afandi, Sajidan, M. Akhyar, and N. Suryani, "Development frameworks of the Indonesian partnership 21st-century skills standards for prospective science teachers: a Delphi study," *Jurnal Pendidikan IPA Indonesia*, vol. 8, no. 1, pp. 89–100, Mar. 2019, doi: 10.15294/jpii.v8i1.11647.

[4] I. Yuliana, M. E. Cahyono, W. Widodo, and I. Irwanto, "The effect of ethnoscience-themed picture books embedded within contextbased learning on students' scientific literacy," *Eurasian Journal of Educational Research*, vol. 92, pp. 317–334, 2021, doi: 10.14689/ejer.2021.92.16.

[5] U. Aiman, S. Hasyda, and U. Uslan, "The influence of process oriented guided inquiry learning (POGIL) model assisted by realia media to improve scientific literacy and critical thinking skill of primary school students," *European Journal of Educational Research*, vol. 9–2, no. 4, pp. 1635–1647, Oct. 2020, doi: 10.12973/eu-jer.9.4.1635.

[6] J. Jufrida, F. R. Basuki, W. Kurniawan, M. D. Pangestu, and O. Fitaloka, "Scientific literacy and science learning achievement at junior high school," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 8, no. 4, pp. 630–636, Dec.

2019, doi: 10.11591/ijere.v8i4.20312.
[7] W. D. Cahya and L. P. Artini, “The implementation of independent reading literacy activities in secondary education,” *Journal of Education Research and Evaluation*, vol. 4, no. 1, pp. 63–72, Mar. 2020, doi: 10.23887/jere.v4i1.23515.
[8] I. G. N. Pujawan, N. N. Rediani, I. G. W. S. Antara, N. N. C. A. Putri, and G. W. Bayu, “Revised bloom taxonomy-oriented learning activities to develop scientific literacy and creative thinking skills,” *Jurnal Pendidikan IPA Indonesia*, vol. 11, no. 1, pp. 47–60, Mar. 2022, doi: 10.15294/jpii.v11i1.34628.
[9] M. Nurtanto, M. Fawaid, and H. Sofyan, “Problem based learning (PBL) in industry 4.0: improving learning quality through character-based literacy learning and life career skill (LL-LCS),” *Journal of Physics: Conference Series*, vol. 1573, no. 1, p. 012006, Jul. 2020, doi: 10.1088/1742-6596/1573/1/012006.
[10] A. Sutiani, M. Situmorang, and A. Silalahi, “Implementation of an inquiry learning model with science literacy to improve student critical thinking skills,” *International Journal of Instruction*, vol. 14, no. 2, p. 117, 2021, doi: 10.29333/iji.2021.1428a.
[11] F. N. N. Al-Momani, “Assessing the development of scientific literacy among undergraduates college of education,” *Journal of Studies in Education*, vol. 6, no. 2, pp. 199–212, 2016.
[12] D. Fatmasari, W. Waridin, and A. S. Kurnia, “Technical analysis and values of Fathonah, Amanah, Shidiq and Tabligh (Fast) in production factors management,” *International Journal of Scientific and Technology Research*, vol. 9, no. 2, pp. 693–704, 2020.
[13] S. M. Glynn and K. D. Muth, “Reading and writing to learn science: achieving scientific literacy,” *Journal of Research in Science Teaching*, vol. 31, no. 9, pp. 1057–1073, Nov. 1994, doi: 10.1002/tea.3660310915.
[14] E. W. C. Lim, “Technology enhanced learning of quantitative critical thinking,” *Education for Chemical Engineers*, vol. 36, pp. 82–89, Jul. 2021, doi: 10.1016/j.ece.2021.04.001.
[15] C. Anggraeni, A. Permanasari, and L. Heliawati, “Students’ scientific literacy in chemistry learning through collaborative techniques as a pillar of 21st-century skills,” *Journal of Innovation in Educational and Cultural Research*, vol. 3, no. 3, pp. 457–462, May 2022, doi: 10.46843/jiecr.v3i3.162.
[16] Adnan, U. Mulbar, Sugiarti, and A. Bahri, “Scientific literacy skills of students: problem of biology teaching in junior high school in South Sulawesi, Indonesia,” *International Journal of Instruction*, vol. 14, no. 3, p. 847, 2021, doi: 10.29333/iji.2021.14349a.
[17] M. D. Prastika, M. Wati, and Suyidno, “The effectiveness of problem-based learning in improving students scientific literacy skills and scientific attitudes,” *Berkala Ilmiah Pendidikan Fisika*, vol. 7, no. 3, pp. 185–195, 2019, doi: 10.20527/bipf.v7i3.7027.
[18] T. Fırat and İ. Koyuncu, “Investigating reading literacy in PISA 2018 assessment,” *International Electronic Journal of Elementary Education*, vol. 13, no. 2, pp. 263–275, Jan. 2021, doi: 10.26822/iejee.2021.189.
[19] K. Putri, Z. Muchtar, and A. Darmana, “Develop an Android-based learning media integrated with a scientific approach to the colligative solution’s nature,” *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, vol. 4, no. 1, pp. 322–329, Jan. 2021, doi: 10.33258/birle.v4i1.1605.
[20] A. Supriyadi, Desy, Y. Suharyat, T. A. Santosa, and A. Sofianora, “The effectiveness of STEM-integrated blended learning on Indonesia student scientific literacy: a meta-analysis,” *International Journal of Education and Literature*, vol. 2, no. 1, pp. 41–48, Feb. 2023, doi: 10.55606/ijel.v2i1.53.
[21] Hasbiyallah, M. Munadi, and D. Nurulhaq, “Character education model for high school students during the pandemic in terms of pedagogic competence and teacher personality,” *International Journal of Instruction*, vol. 16, no. 2, pp. 1077–1094, Apr. 2023, doi: 10.29333/iji.2023.16257a.
[22] R. Arliza, A. Yani, and I. Setiawan, “Development of interactive learning media based on Android education geography,” *Journal of Physics: Conference Series*, vol. 1387, no. 1, p. 012023, Nov. 2019, doi: 10.1088/1742-6596/1387/1/012023.
[23] M. Ş. Akbulut and J. R. Hill, “Case-based pedagogy for teacher education: an instructional model,” *Contemporary Educational Technology*, vol. 12, no. 2, p. ep287, Oct. 2020, doi: 10.30935/cedtech/8937.
[24] R. A. M. de Kleijn, “Supporting student and teacher feedback literacy: an instructional model for student feedback processes,” *Assessment & Evaluation in Higher Education*, vol. 48, no. 2, pp. 186–200, Feb. 2023, doi: 10.1080/02602938.2021.1967283.
[25] X. Tang and D. Zhang, “How informal science learning experience influences students’ science performance: a cross-cultural study based on PISA 2015,” *International Journal of Science Education*, vol. 42, no. 4, pp. 598–616, Mar. 2020, doi: 10.1080/09500693.2020.1719290.
[26] K. C. Dewi, P. I. Ciptayani, H. D. Surjono, and P. Priyanto, “Study of instructional model on blended learning in polytechnic,” *Jurnal Cakrawala Pendidikan*, vol. 37, no. 2, p. 260570, Jul. 2018, doi: 10.21831/cp.v37i2.18267.
[27] S. Turan, “Pre-service teacher experiences of the 5E instructional model: a systematic review of qualitative studies,” *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 17, no. 8, p. em1994, Jul. 2021, doi: 10.29333/ejmste/11102.
[28] S.-N. C. Rundgren and C.-J. Rundgren, “What are we aiming for?—A Delphi study on the development of civic scientific literacy in Sweden,” *Scandinavian Journal of Educational Research*, vol. 61, no. 2, p. 224, 2017, doi: 10.1080/00313831.2015.1120231.
[29] A. V. Manzo and U. P. Casale, “Listen-read-discuss: a content reading heuristic,” *Journal of Reading*, vol. 28, no. 8, pp. 732–734, 1985.
[30] D. Darwin and U. A. Chaeruman, “The implementation of self determination theory in e-learning to improve listening skills,” *Journal of Education Research and Evaluation*, vol. 6, no. 2, pp. 264–272, Feb. 2022, doi: 10.23887/jere.v6i2.35693.
[31] R. bin Sahib, “The use of translanguaging as a pedagogical strategy in efl classroom: a case study at Bulukumba Regency,” *LET: Linguistics, Literature and English Teaching Journal*, vol. 9, no. 2, pp. 22–48, Dec. 2019, doi: 10.18592/let.v9i2.3124.
[32] V. O. Acero, E. S. Javier, and H. O. Castro, *Principles and strategies of teaching*. Quezon City: Rex Bookstore, Inc., 2000.
[33] A. V. Manzo and U. C. Manzo, *Teaching children to be literate: a reflective approach*. Literacy Leaders, 1995.
[34] C. D. S. Indrawati, “The effectiveness of archiving videos and online learning on student’s learning and innovation skills,” *International Journal of Instruction*, vol. 14, no. 4, pp. 135–154, Oct. 2021, doi: 10.29333/iji.2021.1449a.
[35] J. H. Nunaki, I. Damopolii, N. Y. Kandowangko, and E. Nusantari, “The effectiveness of inquiry-based learning to train the students’ metacognitive skills based on gender differences,” *International Journal of Instruction*, vol. 12, no. 2, pp. 505–516, Apr. 2019, doi: 10.29333/iji.2019.12232a.
[36] K. Nikolopoulou, V. Gialamas, K. Lavidas, and V. Komis, “Teachers’ readiness to adopt mobile learning in classrooms: a study in Greece,” *Technology, Knowledge and Learning*, vol. 26, no. 1, pp. 53–77, Mar. 2021, doi: 10.1007/s10758-020-09453-7.
[37] A. Alqahtani, “Usability testing of Google cloud applications: students’ perspective,” *Journal of Technology and Science Education*, vol. 9, no. 3, pp. 326–339, May 2019, doi: 10.3926/jotse.585.
[38] S. Sumarni, M. Akhyar, M. Nizam, and H. Widyastono, “Designing and validating an instrument to measure the practicality of the research-based blended flipped learning model,” *World Transactions on Engineering and Technology Education*, vol. 20, no. 4, pp. 1–8, 2022.
[39] C. Gormally, P. Brickman, and M. Lutz, “Developing a test of scientific literacy skills (TOSLS): measuring undergraduates’ evaluation of scientific information and arguments,” *CBE—Life Sciences Education*, vol. 11, no. 4, pp. 364–377, 2012.

[40] H. Cooper, L. V. Hedges, and J. C. Valente, *The handbook of research synthesis and meta-analysis*, 3rd ed. Russell Sage Foundation, 2019.
[41] A. Asrizal, A. M. Zan, V. Mardian, and F. Festiyed, "The impact of static fluid e-module by integrating stem on learning outcomes of students," *Journal of Education Technology*, vol. 6, no. 1, pp. 110–118, Mar. 2022, doi: 10.23887/jet.v6i1.42458.
[42] T. Junanto, M. Akhyar, Budiyono, and N. Suryani, "Profile of undergraduate students as prospective science teachers in terms of science literacy," in *International Conference on Progressive Education (ICOPE 2019)*, Paris, France: Atlantis Press, 2020, pp. 398–402, doi: 10.2991/assehr.k.200323.158.
[43] S. Fazilla, A. Yus, and Muthmainnah, "Digital literacy and TPACK's impact on preservice elementary teachers' ability to develop science learning tools," *Profesi Pendidikan Dasar*, vol. 9, no. 1, pp. 71–80, Jul. 2022, doi: 10.23917/ppd.v9i1.17493.
[44] A. Zendler and K. Klein, "The effect of direct instruction and web quest on learning outcome in computer science education," *Education and Information Technologies*, vol. 23, no. 6, pp. 2765–2782, Nov. 2018, doi: 10.1007/s10639-018-9740-4.
[45] S. Sudarmin, S. Mursiti, and A. G. Asih, "The use of scientific direct instruction model with video learning of ethnoscience to improve students' critical thinking skills," *Journal of Physics: Conference Series*, vol. 1006, no. 1, p. 12011, 2018.
[46] E. Purwaningsih, S. P. Sari, A. M. Sari, and A. Suryadi, "The effect of STEM-PJBL and discovery learning on improving students' problem-solving skills of the impulse and momentum topic," *Jurnal Pendidikan IPA Indonesia*, vol. 9, no. 4, pp. 465–476, Dec. 2020, doi: 10.15294/jpii.v9i4.26432.
[47] K. S. Yaghmour and L. T. Obaidat, "The effectiveness of using direct instruction in teaching comprehension skill of third-grade students," *International Journal of Instruction*, vol. 15, no. 2, pp. 373–392, Apr. 2022, doi: 10.29333/iji.2022.15221a.
[48] D. G. E. Setiawan *et al.*, "Influence of inquiry-based learning model on scientific literacy in the rotational dynamics of a rigid bodies," *Jurnal Penelitian Pendidikan IPA*, vol. 9, no. 3, pp. 1118–1123, Mar. 2023, doi: 10.29303/jppipa.v9i3.3249.
[49] E. Andriana, T. Djudin, and S. B. Arsyid, "Remediation of misconceptions about light refraction in thin lenses using direct instruction assisted by Flash animation in high school," (in Indonesian), *Jurnal Pendidikan dan Pembelajaran*, vol. 3, no. 1, 2019, doi: 10.26418/jppk.v3i1.4255.

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