Orbital
The electronic journal of chemistry

the electronic journal of chemistry

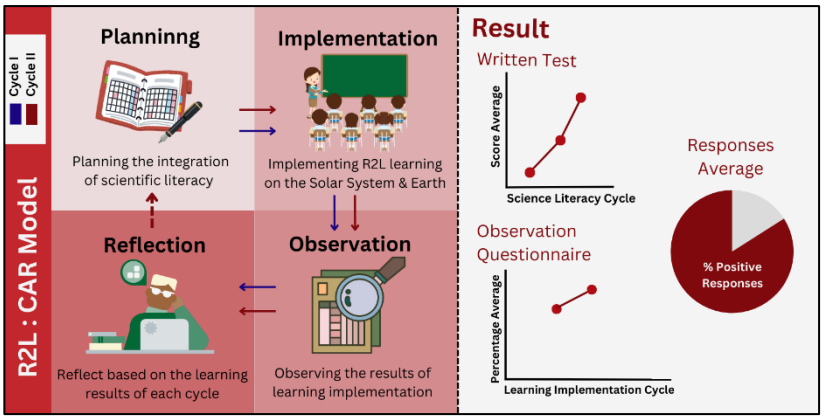
Paper on Education | http://dx.doi.org/10.17807/orbital.v17i4.23066

# Enhancing Scientific Literacy on Earth and Solar System Concepts Through the Reading to Learn (R2L) Model: A Classroom Action Research Study

Luqmanul Hakiim* [a], Herunata [b], Agustuti Hasto Welas Asih [c], Gufron [c], Deni Ainur Rokhim [d], Eukharistia Yenadiputri [e], and Diana Novel Smith [f]

Indonesia's low science literacy, as reflected by its 70th place ranking out of 78 countries in the 2018 PISA rankings, highlights the need for better education strategies. This research aims to examine the application of the R2L (Reading to Learn) model to increase scientific literacy. Using a Collaborative Classroom Action Research design (Kemmis and Taggart model), the study was conducted over two cycles with 36 students from class VII-8 at SMP Negeri 3 Candi. Data collected included students' scientific literacy, learning implementation, reflection, and responses through written tests, observation, and questionnaires. Learning implementation quality also increased from 92.01% to 97.57%, with student responses averaging 83.61%, indicating high engagement. Thus, this research confirms that the R2L model effectively improves scientific literacy of class VII students at SMP Negeri 3 Candi in science learning.

## Graphical abstract




## Keywords

Earth and solar system
reading to learn
scientific literacy

## Article history

**Received** 29 Mar 2025
**Revised** 30 May 2025
**Accepted** 30 May 2025
**Available online** 07 Sep 2025

**Handling Editor:** Mayker L. D. Miranda

## 1. Introduction

The vision of 21st-century learning in education has shifted from an emphasis on cognitive understanding to a focus on learning and thinking that prioritize logical and rational knowledge, as well as problem-solving skills and the ability to live independently. Teachers need to adapt their teaching methods to align with the emerging trends in

[a] Teacher Professional Education, Universitas Negeri Malang, Malang, Jl. Semarang 5, zip code 65145, Indonesia. [b] Chemistry Department, Universitas Negeri Malang, Malang, Jl. Semarang 5, zip code 65145, Indonesia. [c] SMP Negeri 3 Candi, Jl. Kedaton, Sidoarjo, zip code 61213, Indonesia. [d] Faculty of Mathematics and Science, Universitas Negeri Malang, Malang, Jl. Semarang 5, zip code 65145, Indonesia. [e] Science and Data Analytics, Insitute Technology of Sepuluh Nopember, Surabaya, Jl. Teknik Kimia, zip code 60111, Indonesia. [f] Pharmacy, Universitas Airlangga, Surabaya, Jl. Dr. Ir. H. Soekarno, zip code 60115, Indonesia. *Corresponding author. E-mail: **luqmanul.hakiim.2203519@students.um.ac.id: herunata.fmipa@um.ac.id; deniainurrokhim@gmail.com**

education [1]. A current trend is the emphasis on scientific literacy in relation to science education. This presents a challenge for science teachers to design instructional strategies that motivate students to enhance their scientific competence [2].

Integrated science learning at the junior high school/MTs level is integrated science learning that integrates various concepts and theories of science in the subject matter of natural science and phenomena that occur in the surrounding environment [3]. Science learning does not only focus on learning facts, concepts, principles, laws, and theories. However, science learning can also train students' skills to think and apply science knowledge in everyday life [4]. Science learning aims to prepare students to survive and succeed in the 21st century [5]. All learning tools must be oriented towards 21st-century competencies so that students can have these competencies [6].

Scientific literacy is the ability to apply scientific knowledge based on scientific evidence to solve problems that occur in real life [7]. The results of the Program for International Student Assessment (PISA) test show that Indonesia is in the lower position of other countries in the world. Indonesia scored 396 in 2018, which decreased from 2015 with a score of 403 [7]. There are three scientific literacy competencies measured by PISA, namely the competency to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence scientifically [8].

The low scientific literacy scores of Indonesian students may result from a lack of ability to solve complex problems, including the ability to identify, understand, and apply basic science concepts [9]. Additionally, students need to develop their reasoning abilities through the practice of critical thinking, which involves analyzing factual texts in science education [10]. Interviews with science teachers at SMP Negeri 3 Candi revealed that literacy is considered an important area for development in the school's educational report card. According to these interviews, the school's literacy and numeracy scores remain low compared to other schools in Sidoarjo. The school has implemented literacy activities on Saturdays, but these have not been sufficiently effective. Therefore, literacy and numeracy need to be integrated into regular classroom instruction.

Active learning that directly engages students makes the learning experience more meaningful and can enhance scientific literacy [11]. Learners are expected to possess scientific literacy skills to understand material concepts, the relationships between various aspects, and the ability to solve real-life problems [12].

In science education, a learning model is necessary to provide direction, as it outlines the steps to be followed during the learning process [13]. One learning model that facilitates the development of scientific literacy is the Reading to Learn (R2L) model. The R2L model helps students understand factual texts by identifying unfamiliar words and synonyms, allowing them to interpret the text in their own words. Through the steps of the model, learners are effectively supported in developing scientific literacy by comprehending the meaning of factual texts. The steps in this learning model include preparing and reading factual texts, taking notes, and co-constructing knowledge from the notes [14].

The R2L model actively engages students in learning activities and helps them develop a deeper understanding of scientific concepts, thereby enhancing their scientific literacy skills [15, 16]. This model emphasizes the interaction between teachers and learners to collaboratively build scientific knowledge [17]. The R2L model guides learners in reading factual texts and encourages them to learn from what they read by recording their understanding [18]. The R2L model includes structured steps that encourage learners to articulate their understanding [19]. R2L has proven successful in enhancing learners' literacy skills in several countries and is currently being implemented in various regions worldwide [20].

Using stories or reading texts in middle school can enhance students' motivation and writing skills [21]. Additionally, in middle school, the application of scientific language elements is beginning, making the use of factual texts in learning highly beneficial [22]. In learning, students need to be engaged and accustomed to reading activities [23]. The reading material should align with the content being studied, and the language and structure of the text must be tailored to students' abilities, ensuring that the text helps readers optimize their reading skills [24]. Interviews with several junior high school science teachers revealed that science education has not yet integrated scientific literacy. During science lessons, teachers primarily focus on helping students understand scientific concepts rather than developing their scientific literacy skills. Teachers typically provide tables during practical sessions and guide students through the design process and reporting, but this has not yet led to students becoming accustomed to developing scientific literacy skills.

To enhance students' scientific literacy, strategies can be employed to identify science-related topics that engage students' attention and integrate them into classroom learning [25]. The Earth and the solar system are among the science topics that can capture students' attention but cannot be directly presented in the classroom [26]. Earth and solar system content is considered challenging by most students because it involves numerous concepts that need to be understood, and there is a lack of tangible objects or sufficient illustrations [27].

The purpose of this study was to evaluate the impact of the Reading-to-Learn model on students' scientific literacy regarding Earth and solar system topics, assess the implementation of the learning process, reflect on the learning outcomes, and examine students' responses to the instructional methods applied

## 2. Results and Discussion

In this research, the primary focus is measuring scientific literacy on Solar System content through the application of the R2L learning model. This study was designed with two cycles. Cycle I consists of planning, implementation, observation, and reflection. If Cycle I does not meet the minimum achievement criteria, established minimum completeness criteria, it will proceed to Cycle II. The lesson planning integrates competencies in scientific literacy, which include the ability to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence scientifically, in accordance with the PISA test framework [7]. The results of the scientific literacy-based learning framework and the R2L model are presented in Table 1.

Prior to the implementation of Cycle I, a diagnostic assessment of scientific literacy competence (pre-test) was conducted to assess students' initial scientific literacy skills on Earth and Solar System material in Grade VII. The pre-test, administered before Cycle I as a pre-cycle action, consisted of

general questions assessing students' scientific literacy on Earth and Solar System material. The results of the pre-cycle assessment are presented in Table 2.

**Table 1.** Learning device framework results.

| Syntax of R2L Learning Model | Scientific literacy Competency | Students Learning Activities |
|---|---|---|
| Prepare and Reading Factual Text | Explain phenomena scientifically | Find the meaning of unfamiliar words and look for synonyms of words in the factual text that has been given |
| Note Making from Factual Text | Evaluate and design scientific investigations | Formulate questions and explore questions scientifically |
| Joint Construction from Note | Interpret data and evidence scientifically | Process, analyse, and interpret data based on word synonyms and foreign word explanations to produce conclusions or new factual texts |

**Table 2.** Scientific literacy results of pre-cycle students.

| Cycle | Total value | Mean | Highest score | Lowest score |
|---|---|---|---|---|
| Pre | 480 | 15.00 | 40 | 0 |

Table 2 indicates that students' scientific literacy competence is significantly low, with an average score of 15. This finding highlights a critical issue in the classroom, as the low level of scientific literacy necessitates improvement through the implementation of scientific literacy-based learning using the R2L model.

In Cycle I, learning was implemented using the Solar System and Earth's position within it. Teachers prepared by developing teaching modules and designing observation sheets for learning implementation and reflection. Additionally, teachers prepared learning media and scientific literacy assessment tools, including written tests with various question formats. The results of Cycle I are presented in Table 3.

**Table 3.** Scientific literacy results of Cycle I students.

| Cycle | Total value | Mean | Highest score | Lowest score |
|---|---|---|---|---|
| I | 1430 | 40.86 | 60 | 20 |

Students' scientific literacy improved in Cycle I, as indicated by an average score of 40.86 (Table 3). Based on observers' assessments, the reflection from Cycle I highlights an issue with the grouping technique, where each group consisted of six students, which was deemed less effective. This grouping method was found to reduce learning effectiveness, as it led to a lack of student responsibility in engaging with classroom activities. The results of learning implementation in cycle I can be presented in Table 4.

Table 4 indicates that the implementation of learning in Cycle I was effective, with an average percentage of 92.01%, categorized as very good. According to [31], a learning implementation percentage of 40% or higher indicates that students have successfully engaged in the learning process. These findings suggest that, overall, students were able to effectively engage in scientific literacy-based learning using the R2L model.

**Table 4.** Cycle I learning implementation results.

| Observation Aspect | Percentage (%) | Description |
|---|---|---|
| Student Learning Process | 83.33 | Most of the students have participated in the learning process effectively |
| Teacher's Teaching Process | 93.75 | The teacher has shown firmness in the learning process and adequately facilitated the diverse needs of the students. |
| Learning Process Runs Effectively | 100 | The learning process was effective, involving students actively |
| Appropriate Learning Media | 100 | The learning media used were appropriate to the context of the lesson |
| Appropriate Learning Assessment | 100 | The assessment successfully measured scientific literacy competencies |
| Implementation of Learning Reflection | 75 | The reflection process was generally good but was conducted hastily |
| **Mean** | **92.01** | **Very Good** |

However, the scores in Cycle I did not meet the Minimum Mastery Criteria (KKM). The KKM based on the policy of SMP Negeri 3 Candi is 70 in science subjects, which is the minimum passing score to show that students have achieved sufficient understanding of the material. Therefore, he reflection from Cycle I serves as a basis for planning the next cycle. A good learning process will be a determining factor for good learning outcomes. In cycle II, the implementation of learning with the R2L learning model was carried out on the subject of satellites in the solar system and the sun in the solar system. Teachers make preparations by making teaching modules, learning implementation observation sheets, and student response questionnaires to learning. In addition, teachers also prepare learning media and scientific literacy evaluation tools in the form of written tests with various forms of questions. Cycle II learning results are presented in Table 5.

**Table 5.** Scientific literacy results of Cycle II students.

| Cycle | Total value | Mean | Highest score | Lowest score |
|---|---|---|---|---|
| II | 2540 | 72.57 | 80 | 60 |

Compared to the previous cycle, Table 5 shows that there has been a further increase in students' scientific literacy competence, with an average score of 72.57. Thus, based on the average scores from Cycles I and II, it can be concluded that the R2L model effectively enhances students' scientific literacy. This finding aligns with the theory that the R2L model facilitates scientific literacy-based learning by enabling students to comprehend factual texts in depth, thereby supporting the learning process [14]. Additionally, previous research has found that the R2L model has a positive effect on improving students' scientific literacy skills [29]. The R2L model enhances students' ability to read in detail and take notes, which in turn fosters positive character traits [30]. The results of the learning implementation in Cycle II are presented in Table 6.

Based on Figure 1, the results of the learner response questionnaire indicate that there were no negative responses (0%) for 'strongly disagree,' while 14.72% of students responded with 'disagree.' Conversely, positive responses comprised 36.11% for 'agree' and 49.17% for 'strongly agree.' These results suggest that students responded positively to the implemented learning approach and found the learning experience meaningful. Engaging in text creation activities can help students practice constructing sentences in their own words, thereby enhancing their comprehension of the material [32]. Students also demonstrated increased engagement, enthusiasm, and curiosity during the learning process. The implementation of the R2L model serves as a viable alternative for teachers to facilitate meaningful learning experiences and enhance students' scientific literacy skills. When compared to previous literature, the R2L model may be the answer to overcoming the limitations of other text-based models such as the Text-Based Approach (TBA).

The Reading to Learn (R2L) model can be considered a more inclusive framework for addressing some of the limitations of TBA. In Sara Nachtigal's (2016) dissertation titled "Learning from Text: Analyzing Teachers' Thinking and Practices in AP Environmental Science," the implementation of TBA in science education faced several challenges, such as low student engagement with academic texts and inadequate support for students from disadvantaged backgrounds [33]. These limitations highlight the need for a more structured approach to text-based learning. Through R2L as a reinforcement, step-by-step reading strategies, interactions with texts designed to support diverse students, and the introduction of deeper academic literacy, these needs can be addressed.

**Table 6.** Cycle II learning implementation results.

| Observation aspect | Percentage (%) | Description |
|---|---|---|
| Student Learning Process | 91.67 | Most of the students have participated in the learning process effectively |
| Teacher's Teaching Process | 93.75 | The teacher has shown firmness in the learning process and adequately facilitated the diverse needs of the students. |
| Learning Process Runs Effectively | 100 | The learning process was effective, involving students actively |
| Appropriate Learning Media | 100 | The learning media used were appropriate to the context of the lesson |
| Appropriate Learning Assessment | 100 | The assessment successfully measured scientific literacy competencies |
| Implementation of Learning Reflection | 100 | The implementation of reflection in classroom learning goes well |
| **Mean** | **97.57** | **Very Good** |

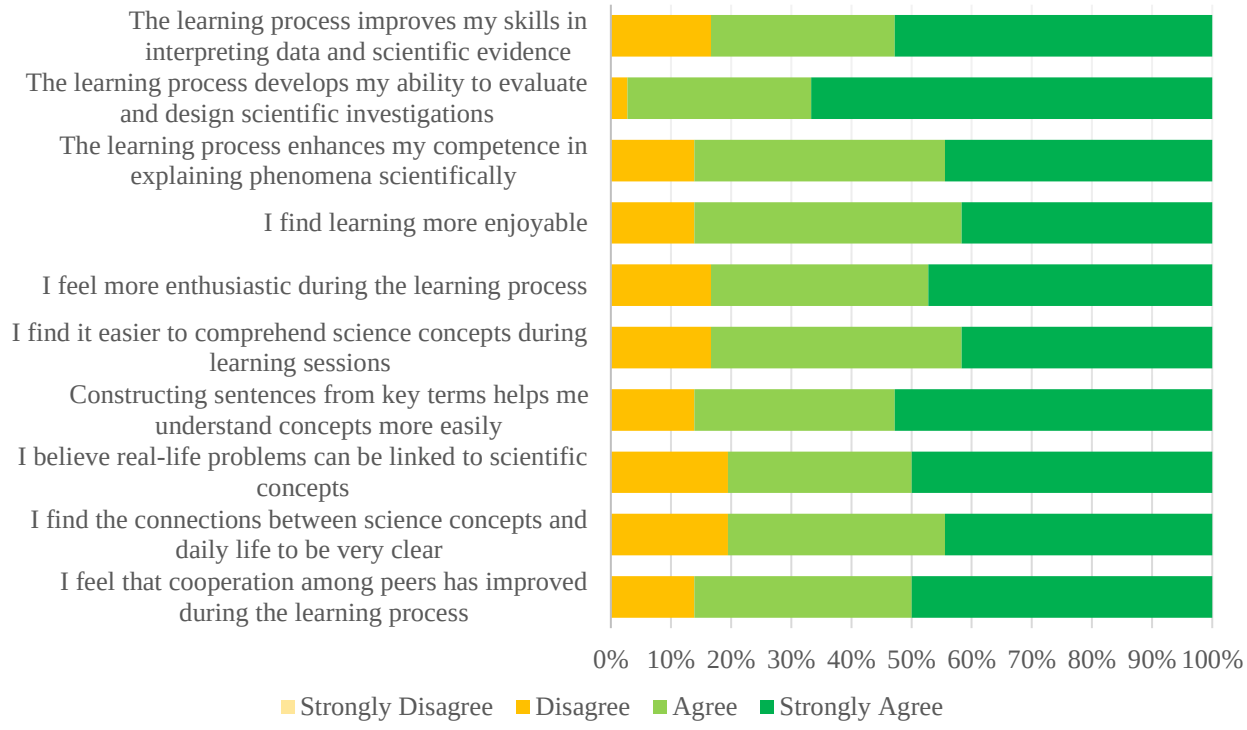



**Fig. 1.** Recapitulation of Learner Response Questionnaire.

## 3. Material and Methods

The type of research used is the Collaborative Classroom Action Research (CAR) model by Kemmis and Taggart. This research was conducted in 2 cycles with a total of 4 meetings. Each cycle has 4 stages, namely planning, implementation, observation, and reflection. The cycle diagram is presented in Figure 2.

The research was conducted between May and June 2023 at SMP Negeri 3 Candi. The participants in this study were students from class VII-8, comprising a total of 36 students during the 2022/2023 academic year. The data collected in this study included students' scientific literacy scores,

observations of learning implementation, reflections on the learning process, and students' responses to the learning activities. The instruments used in this study included a scientific literacy questionnaire to assess improvements in scientific literacy, with a pre-test administered at the beginning of the material scope and a post-test at the end of each cycle; an observation sheet for learning implementation and reflection; and a questionnaire to gather students' responses to the learning activities.

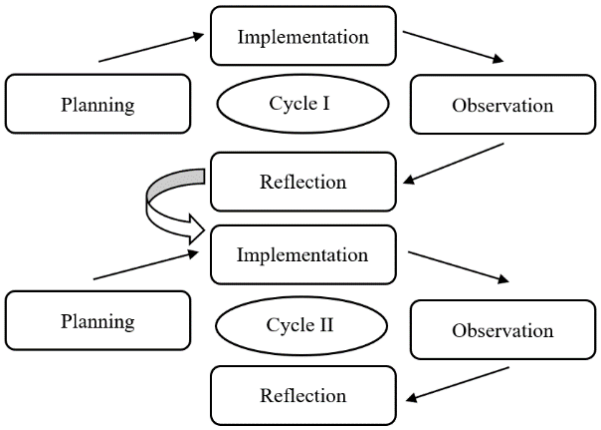



**Fig. 2.** Flow of CAR model Kemmis and Taggart.

The observation sheet instrument and the student response questionnaire used a Likert scale. The Likert scale used has a score range from 1 to 4, where a score of 1 indicates 'strongly disagree' and a score of 4 indicates 'strongly agree.' Data on scientific literacy outcomes and students' responses to learning were analyzed using descriptive statistics. Meanwhile, observation data on learning implementation and reflection were analyzed qualitatively. The scores obtained from the learning implementation observer and the student response questionnaire were then processed using the following formula.

$$\%P = \frac{\text{number of scores obtained}}{\text{maximum number of scores}} \times 100\%$$

Description:

%P = percentage of assessment score

The scores from the observation results are crucial, as they assess the quality of learning implementation and students' responses to learning. The percentage score obtained is then categorized according to the assessment interpretation scale, as shown in Table 7.

**Table 7.** Score interpretation criteria.

| Assessment Score (%) | Category | Description |
|---|---|---|
| 81-100 | Very Good | Highly Feasible / Highly Valid / Highly Practical |
| 61-80 | Good | Feasible / Valid / Practical |
| 41-60 | Moderate | Moderately Feasible / Moderately Valid / Moderately Practical |
| 21-40 | Poor | Less Feasible / Less Valid / Less Practical |
| <20 | Very Poor | Highly Infeasible / Highly Invalid / Highly Impractical |

Source: [28]

## 4. Conclusions

The results of the study showed an improvement in students' scientific literacy, with scores increasing from 15.00 in the pre-cycle to 40.86 in Cycle I and further rising to 72.57 in Cycle II. The implementation of learning was assessed at 92.01% in Cycle I and improved to 97.57% in Cycle II, both of which fall into the 'very good' category. The student response questionnaire yielded an average score of 83.61%, also classified as 'very good.' These findings indicate that the implementation of the Reading to Learn (R2L) model in science subjects effectively enhances the scientific literacy of seventh-grade students at SMP Negeri 3 Candi.

## Acknowledgments

The researchers are very grateful for all the support and guidance provided by all parties who contributed to the successful completion of this research. Thanks are expressed to the principal of SMPN 3 Candi along with the teachers and staff who have allowed research in the school and the seventh-grade students who have been willing to assist the research process.

## Author Contributions

Luqmanul Hakiim: conceptualization, methodology, formal analysis, validation, investigation, data curation and writing-original draft. Herunata and Gufron: conceptualization, methodology, formal analysis, writing-original draft. Agustuti Hasto Welas Asih: conceptualization, methodology, formal analysis, resources, writing-original draft, supervision, project administration and funding acquisition. Eukharistia Yenadiputri: conceptualization, resources, writing-original draft, supervision, project administration and funding acquisition. Deni Ainur Rokhim: conceptualization, resources, writing-original draft, supervision, project administration and funding acquisition. Diana Novel Smith: conceptualization, resources, writing-original draft, supervision, project administration and funding acquisition.

## References and Notes

[1] Mirra, N.; Garcia, A. *Read Res. Q.* **2020**, *56*, 463. [Crossref]

[2] Hermansyah, H. *Jurnal Ilmiah Profesi Pendidikan* **2020**, *5*, 129. [Crossref]

[3] Noeraida. *LIK* **2014,** *43*, 25. [Crossref]

[4] Tursinawati. *Jurnal Pesona Dasar*. **2019**, *7*, 1. [Crossref]

[5] Robbia, A. Z.; Fuadi, H. *Jurnal Ilmiah Profesi Pendidikan* **2020**, *5*, 117. [Crossref]

[6] Sari, S. Y.; Sundari, P. D.; Jhora, F. U.; Hidayati, H. *JEP* **2020**, *4*, *189*. [Crossref]

[7] Available from: https://www.oecd.org/pisa/publications/pisa-2018-results.htm. Access January 2025.

[8] Available from: https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/student-problem-solving-skills/PISA2015-Released-FT-Cognitive-Items.pdf. Access January 2025

[9] Hawa, A. M.; Putra, L. V. *Janacitta* **2018**, *1*, 1. [Crossref]

[10] Nurwahidah, I. *Thabiea: Journal of Natural Science Teaching*. **2018**, *1*, 20. **[Crossref]**

[11] Wicaksono, I.; Indrawati; Supeno. *Webinar Pendidikan Fisika* **2020**, *5*, 1.

[12] Angelina, N.; Rosdiana, L. *PENSA* **2019**, *7*, 161. **[Crossref]**

[13] Afandi, M.; Chamalah, E.; & Wardani, O. P. Model dan Metode Pembelajaran di Sekolah. UNISSULA Press: Semarang, 2013.

[14] Ningsih, K. H.; Rose, D. *SFL in Practice* **2021**, *26*, 1.

[15] Hubner, N.; Merrell, C.; Cramman, H.; Little, J. *Child Development* **2022**, *93*, 1760. **[Crossref]**

[16] Rose, D. Doing maths: (De)constructing procedures for maths processes. In Teaching Science, 1st ed. Routledge, 2021, p. 30.

[17] Tasman, F.; Dewanti, A.; Hutapea, D. W.; Kurnia SN, P. A.; Lubis, A. S. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika* **2022**, *11*, 1749. **[Crossref]**

[18] Damayanti, I. L. *Indonesian Journal of Applied Linguistics* **2017**, *6*, 232. **[Crossref]**

[19] Husein, R.; Sembiring, M.; Wulandari, S.; Andary, S.; Rahman, Ma. *BirLE*. **2022**, *5*, 23. **[Crossref]**

[20] Widyastuti, T.; Awaliah, Y. R.; Hardini, T. I. 3rd International Conference on Language, Literature, Culture, and Education - Reading to Learn Strategy in Teaching and Learning Writing for the Students of Sundanese Language Education Department, 2015.

[21] Megawati, F. *TEFLIN* **2012**, *23*, 183. **[Crossref]**

[22] Tong, F.; Irby, B. J.; Lara-alecio, R.; Koch, Mirra, N.; Garcia, A. *Reading Research Quarterly* **2021**, *56*, 463. **[Crossref]**

[23] Muttaqin, A.; Sopandi, W. *Edusains* **2016**, *8*, 57. **[Crossref]**

[24] Wright, T. S. *American Educator* **2019**, *42*, 4. **[Link]**

[25] Ogunkola, B. J. *Journal of Educational and Social Research* **2013**, *3*, 265. **[Crossref]**

[26] Fitriani, D. K.; Supeno, Wahyuni, D.; Rahayuningsih. *JES* **2022**, *9*, 294. **[Crossref]**

[27] Nuqisari, R.; Sudarmilah, E. *Emitor: Jurnal Teknik Elektro* **2019**, *19*, 90. **[Link]**

[28] Arikunto. Prosedur Penelitian Suatu Pendekatan Praktik. Rineka Cipta, 2015.

[29] Wulandari, A. T.; Jahro, I. S. *Jurnal Pendidikan Sosial Dan Humaniora* **2023**, *2*, 289. **[Link]**

[30] Muttaqiin, A.; Ananda, A. S. D.; Aulia, P.; Razi, P.; Yusefarina, Y.; Yanuarsi, L. *AL-ISHLAH: Jurnal Pendidikan* **2022**, *14*, 5431. **[Crossref]**

[31] Rasyidi, M. *Khatulistiwa: Jurnal Pendidikan dan Sosial Humaniora* **2022**, *2*, 1. **[Crossref]**

[32] Berliana, G. Y.; Fardhani, I.; Sugiyanto. *ICOPE* **2023**, 107. **[Crossref]**

[33] Sara, N. *University of Washington*. 2016. 1-112. **[Link]**

## How to cite this article

Hakiim, L.; Herunata, Asih, A. H. W.; Gufron, Rokhim, D. A.; Yenadiputri, E.; Smith, D. N. *Orbital: Electronic J. Chem*. **2025**, *17*, 409. DOI: **http://dx.doi.org/10.17807/orbital.v17i4.23066**