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Research Article

The effectiveness of BRADeR learning model to improve junior high school students' science literacy abilities

Aprido Bernando Simamora [a,1,*] , **Andriono Manalu** [a,2], **Rianita Simamora** [b,3]

[a] Department of Science Education, Faculty of Teacher Training and Education, Universitas HKBP Nommensen Pematangsiantar, Jl. Sangnawaluh Siopat Suhu, Pematangsiantar, North Sumatera, 21136 Indonesia
[b] Department of Mathematics Education, Faculty of Teacher Training and Education, Universitas HKBP Nommensen Pematangsiantar, Jl. Sangnawaluh Siopat Suhu, Pematangsiantar, North Sumatera, 21136 Indonesia
[1] aprido.simamora@uhnp.ac.id; [2] andriono.manalu@uhnp.ac.id; [3] rianitacharlito@gmail.com
* Corresponding author

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Abstract: The BRADeR learning model is an innovative model developed to help teachers train students' scientific literacy skills. The aim of this research is to determine the effectiveness of the BRADeR learning model in improving junior high school students' scientific literacy skills. This research is included in the type of quasi-experimental research. The research design used is quantitative research using descriptive methods (descriptive-quantitative). The subjects of this research were seventh class students at State Junior High School 5 of Pematangsiantar. Data collection techniques are in the form of tests, and the data analysis process uses descriptive quantitative-qualitative and n-gain. The results of the research show that the BRADeR learning model is effective, in terms of: a) its influence on the scientific literacy abilities of junior high school students, where: (1) n-gain in the scientific literacy abilities of junior high school students is in the medium to high category, and (2) there is an increase in literacy abilities science junior high school students. From the research results, it can be concluded that the BRADeR learning model is effective in improving junior high school students' scientific literacy skills. Other researchers can strengthen research in this area, expand its scope, and ensure that the learning models developed can be applied more effectively and are relevant to broader contexts.

Keywords: BRADeR learning model; effectiveness; scientific literacy abilities

1. Introduction

The 21st century is a century of globalization full of challenges. Countries in the world are increasingly racing to win in the era of global competition marked by advances in science and technology (Barak & Assal, 2018; Greenstein, 2012; Snow & Dibner, 2016). The 21st century can also be said to be a century marked by a massive transformation from an agrarian society to an industrial society and continuing to a knowledgeable society (Barak & Assal, 2018; Chalkiadaki, 2018; Oral & Erkilic, 2021). The transformation process of the 21st century is an era in which science and technology, especially communication technology, is developing very rapidly, which has an impact on intense free competition in all aspects of human life (Kan'an, 2018; Tomovic et al., 2017). In the tight challenges facing society, a paradigm shift is needed in the education system that can provide a set of 21st century skills needed by students to face every aspect of global life. Students who have the knowledge to understand scientific facts and the relationship between science, technology and society, and are able to apply their knowledge to solve problems in real life are called scientifically literate citizens (Odegaard et al., 2015; Wang & Zhao, 2016).

Literacy ability is one of the learning outcomes in the independent curriculum (Kemendikbudristek, 2022). Literacy skills are not only limited to the ability to read and write, however, there are six basic literacy skills that students must achieve in the independent curriculum, one of which is the ability in scientific literacy. Scientific literacy is part of science, is practical, relates to issues about science and scientific ideas (OECD, 2019). Citizens must have sensitivity to health, natural resources, environmental quality and natural disasters in personal, local, national and global contexts. Given the importance of scientific literacy, educating people to have scientific literacy is the main goal in every science education reform (Holbrook & Rannikmae, 2009; Odegaard et al., 2015; Wang & Zhao, 2016).

The National Science Education Standards (NSES) in Alake-Tuenter et al (2012) state that someone who is skilled in science will have an understanding of the six main elements of scientific literacy, namely: (1) science as inquiry, (2) science content, (3) science and technology, (4) science in personal and social perspectives, (5) the history and nature of science, and (6) the unity of concepts and processes. OECD (2016a) describes the characteristics of someone who is skilled in science, namely someone who has the ability to: (1) explain phenomena scientifically; (2) design and evaluate scientific investigations; and (3) interpret data and facts scientifically. Therefore, a science-skilled person is a person who uses scientific knowledge to identify questions and draw conclusions based on evidence in order to understand and help make decisions about the natural environment and changes resulting from human activities. With science skills, a person has the ability to engage with issues related to science, and with the ideas of science as a reflection of society (Abrori et al., 2023; Ke et al., 2021). Based on these characteristics, scientific literacy is not only needed by people who want to become scientists in the future, but is also a very important ability for all humans to master.

Education is currently undergoing development aimed at improving students' scientific literacy abilities (Situmorang, 2016). Several countries make scientific literacy the main goal in science education (Fortus et al., 2022; Ke et al., 2021; Simamora et al., 2020; Walag et al., 2022). Science learning in schools is expected to develop students' abilities in facing current educational trends, namely through scientific literacy learning. Scientific literacy skills for students are very much needed. Literature in the field of science education also shows that scientific literacy is increasingly accepted and valued by educators as an expected learning outcome (Siagian et al., 2023). Scientific literacy is defined as the ability to engage in science-related issues and think about science as a thoughtful citizen (OECD, 2019). Scientific literacy is needed to understand scientific issues, the benefits and risks of science (Fahmi et al., 2022) and with scientific literacy skills you can understand the social and environmental problems faced by society in this modern era, especially those that rely on knowledge and technology (Simamora et al., 2022).

The Indonesian government always continues to improve in improving students' scientific literacy skills. However, the condition of students' scientific literacy abilities in Indonesia has not yet achieved the expected results. The results of the Program for International Student Assessment (PISA) assessment as quoted from The Organization for Economic Cooperation and Development (OECD) ranked Indonesia in PISA in 2003, namely 38th out of 41 with a score of 395. In 2006 Indonesia was in 50th place out of 57 with a score of 393. In 2009, Indonesia was ranked 57th out of 65 with a score of 383. In 2012 Indonesia was ranked 64th out of a total of 65 countries with a score at that time of 382. Furthermore, in 2015 Indonesia was ranked 3rd. 64th out of 72 participating countries, with a score of 403, and in 2018 Indonesia was ranked 70th out of 78 participating countries, with a score of 396 (OECD, 2016a, 2019).

This is also in accordance with several research results regarding students' scientific literacy abilities in several regions in Indonesia which provide low results. Some aspects of low scientific literacy are in explaining natural phenomena which include aspects of thinking and working scientifically (Diana et al., 2015; Hasanah et al., 2017; Putra et al., 2016). Likewise, the results of research on scientific literacy abilities carried out in five public junior high schools in Pematangsiantar showed that students' scientific literacy abilities were still low (Simamora et al., 2020). Students' scientific literacy abilities in the content knowledge aspect are still relatively low, namely 31.88%, for the procedural knowledge aspect it is also very low, namely 8.56%, and for the epistemic knowledge aspect it is classified as very low, namely 2.05%.

The factors that influence students' low scientific literacy abilities are due to science learning habits which are still conventional in nature and ignore the importance of the ability to read and write science as competencies that students must have, so that there is a tendency that the learning process does not support students in developing scientific literacy abilities (Siagian et al., 2023; Simamora et al., 2022) The cause of the problem of students' low scientific literacy skills requires efforts to overcome it. For this reason, problem solving is needed by focusing on the application of a learning model in improving the learning process which aims to improve students' scientific literacy abilities.

The urgency of this research is to improve scientific literacy, where scientific literacy at the junior high school level is very important to equip students to be able to think critically and have problem-solving skills in facing real-world problems (Solheri et al., 2022; Wen et al., 2020). However, there are still many students in various countries who even have low levels of scientific literacy, as shown by the results of international studies (OECD, 2023a, 2023b). On the other hand, the traditional learning model that is still often applied has been proven to be ineffective in improving students' scientific literacy, because it is less interactive in involving students in active learning (Adnan & Bahri, 2018; Kamsi et al., 2019). Therefore, the developing research on new learning models with contextual enrichment and encouraging students' participation is need to develop. The BRADeR model used in this study is an innovative learning model that has not been widely used in various schools (Siagian et al., 2023; Simamora et al., 2022). In fact, this study offers a new approach that combines activity-based learning with the reinforcement of science concepts designed to improve students' science literacy holistically. Many studies focus on cognitive aspects, but this study focuses on science literacy, which includes understanding, applying, and reflecting on science in everyday life (Hussin, 2018; Park & Green, 2019).

Recent research on scientific literacy shows that contextual and interactive approaches, such as those implemented in the BRADeR model, are more effective than traditional methods. This model likely utilizes strategies such as problem-based learning and collaborative discussion, which are current approaches in science pedagogy. It also integrate 21st century skills. It is in line with recent findings in educational research that emphasize the importance of developing these skills for students' futures. Based on the background of the problem stated above, the BRADeR learning model is thought to be effective in improving junior high school students' scientific literacy skills. This research focuses on implementing the BRADeR learning model and finding out whether the model is effective in improving students' scientific literacy skills.

2. Materials and Methods

2.1 Type of Research

This research is included in the type of quasi-experimental research. The research design used is quantitative research using descriptive methods (descriptive-quantitative), using the one-group pretest-posttest design (Fraenkel et al., 2012). The use of descriptive quantitative methods with a one-group pretest-posttest design in this research is because this research focuses on measuring the effectiveness of the BRADeR learning model in increasing students' scientific literacy. Therefore, a quantitative approach is used to enable researchers to collect numerical data, so that the results can be calculated objectively and interpreted statistically. Descriptive research aims to describe the phenomenon being studied in detail, in this case increasing students' scientific literacy. Using descriptive methods, researchers can explain how changes occur in students' scientific literacy before and after implementing the BRADeR learning model. The one-group pretest-posttest design allows researchers to measure changes that occur in the same group of students before and after being given treatment, namely the application of the BRADeR model. It is very important to know whether there is an increase in students' scientific literacy after learning with BRADeR model.

2.2 Research Subjects and Objects

The research subjects are students of seventh class at State Junior High School (SJHS) 5 of Pematangsiantar. This research involved one class being observed at the pretest stage (O_1) which was then continued with learning treatment using the BRADeR (X) and posttest (O_2) learning models.

2.3 Data types and sources

The types of data used in this research are primary data. Primary data was obtained from the pretest and posttest results of students who were the subjects of this research.

2.4 Data collection technique

The data collection technique in this research is a test, namely a scientific literacy ability test. Scientific literacy ability test data was collected by administering a pretest and posttest. The tests given are in accordance with the indicators and objectives developed by researchers. The test is used to measure or determine the contribution of the BRADeR learning model to improving students' scientific literacy skills. A pretest is given to students before learning, then they are given learning treatment using the BRADeR learning model. After five meetings, a posttest was carried out. The pretest and posttest results are then analyzed to be used as a contribution to the learning model.

2.5 Data analysis techniques

Data analysis of scientific literacy abilities was carried out based on the scores obtained by students from pretest and posttest activities. Based on the data obtained from the pretest and posttest results, it was then analyzed to determine the increase in students' scientific literacy abilities. The formulation for determining the results of scientific literacy abilities is by testing the differences in students' scientific literacy abilities before and after participating in learning using the BRADeR learning model. The magnitude of the increase in students' scientific literacy skills before and after treatment is calculated using the n-gain equation in Formula 1 (Bao & Redish, 2006). While the N-gain is adjusted to the assessment criteria presented in the Table 1.

$$N_{gain} = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \quad (1)$$

Note:
N-gain = normalized gain value (normalized gain)
S_{post} = posttest score for scientific literacy abilities
S_{pre} = pretest score for scientific literacy skills
S_{max} = maximum value of scientific literacy abilities

Table 1. N-gain criteria

N-gain Score	Criteria
> 0.70	High
0.30 ≤ *n-gain* ≤ 0.70	Moderate
n-gain < 0.30	Low

One of the conditions for a learning model to be said to be effective in improving students' scientific literacy skills is if the average n-gain is at least in the medium category (N-gain ≥ 0.30).

3. Results

3.1 Implementation of the project-based learning model

Based on the problem formulation that has been described, this research determines the effectiveness of the BRADeR model for improving junior high school students' scientific literacy skills. The effectiveness of this model can be seen from the results of scientific literacy ability tests before and after learning is carried out using the BRADeR learning model. Before carrying out learning by applying the BRADeR learning model, students are first provided with an understanding of scientific literacy. Based on the problem formulation that has been described, this research determines the effectiveness of the BRADeR model for improving junior high school students' scientific literacy skills.

The effectiveness of this model can be seen from the results of scientific literacy ability tests before and after learning is carried out using the BRADeR learning model. Before carrying out learning by applying the BRADeR learning model, students are first provided with an understanding of scientific literacy. Students' scientific literacy abilities were measured using a test of students' scientific literacy abilities and analyzed quantitatively descriptively. The scientific literacy ability test is designed to evaluate the learning material that students acquire during the learning process by applying the BRADeR learning model (Siagian et al., 2023). The test preparation is based on the abilities that will be measured by the students. The results of the achievements of individual students' scientific literacy abilities in limited trials are presented in the Figure 1.

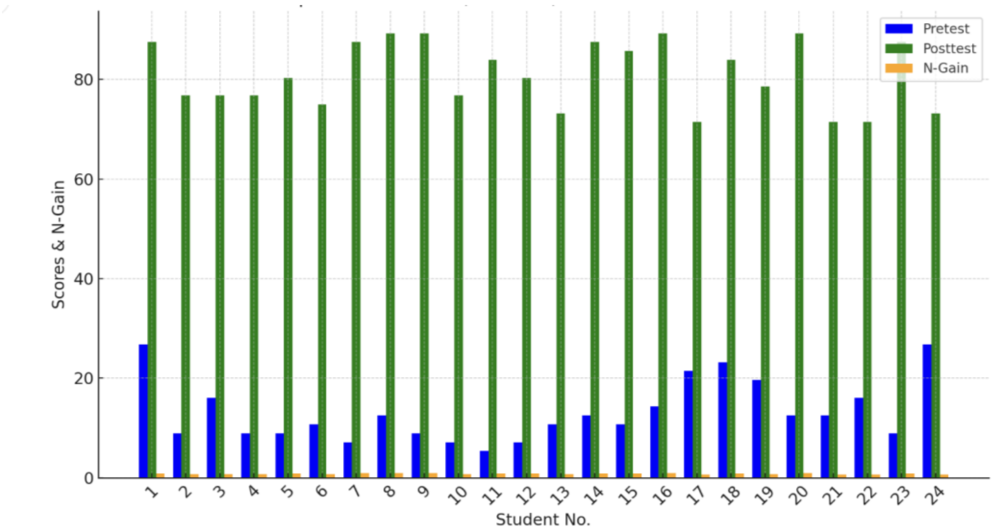


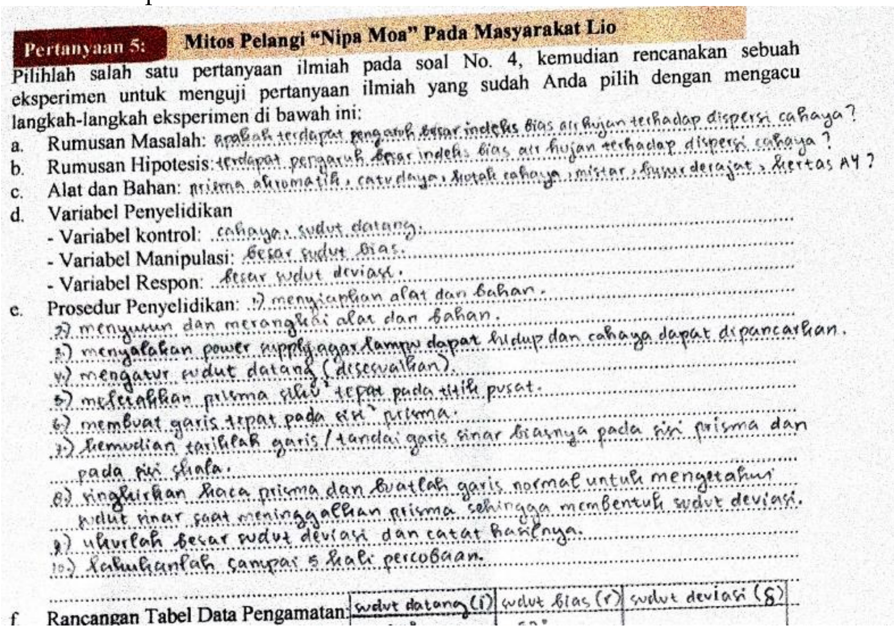
Figure 1. Diagram results of analysis of students' scientific literacy ability

4. Discussion

In general, the post-test results showed an increase compared to the pre-test results, although some students still had not achieved optimal results due to several reasons. The N-Gain score showed a significant increase between the pretest and posttest scores. These results indicate that the BRADer learning model is effective in improving student understanding (Siagian et al., 2023). Students who had low pretest scores (<15) were able to improve their understanding after the learning process.

For instance, student number 7 with a pretest score of 7.14 was able to achieve a posttest of 87.50 with an N-Gain of 0.87. The high N-Gain score indicates that the BRADer learning model can facilitate most students to achieve significant improvements in scientific literacy, with little difference between students in terms of effectiveness. On the other hand, the analysis of student answer sheets showed that there were still students who had difficulty designing scientific investigations. Students were able to formulate problems, formulate hypotheses, and determine investigation variables, but were not yet able to design investigation procedures. The results of student answers to the scientific investigation design indicator are presented in Figure 2.

The fifth (Figure 2) and eighth (Figure 3) questions are questions with indicators of scientific literacy in designing inquiry investigations. These two questions are intended to measure students' ability in order to make decisions related to a scientific concept. Furthermore, through these questions, students are required to be able to design scientific investigations in order to obtain scientific conclusions that are used as a basis for decision making. The results of the study showed that most students were able to solve these questions.



Pertanyaan 5: **Mitos Pelangi "Nipa Moa" Pada Masyarakat Lio**

Pilihlah salah satu pertanyaan ilmiah pada soal No. 4, kemudian rencanakan sebuah eksperimen untuk menguji pertanyaan ilmiah yang sudah Anda pilih dengan mengacu langkah-langkah eksperimen di bawah ini:

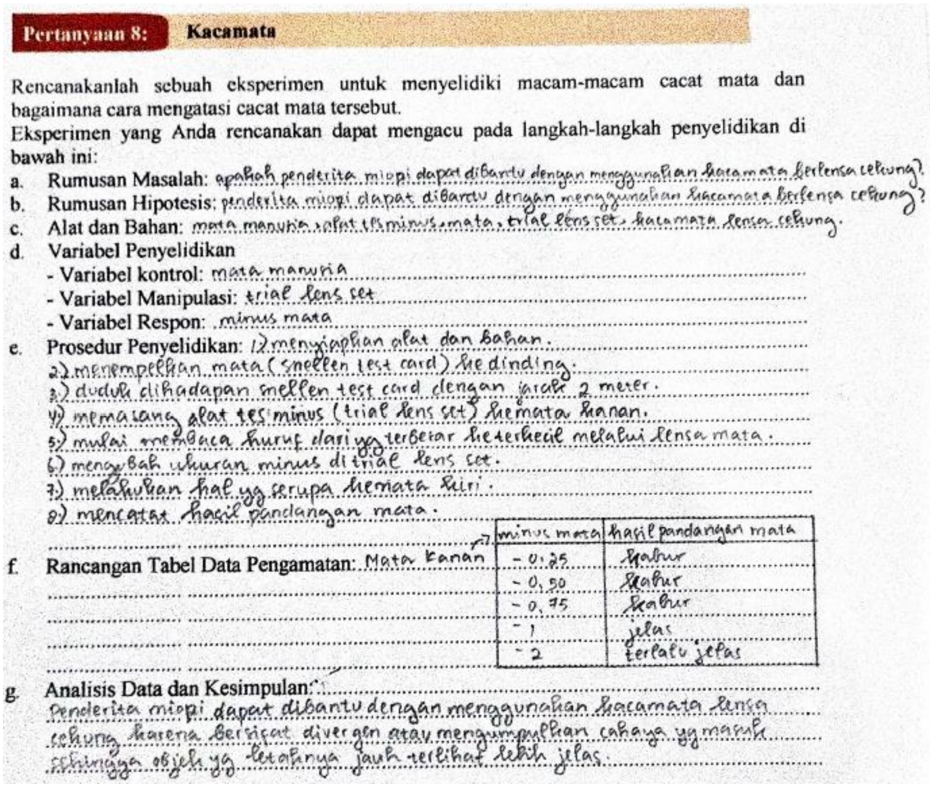
a. Rumusan Masalah: apakah terdapat pengaruh besar indeks bias air hujan terhadap dispersi cahaya?
b. Rumusan Hipotesis: terdapat pengaruh besar indeks bias air hujan terhadap dispersi cahaya?
c. Alat dan Bahan: prisma akromatik, catu daya, kotak cahaya, mistar, busur derajat, kertas A4?
d. Variabel Penyelidikan
- Variabel kontrol: cahaya, sudut datang.
- Variabel Manipulasi: besar sudut bias.
- Variabel Respon: besar sudut deviasi.

e. Prosedur Penyelidikan: 1) menyiapkan alat dan bahan.
2) menyusun dan merangkai alat dan bahan.
3) menyalakan power supply agar lampu dapat hidup dan cahaya dapat dipancarkan.
4) mengatur sudut datang (disesuaikan).
5) meletakkan prisma siku tepat pada titik pusat.
6) membuat garis tepat pada sisi prisma.
7) kemudian tariklah garis/tandai garis sinar biasnya pada sisi prisma dan pada sisi skala.
8) singkirkan kaca prisma dan buatlah garis normal untuk mengetahui sudut sinar saat meninggalkan prisma sehingga membentuk sudut deviasi.
9) ukurlah besar sudut deviasi dan catat hasilnya.
10) lakukanlah sampai 5 kali percobaan.

f. Rancangan Tabel Data Pengamatan:

sudut datang (i)	sudut bias (r)	sudut deviasi (δ)

Figure 2. Example of a complete student answer to fifth question



Pertanyaan 8: **Kacamata**

Rencanakanlah sebuah eksperimen untuk menyelidiki macam-macam cacat mata dan bagaimana cara mengatasi cacat mata tersebut.
Eksperimen yang Anda rencanakan dapat mengacu pada langkah-langkah penyelidikan di bawah ini:

a. Rumusan Masalah: apakah penderita miopi dapat dibantu dengan menggunakan kacamata berlensa cekung?
b. Rumusan Hipotesis: penderita miopi dapat dibantu dengan menggunakan kacamata berlensa cekung?
c. Alat dan Bahan: mata manusia, alat tes minus mata, trial lens set, kacamata lensa cekung.
d. Variabel Penyelidikan
- Variabel kontrol: mata manusia
- Variabel Manipulasi: trial lens set
- Variabel Respon: minus mata

e. Prosedur Penyelidikan: 1) menyiapkan alat dan bahan.
2) menempelkan mata (snellen test card) ke dinding.
3) duduk dihadapan snellen test card dengan jarak 2 meter.
4) memasang alat tes minus (trial lens set) ke mata kanan.
5) mulai membaca huruf dari yg terbesar ke terkecil melalui lensa mata.
6) mengubah ukuran minus di trial lens set.
7) melakukan hal yg serupa ke mata kiri.
8) mencatat hasil pandangan mata.

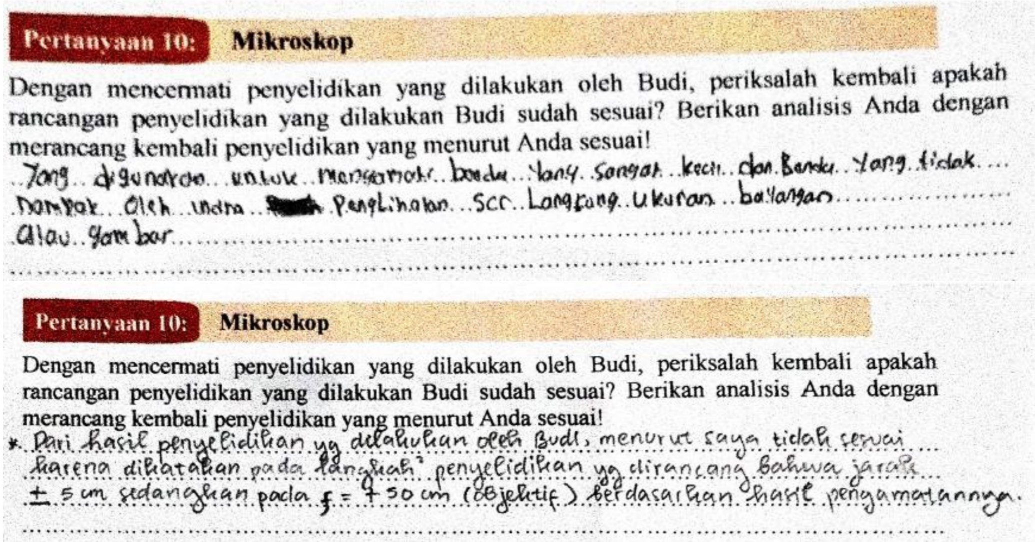
f. Rancangan Tabel Data Pengamatan: Mata kanan

minus mata	hasil pandangan mata
- 0,25	kabur
- 0,50	kabur
- 0,75	kabur
- 1	jelas
- 2	terlalu jelas

g. Analisis Data dan Kesimpulan:
Penderita miopi dapat dibantu dengan menggunakan kacamata lensa cekung karena bersifat divergen atau mengumpulkan cahaya yg masuk sehingga objek yg letaknya jauh terlihat lebih jelas.

Figure 3. Example of a complete student answer to eighth question

Meanwhile, the tenth question is an evaluation type question. Evaluation, in the inquiry stage, is a crucial stage carried out to analyze whether the scientific investigation design presented is correct or not. The results of the analysis of the student answer sheets showed that some students were able to provide responses to the investigation design presented, but others were not yet able to evaluate the investigation design (Figure 4).


Pertanyaan 10: Mikroskop

Dengan mencermati penyelidikan yang dilakukan oleh Budi, periksalah kembali apakah rancangan penyelidikan yang dilakukan Budi sudah sesuai? Berikan analisis Anda dengan merancang kembali penyelidikan yang menurut Anda sesuai!

Yang digunakan untuk mengamati benda yang sangat kecil dan benda yang tidak nampak oleh indra [redacted] penglihatan scr langsung ukuran bayangan atau gambar

Pertanyaan 10: Mikroskop

Dengan mencermati penyelidikan yang dilakukan oleh Budi, periksalah kembali apakah rancangan penyelidikan yang dilakukan Budi sudah sesuai? Berikan analisis Anda dengan merancang kembali penyelidikan yang menurut Anda sesuai!

* Dari hasil penyelidikan yg dilakukan oleh Budi, menurut saya tidak sesuai karena dikatakan pada langkah² penyelidikan yg dirancang bahwa jarak ± 5 cm sedangkan pada f = ± 50 cm (objektif) berdasarkan hasil pengamatannya.

Figure 4. Example of an incomplete student answer regarding to tenth question

It was strongly indicated that students' inability to design and evaluate scientific investigation plans was closely related to their involvement in group discussions (Zhou, 2021; Zulkarnaen et al., 2017). In this case, the discussion activities are integrated into the student worksheet. Students who are actively involved in group discussions are thought to be more capable of designing and evaluating a scientific investigation because the activities have been integrated in such a way into the student worksheet (Mumtaza & Zulfiani, 2023; Orosz et al., 2022). The second activity in the worksheet is designed to facilitate students in designing scientific investigation procedures independently (Holbrook & Rannikmae, 2009). Furthermore, in the fourth and fifth activities, students are given space to evaluate the results of the investigation designs prepared by their group or their friends' groups. It ensure that the indicators of scientific literacy in the aspect of designing and evaluating scientific investigations are achieved as expected. It overcome if the components of scientific investigations are trained well in advance, so that students are accustomed to carrying out scientific investigation design activities and can evaluate the designs (Sun et al., 2014; Yanto et al., 2019).

The increase in the N-gain score in science literacy skills is in the moderate to high category, namely 0.63 - 0.84 (Hake, 1999). This shows that the BRADeR learning model can improve students' science literacy skills in each indicator. The improvement of students' science literacy skills is supported by the availability of science information presented in student books. It can inspire students to contribute ideas in responding to scientific phenomena in science information as in the first scenario of the BRADeR learning model (Ke et al., 2021). Moreno and Park (2010) said that changes in mental structure in the learning process are the result of interactions between individuals and their environment, steady and continuously.

As a learner, students always try to understand the world through interactions with their environment (Abrori et al., 2023; Rospitasari et al., 2017; Saxena & Behari, 2021). It cannot be separated from the reading activities carried out by students as stated in the BRADeR learning model second phase (Simamora et al., 2020). Activities in second phase provide students with space to understand, select, process, and remember the information they obtain through discourse texts. In this phase, students also collect information related to science and then respond to that information. Slavin (2012) stated that giving complex and realistic tasks with sufficient assistance will help students solve problems well. Thus, through the presentation of scientific information followed by scientific reading activities, it can develop the ability to contribute ideas, collect various information and respond to the information by linking the ideas put forward so that this can facilitate the development of student knowledge to explain scientific phenomena.

Analysis activities, third phase in the BRADer learning model, are indicated to have a crucial role in improving scientific literacy skills. Teachers facilitate students in constructing knowledge through investigative activities arranged on worksheets by applying problem-solving skills. Students can experience direct experience in constructing scientific literacy with the competence to design and evaluate scientific investigation plans. Teacher facilitation in student learning is fundamental in helping them improve their level of cognitive knowledge and higher skills (Moreno & Park, 2010). Slavin (2012) also stated that students process information when they manipulate and observe the information from various perspectives and analyze it. This theory is supported by findings from McConney et al (2014) which stated that the analysis process in scientific literacy can include high-level thinking investigations. Kemendikbud (2016) and Situmorang (2016) also revealed that the scientific process in terms of searching, interpreting, and analyzing facts or data is a form of activity that has the potential to train students' scientific literacy. Thus, the third stage in the BRADer learning model can facilitate the development of students' knowledge to design and evaluate scientific investigations, as well as interpret data and provide scientific evidence.

The fourth phase also influences the increasing of students' scientific literacy abilities. The learning activities carried out in this phase are introducing problems that need to be decided on from the results of the investigation in previous phase. The teacher convinces students to solidify decision making from various alternative solutions obtained during the investigation activity (Bramastia & Rahayu, 2023). Students compare several alternative ideas and assess the explanation of a scientific phenomenon presented at the beginning of learning. Moreno and Park (2010) stated that students should be encouraged and even encouraged not to be hasty in making decisions and consider all possibilities before trying to solve a problem. Binkley et al (2014); Shamuganathan and Karpudewan (2015) which states that by making decisions, there is a change in the way of thinking of students who are more able to make decisions logically, and can draw conclusions related to everyday life. Moreover, the fourth phase is facilitates the students' abilities to explain scientific phenomena through a series of syntheses of the ideas that have been expressed (Arief & Utari, 2015; Simamora et al., 2020).

Increasing students' scientific literacy skills cannot be separated from the support of fifth phase, reflection the learning activities. In this final phase, teachers can find out the level of success of students in the material that has been taught, and find out how students concentrate by giving correct responses to tasks, which in the end can be used as information in the next lesson, so that students' learning process needs can be met properly. In accordance with the opinion of Eggen and Kauchak (2020) who stated that feedback is crucial to lift student motivation because it can improve the quality of work, perceptions of competence, self-determination and intrinsic motivation. Due to reflection activity, students can get to know themselves better, understand problems and think about solutions by utilizing their scientific literacy skills in solving everyday problems (Fakhriyah et al., 2017; Heyworth-Thomas, 2023).

The research results are in accordance with the opinion of Simamora et al (2020); Yanto et al (2019) that students' involvement in conducting scientific investigations arises from hands-on practice during joint activities from cognitive abilities and the ability to process the amount of information they receive. To support this opinion, Aulia et al (2018) revealed that the use of student performance sheets functions as implicit scaffolding that supports involvement in investigations. Model teachers who facilitate students to carry out investigations using authentic tools and materials will be able to strengthen students' conceptual understanding in practicing their scientific investigation skills. It is indicated as the reason why the application of the BRADeR learning model can help students to improve their scientific literacy skills.

5. Conclusion

This research results was indicated that the BRADeR learning model is effective in improving students' scientific literacy skills due to the significance of N-gain score of students' scientific literacy. The improving of students' scientific literacy may be refer to the quality of learning conducted through BRADeR model.

Author Contributions: A.B. Simamora: conceptualization, methodology, and designing research, writing original draft, review and editing. A. Manalu: develop media, collecting data, writing original draft, and editing. R. Simamora: methodology, formal analysis, and data curation.

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References

Abrori, F. M., Lavicza, Z., & Anđić, B. (2023). Enhancing socio-scientific reasoning of elementary school students through educational comics: a comprehensive exploration across diverse domain of knowledge. *Education 3-13*, 1–22. https://doi.org/10.1080 /03004279.2023.2266457

Adnan, A., & Bahri, A. (2018). Beyond effective teaching: Enhancing students' metacognitive skill through guided inquiry. *Journal of Physics: Conference Series*, *954*, 012022. https://doi.org/10.1088/1742-6596/954/1/012022

Alake-Tuenter, E., Biemans, H. J. A., Tobi, H., Wals, A. E. J., Oosterheert, I., & Mulder, M. (2012). Inquiry-based science education competencies of primary school teachers: A literature study and critical review of the American National Science Education Standards. *International Journal of Science Education*, *34*(17), 2609–2640. https://doi.org/10.1080/09500693.2012.669076

Arief, M. K., & Utari, S. (2015). Implementation of Levels of Inquiry on Science Learning To Improve Junior High School Student'S Scientific Literacy. *Indonesian Journal of Physics Education*, *11*(2), 117–125. https://doi.org/10.15294/jpfi.v11i2.4233

Aulia, E. V., Poedjiastoeti, S., & Agustini, R. (2018). The effectiveness of guided inquiry-based learning material on students' science literacy skills. *Journal of Physics: Conference Series*, *947*(1), 0–7. https://doi.org/10.1088/1742-6596/947/1/012049

Bao, L., & Redish, E. F. (2006). Model analysis: Representing and assessing the dynamics of student learning. *Physical Review Special Topics - Physics Education Research*, *2*(1), 1–16. https://doi.org/10.1103/PhysRevSTPER.2.010103

Barak, M., & Assal, M. (2018). Robotics and STEM learning: students' achievements in assignments according to the P3 Task Taxonomy — practice, problem solving, and projects. *International Journal of Technology and Design Education*, *28*(1), 121–144. https://doi.org/10.1007/s10798-016-9385-9

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2014). Defining twenty-first century skills. In *Assessment and teaching of 21st century skills*. https://doi.org/10.1007/978-94-007-2324-5_2

Bramastia, B., & Rahayu, S. (2023). Study of science learning based on scientific literacy in improving critical thinking : A scoping review. *Jurnl Penelitian Pendidikan IPA*, *9*(8), 499–510. https://doi.org/10.29303/jppipa.v9i8.5667

Chalkiadaki, A. (2018). A systematic literature review of 21st century skills and competencies in primary education. *International Journal of Instruction*, *11*(3), 1–16. https://doi.org/10.12973/iji.2018.1131a

Diana, S., Rachmatulloh, A., & Rahmawati, E. S. (2015). Profil kemampuan literasi sains siswa SMA berdasarkan instrumen Scientific Literacy Assesments (SLA). *Seminar*

Nasional XII Pendidikan Biologi FKIP UNS, 285–291. https://media.neliti.com/media/pu blications/171085-ID-none.pdf

Eggen, P., & Kauchak, D. (2020). *Using educational psychology in teaching*. https://nuacresults. com/wp-content/uploads/2023/06/using-educational-psychology-in-teaching-pdf.pd f

Fahmi, F., Chalisah, N., Istyadji, M., Irhasyuarna, Y., & Kusasi, M. (2022). Scientific literacy on the topic of light and optical instruments in the innovation of science teaching materials. *Jurnal Inovasi Pendidikan IPA*, *8*(2), 154–163. https://doi.org/10.21831/jipi.v8 i2.41343

Fakhriyah, F., Masfuah, S., Roysa, M., Rusilowati, A., & Rahayu, E. S. (2017). Student's science literacy in the aspect of content science? *Jurnal Pendidikan IPA Indonesia*, *6*(1), 81–87. https://doi.org/10.15294/jpii.v6i1.7245

Fortus, D., Lin, J., Neumann, K., & Sadler, T. D. (2022). The role of affect in science literacy for all. *International Journal of Science Education*, *44*(4), 535–555. https://doi.org/10.1080/ 09500693.2022.2036384

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (Eighth Edi). https://saochhengpheng.files.wordpress.com/2017/03/jack_fraenkel_norman_wallen_helen_hyun-how_to_design_and_evaluate_research_in_education_8th_edition_-mcgraw-hill_humanities_social_sciences_languages2011.pdf

Greenstein, L. M. (2012). Assessing 21st Century skills. In *Assessing 21st Century Skills* (Issue September). Corwin Press. https://doi.org/10.17226/13215

Hake, R. R. (1999). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *64*(1998). https://doi.org/10.1119/1.18809

Hasanah, U., Hamidah, I., & Utari, S. (2017). Trained Inquiry Skills on Heat and Temperature Concepts. *Journal of Physics: Conference Series*, *895*(1), 0–6. https://doi.org/ 10.1088/1742-6596/895/1/012103

Heyworth-Thomas, E. M. (2023). Creating experiential learning opportunities in enterprise education: an example of a facilitator-led business simulation game in a taught setting. *Journal of Work-Applied Management*, *15*(2), 173–187. https://doi.org/10.1108/JWAM-02-2023-0018

Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environment & Science Education*, *4*(3), 275–288. https://doi.org/10.1097/00006199-195402000-00010

Hussin, A. A. (2018). Education 4.0 made simple: Ideas for teaching. *International Journal of Education and Literacy Studies*, *6*(3), 92–98. https://doi.org/10.7575/aiac.ijels.v.6n.3p.92

Kamsi, N. S., Radin Firdaus, R. B., Abdul Razak, F. D., & Ridha Siregar, M. (2019). Realizing Industry 4.0 through STEM education: But why STEM is not preferred? *IOP Conference Series: Materials Science and Engineering*, *506*(1), 0–7. https://doi.org/10.1088/1757-899X/506/1/012005

Kan'an, A. (2018). The relationship between Jordanian students' 21st Century skills (Cs21) and academic achievement in science. *Journal of Turkish Science Education*, *15*(2), 82–94. https://doi.org/10.12973/tused.10232a

Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2021). Developing and using multiple models to promote scientific literacy in the context of Socio-Scientific Issues. *Science and Education*, *30*(3), 589–607. https://doi.org/10.1007/s11191-021-00206-1

Kemendikbud, K. (2016). *Pedoman pelaksanaan gerakan nasional literasi bangsa*. https://gln.ke mdikbud.go.id/glnsite/wp-content/uploads/2017/09/Pedoman-GLNB-2016-2019.pdf

Kemendikbudristek, Peraturan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia (2022). https://jdih.kemdikbud.go.id/sjdih/siperpu/dokumen

/salinan/salinan_20220421_105322_Final JDIH Salinan Permendikbudristek No 16 Tahun 2022 ttg Standar Proses.pdf

McConney, A., Oliver, M. C., Woods-Mcconney, A., Schibeci, R., & Maor, D. (2014). Inquiry, engagement, and literacy in science: A retrospective, cross-national analysis using PISA 2006. *Science Education*, *98*(6), 963–980. https://doi.org/10.1002/sce.21135

Moreno, R., & Park, B. (2010). Cognitive load theory: Historical development and relation to other theories. *Cognitive Load Theory*, 7–28. https://doi.org/10.1017/CBO9780511844744.003

Mumtaza, M. F., & Zulfiani, Z. (2023). Development of student worksheets based on science process skills on excretory system concepts. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 265–272. https://doi.org/10.29303/jppipa.v9i1.1474

Odegaard, M., Haug, B., Mork, S., & Sorvik, G. O. (2015). Budding science and literacy: A classroom video study of the challenges and support in an integrated inquiry and literacy teaching model. *Procedia - Social and Behavioral Sciences*, *167*(1877), 274–278. https://doi.org/10.1016/j.sbspro.2014.12.674

OECD. (2016a). *Country note – results from PISA 2015: Indonesia*. OECD. https://www.oecd.org/content/dam/oecd/en/about/programmes/edu/pisa/publications/national-reports/pisa-2015/country-snapshots/PISA-2015-Indonesia.pdf

OECD. (2016b). PISA 2016 Assessment and Analytical Framework. In *OECD Publishing*. https://www.oecd-ilibrary.org/pisa-for-development-assessment-and-analytical-framework_5j8mznrtw131.pdf%0A

OECD, O. (2019). *PISA 2018 Results: What students know and can do: Vol. I*. https://doi.org/10.1787/5f07c754-en

OECD, O. (2023a). PISA 2022 Results (Volume I): The state of learning and equity in education. In *PISA: Vol. I*. https://doi.org/10.31244/9783830998488

OECD, O. (2023b). PISA 2022 Results (Volume II): Learning During – and From – Disruption. In *OECD Publishing: Vol. II*. https://www.oecd-ilibrary.org/education/pisa -2022-results-volume-ii_a97db61c-en

Oral, I., & Erkilic, M. (2021). Investigating the effect of demographic features of undergraduate students on their 21st-century skills. *Global Conference on Education and Research*, *4*. https://digitalcommons.usf.edu/cgi/viewcontent.cgi?article=1068&context=m3publishing#page=148

Orosz, G., Németh, V., Kovács, L., Somogyi, Z., & Korom, E. (2022). Guided inquiry-based learning in secondary-school chemistry classes: a case study. *Chemistry Education Research and Practice*, *24*(1), 50–70. https://doi.org/10.1039/d2rp00110a

Park, Y.-S., & Green, J. (2019). Bringing Computational Thinking into Science Education. *Journal of the Korean Earth Science Society*, *40*(4), 340–352. https://doi.org/10.5467/jkess.2019.40.4.340

Putra, M. I. S., Widodo, W., & Jatmiko, B. (2016). The development of guided inquiry science learning materials to improve science literacy skill of prospective mi teachers. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 83–93. https://doi.org/10.15294/jpii.v5i1.5794

Rospitasari, R., Harahap, M. B., & Derlina, D. (2017). The effect of scientific inquiry learning model and creative thinking skills on student's science process skills. *IOSR Journal of Research & Method in Education*, *7*(4), 55–57. https://doi.org/10.9790/7388-0704035557

Saxena, A., & Behari, A. (2021). 'Engaging in an argumentative discourse'- narratives from biology classrooms. *European Journal of Science and Mathematics Education*, *3*(1), 14–32. https://doi.org/10.30935/scimath/9418

Shamuganathan, S., & Karpudewan, M. (2015). Modeling environmental literacy of malaysian pre-university students. *International Journal of Environmental and Science Education*, *10*(5), 757–771. https://doi.org/10.12973/ijese.2015.264a

Siagian, A. F., Simamora, R., & Simamora, A. B. (2023). Development of learning tools oriented to the BRADeR learning model to facilitate teachers in teaching science literacy. *EDUTEC : Journal of Education And Technology*, *7*(2), 666–672. https://doi.org/10.29062/edu.v7i2.807

Simamora, A. B., Sanjaya, I. G. M., & Widodo, W. (2022). Validity of BRADeR learning model development: An innovative learning model to improve science literacy skills for junior high school students. *Journal of Curriculum and Teaching*, *11*(8), 311–316. https://doi.org/10.5430/jct.v11n8p311

Simamora, A. B., Widodo, W., & Sanjaya, I. G. M. (2020). Innovative learning model: Improving the students' scientific literacy of junior high school. *IJORER : International Journal of Recent Educational Research*, *1*(3), 271–285. https://doi.org/10.46245/ijorer. v1i3.55

Situmorang, R. P. (2016). Integrasi literasi sains peserta didik dalam pembelajaran sains. *Satya Widya*, *32*(1), 49. https://doi.org/10.24246/j.sw.2016.v32.i1.p49-56

Slavin, R. E. (2012). Cooperative Learning and Achievement: Theory and Research. *Handbook of Psychology, Second Edition*. https://doi.org/10.1002/9781118133880.hop207008

Snow, C. E., & Dibner, K. A. (2016). Science literacy: Concepts, contexts, and consequences. In *Science Literacy: Concepts, Contexts, and Consequences*. https://doi.org/10.17226/23595

Solheri, S., Azhar, M., & Yohandri, Y. (2022). Analysis of ethnoscience integrated environmental literacy for junior high school. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(2), 178–188. https://doi.org/10.22219/jpbi.v8i2.17657

Sun, D., Wang, Z. H., Xie, W. T., & Boon, C. C. (2014). Status of integrated science instruction in junior secondary schools of China: An exploratory study. *International Journal of Science Education*, *36*(5), 808–838. https://doi.org/10.1080/09500693.2013.829254

Tomovic, S., Yoshigoe, K., Maljevic, I., & Radusinovic, I. (2017). Software-defined fog network architecture for IoT. *Wireless Personal Communications*, *92*(1), 181–196. https://doi.org/10.1007/s11277-016-3845-0

Walag, A. M. P., Fajardo, M. T. M., Bacarrisas, P. G., & Guimary, F. M. (2022). A canonical correlation analysis of Filipino science teachers' scientific literacy and science teaching efficacy. *International Journal of Instruction*, *15*(3), 249–266. https://doi.org/10.29333 /iji.2022.15314a

Wang, J., & Zhao, Y. (2016). Comparative research on the understandings of nature of science and scientific inquiry between science teachers from Shanghai and Chicago. *Journal of Baltic Science Education*, *15*(1), 97–108. https://doi.org/10.33225/jbse/16.15.97

Wen, C. T., Liu, C. C., Chang, H. Y., Chang, C. J., Chang, M. H., Fan Chiang, S. H., Yang, C. W., & Hwang, F. K. (2020). Students' guided inquiry with simulation and its relation to school science achievement and scientific literacy. *Computers and Education*, *149*(February), 103830. https://doi.org/10.1016/j.compedu.2020.103830

Yanto, B. E., Subali, B., & Suyanto, S. (2019). Improving students' scientific reasoning skills through the three levels of inquiry. *International Journal of Instruction*, *12*(4), 689–704. https://doi.org/10.29333/iji.2019.12444a

Zhou, C. (2021). The effectiveness of 5E model to improve the scientific creativity of teachers in rural areas. *Thinking Skills and Creativity*, *41*(May), 100900. https://doi.org/10.1016/j.tsc.2021.100900

Zulkarnaen, Z., Supardi, Z. . I., & Jatmiko, B. (2017). Feasibility of creative exploration, creative elaboration, creative modeling, practice scientific creativity, discussion, reflection (C3PDR) teaching model to improve students' scientific creativity of junior high school. *Journal of Baltic Science Education*, *16*(6), 1020–1034. https://doi.org/10. 33225/jbse/17.16.1020