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Fostering Scientific Literacy using RADEC Learning Model in Junior High School

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Abstract: Scientific literacy is the ability of individuals to engage with science-related issues and scientific ideas as reflective citizens. However, many students struggle with low scientific literacy skills, which hampers their ability to understand and engage with scientific concepts effectively. This study aims to describe the implementation of the Read, Answer, Discuss, Explain, and Create (RADEC) learning model on the scientific literacy of junior high school students. This type of research is experimental design. The research design used is descriptive with a one-group pretest-posttest design. The subjects of this study were 34 students of class VII-G at SMP Negeri 54 Surabaya during the even semester of the academic year 2023/2024. Data collection techniques involved observation, tests, and questionnaires. Research instruments included learning implementation observation sheets and scientific literacy tests. Test results were analyzed using N-Gain (Normalized Gain) and paired sample t-test. The study's findings revealed that the implementation of the RADEC learning model was executed very well, as evidenced by an average implementation score of 98.6%, which was categorized as very good. Second, students' scientific literacy skills showed improvement after the RADEC learning model was implemented, as seen from the N-gain analysis, with a score of 0.60, categorized as moderate. The paired sample t-test analysis indicated a significant difference in improving students' scientific literacy skills before and after the learning process with the RADEC learning model.

Keywords: RADEC Model; Science Learning; Scientific Literacy.

Introduction

The era of globalization in the 21st century has rendered education extremely important [1], as it aims to equip students with the ability to learn and develop [2], utilize technology and media [3], and apply these talents to sustain themselves [4]. 21st-century education plays a crucial role in supporting the development of human resource quality [5], thereby requiring education to prepare students to face global competition. In line with this, Rohmawati [6] assert that scientific literacy is one of the competencies needed in the 21st century. Students with scientific literacy skills can effectively apply their knowledge to solve everyday problems [7]. According to the World Economic Forum [8], scientific literacy is one of the 16 essential competencies for 21st-century development. The Ministry of Education and Culture [9] states that scientific literacy has become a top priority for education in Indonesia. Muliani et al. [10] state that scientific literacy is essential for understanding modern issues like the environment, health, and economy. It also involves engaging with scientific topics and thinking reflectively [11]. Therefore, scientific literacy must be introduced as early as possible [12].

Scientific literacy is the ability of individuals to engage with science-related issues and scientific ideas as reflective citizens [13]. It highlights the importance of scientific thinking skills in identifying and solving various problems [14] and social issues for students [15]. This is because scientific literacy focuses on knowledge of scientific processes and concepts and how students can make decisions on issues and participate in modern social life, the environment, economy, technology, culture, and health [16]. Through scientific literacy, individuals or students can clearly understand the meaning of life, solve complex everyday problems, and skillfully connect their scientific understanding with environmental events or facts [17]. This aligns with Fuadi's [18] statement that scientific literacy is the ability or skill to utilize the principles of natural science in everyday life, explain scientific phenomena, and describe them based on scientific evidence. Developing scientific literacy enhances students' critical thinking [19], enabling them to solve various problems creatively. This is consistent with Noor's [20] view that scientific literacy benefits individuals by shaping thinking patterns and behavior, building human character to be caring and responsible towards themselves, society, and the universe, and addressing problems in modern society heavily dependent on technology. This underscores the importance of mastering scientific literacy in the 21st century for every individual.

In reality, Indonesian students' scientific literacy remains low. According to the 2022 Programme for International Student Assessment (PISA), the global standard for scientific literacy is 485, whereas Indonesia's average score is 383, ranking 67th out of 81 countries [13]. This rank has improved from 71st in 2018 to 67th in 2022 [13]. However, despite the improved ranking in PISA 2022, Indonesia recorded a 13-point decline from the 2018 scientific literacy score and is 102 points below the global average [21]. These results indicate a decrease in students' scientific literacy in 2022, with performance still considered low.

The urgency of this research is based on literature review findings from several relevant journals indicating that most teaching in Indonesia is teacher-centered, negatively

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impacting students' scientific literacy by failing to accommodate students' needs for active engagement and developing scientific literacy [18, 22]. This aligns with the results of interviews with teachers at SMP Negeri 54 Surabaya, who stated that science teaching at schools has not been directed towards scientific literacy and has not been student-centered. Preliminary data show that students' scientific literacy in explaining scientific phenomena is 34.4%, evaluating and designing scientific investigations is 36.6%, and interpreting data and scientific evidence is 33.3%. These results indicate that students' scientific literacy remains low.

The current state of students' scientific literacy highlights the urgent need to identify effective teaching methods [23], [24], [25]. Effective teaching models are necessary to improve students' scientific literacy in Indonesia [26]. One model that can enhance students' scientific literacy is the Read, Answer, Discuss, Explain, and Create (RADEC) learning model. Pratama [27] states that the RADEC model is an innovative teaching approach suitable for Indonesia's educational characteristics and introduces breakthroughs in teaching to achieve competencies relevant to the 21st century. The RADEC model, where students play a central role in learning by involving the steps of Read, Answer, Discuss, Explain, and Create, is considered capable and modern in preparing cognitive competencies and skills needed in the 21st century, enhancing students' conceptual understanding, and promoting literacy skills [28]. The RADEC model is an alternative teaching approach that solves educational problems in Indonesia [29]. It is a universal science teaching model that can develop students' conceptual understanding through its application [30]. Implementing RADEC encourages students to be actively engaged in learning [31].

Based on this background, the researcher intends to conduct a study titled " Fostering Scientific Literacy Using RADEC Learning Model in Junior High School".

Research Methods

This study employed an experimental design. Specifically, the method applied was a pre-experimental design without including a control or comparison group. The design utilized was a single group pretest-posttest design, where a pretest was administered before the intervention and a post-test was given after the intervention was completed. The population for this study comprised all students in class VII G at SMPN 54 Surabaya for the 2023/2024 academic year, totaling 34 students. The subjects for this research were chosen using purposive sampling. This is a non-random sampling technique where the selection of participants is based on specific criteria or considerations.

Data collection for this study was conducted through observation, tests, and questionnaires. The research instruments included an observation sheet for monitoring learning implementation and a scientific literacy ability test sheet. The learning implementation observation sheet employed a Guttman scale with definitive responses where "Yes" scored 1 and "No" scored 0. The scientific literacy ability test, comprised of multiple-choice tests, measures scientific literacy and is administered before and after implementing the RADEC learning model.

Data analysis of the learning implementation observations utilized quantitative descriptive techniques, applying the following formula:

$$\text{Percentage} = \frac{\text{Score of Implemented statements}}{\text{Maximum score}} \times 100\%$$

[32]

The implementation percentage obtained can be interpreted based on Table 1

Table 1. Interpretation of Implementation Percentage

Percentage (%)	Category
0 – 20	Very Poor
21 – 40	Poor
41 – 60	Fair
61 - 80	Good
81 – 100	Excellent

[32]

Analysis of students' scientific literacy test results (pretest and post-test) involved the Shapiro-Wilk normality test and paired t-test because the sample size was less than 50. The Shapiro-Wilk test was deemed appropriate for assessing normality under these conditions. Subsequently, a paired t-test was conducted to measure significant differences between the two measurements using SPSS. The increase in students' scientific literacy skills was analyzed using the N-gain method, assessing the difference between post-test and pretest scores. Improvement in literacy skills for each indicator was analyzed descriptively.

The analysis of students' scientific literacy levels used a quantitative descriptive analysis technique with the following formula:

$$\text{Score}=\sum \frac{Bi \times bi}{St} \times 100$$

[33]

Description:

Bi: number of correctly answered items

Bi: weighting test item

St: maximum score

Furthermore, the scores obtained by students were converted by adjusting them to the criteria in Table 3.

Table 3. Conversion of Student Scores into Scientific Literacy Levels.

Score Range	Category
0-3	Below level 1
4-18	Level 1
19-45	Level 2
46-60	Level 3
61-79	Level 4
80-90	Level 5
91-100	Level 6

[33]

Results and Discussion

This study's results were analyzed and discussed, covering the implementation of the learning model and scientific literacy skills.

Implementation of the Learning Model

The implementation of learning using the RADEC model was carried out over three sessions in class 7G. The implementation results from sessions 1 to 3 are presented in Table 3.

Table 3. Result of Learning Implementation

The Meetings	Learning Activity	Implementation Percentage	Criteria
1st Meeting	Preliminary	97.2%	Excellent
	Core		
	Closing		
2nd Meeting	Preliminary	98,6%	Excellent
	Core		
	Closing		
3rd Meeting	Preliminary	100%	Excellent
	Core		
	Closing		

Based on the observational data of the learning implementation presented in Table 3, it can be seen that learning using the RADEC model was implemented in each stage from sessions 1 to 3. The percentage of the RADEC model learning implementation in the first session was 97.2%, with teacher activities categorized as excellent. The observation results for the second session showed a 98.6% implementation rate, which was also classified as excellent. For the third session, the percentage of learning implementation reached 100%, which was categorized as excellent. The overall percentage of learning implementation from sessions 1 to 3 was 98.6%, categorized as excellent.

In the first meeting, the Read stage involves students reading the material at home from various sources such as worksheets, textbooks, magazines, articles, and the Internet. Constructivism theory states that effective learning occurs when students actively construct their knowledge from various sources of information [34]. Research by Hall [35] also supports that independent reading enhances students' understanding and engagement in learning. The Answer stage is implemented when students answer pre-learning questions provided by the teacher. These questions are designed to help students identify essential cognitive aspects of the material and guide them to think critically. This aligns with Listiani [36], who states that answering critical questions can enhance students' concept understanding and scientific literacy skills. The Discuss stage is conducted in the classroom, with students discussing their answers in groups. Group discussions allow students to share perspectives, correct errors, and develop a deeper understanding through collaboration [37].

Additionally, Vygotsky emphasized the importance of social interaction in learning [38]. In the Explain stage, randomly selected group representatives present their discussion results. The teacher provides feedback on the accuracy of the answers, which helps reinforce students' conceptual understanding. Research by Wulandari & Anugerahwati [39] indicates that constructive feedback is one of the most important factors influencing student learning. The Create stage was not conducted in the first meeting because it is implemented after all the material on a topic has been read, discussed, and presented classically, namely in the third meeting.

The Read and Answer stages are still conducted at home in the second meeting. The Discuss stage is carried out more intensively, with students being more active and participating in group discussions. The Explain stage in the second meeting involves more structured presentations, with students able to explain their answers more clearly and confidently. The teacher provides constructive feedback, helping students correct mistakes and deepen their understanding of the material. Timely and specific feedback assists students in the learning process [40].

In the third meeting, all RADEC stages are implemented very well. The Read and Answer stages are still conducted at home. The Discuss stage is carried out with students becoming more accustomed to discussing and finding the right answers through group collaboration. Research by Jones [41] shows that effective group discussions can enhance students' understanding and critical thinking skills. Students present their discussion results in the Explain stage of the third meeting. The teacher provides feedback that helps students clarify concepts and correct mistakes. The Create stage is finally implemented in this meeting. Students conduct a physical water test experiment and then create projects based on group ideas related to the material they have learned.

Scientific Literacy

The pretest and post-test scores analyzed using N-gain and categorized for improving students' scientific literacy skills related to implementing the Read, Answer, Discuss, Explain, and Create (RADEC) model yielded an N-gain score of 0.60, categorized as moderate. Subsequently, the Shapiro-Wilk normality test will be conducted using the SPSS application program as a prerequisite test to determine whether the obtained data are normally distributed. The dependent sample t-test can be performed if the data are normally distributed. The dependent sample t-test aims to ascertain whether there is a significant effect on students' scientific literacy skills after implementing the RADEC model in environmental pollution science learning. The data used for the normality test are the pretest and post-test scores.

Table 4. Result of Normality Test Shapiro-Wilk

	Statistic	df	Sig,
Pretest	0.954	34	0.162
Posttest	0.939	34	0.056

The results of the Shapiro-Wilk normality test presented in Table 4 indicate that the pretest scores of the students are normally distributed, with a significance value of 0.162, where this value is more significant than 0.05 (0.162 > 0.05). Similarly, the post-test scores of the students are also normally distributed, with a significance value of 0.056, where this value is more significant than 0.05 (0.056 > 0.05). Based on the Shapiro-Wilk normality test results, it can be concluded that the pretest and post-test scores of the students are normally distributed, allowing for the application of parametric statistical tests. The pretest and post-test scores of the students, which are normally distributed, are subsequently subjected to hypothesis testing using the parametric statistical test, namely the dependent

sample t-test, with the assistance of the SPSS version 20.0 application program. The results of the paired sample t-test are presented in Table 5.

Table 5. Result of Paired Sample t-test

	Mean	t	df	Sig,
Pretest-Posttest	-35.588	-23.308	33	0.000

Based on Table 5, the paired t-test results indicate a significance level of <0.05. This suggests that the null hypothesis (H_o) is rejected, and the alternative hypothesis (H_a) is accepted. Based on this decision, it can be concluded that there is a significant difference in improving students' scientific literacy skills before and after the learning process with the implementation of the RADEC model. Based on previous data analysis, it was found that the improvement in students' scientific literacy, analyzed using N-gain, showed an average increase in scientific literacy skills of 0.68, categorized as moderate. The improvement of scientific literacy using the RADEC model (Read, Answer, Discuss, Explain, and Create) showed an average N-gain of 0.60, which is in the medium category. This achievement indicates that the RADEC model effectively facilitates students' scientific literacy. Each component in the RADEC model contributed to improving scientific literacy [42]. The paired t-test results also indicated a significant difference in the improvement of students' scientific literacy skills before and after the learning process with the RADEC model. This study aligns with previous research, such as that conducted by Sukmawati & Zulherman [43], which showed that applying the RADEC model can enhance scientific literacy skills. Research by Hasbi [44] and Putri & Zulfadewina [42] also confirms that the RADEC model effectively improves students' scientific literacy. Additionally, [45] states that students' scientific literacy skills can increase with implementing the RADEC model, as it teaches students to read, write, think critically, and be innovative and creative.

The improvement in students' scientific literacy skills is also evident in each scientific literacy indicator, as presented in Figure 1.

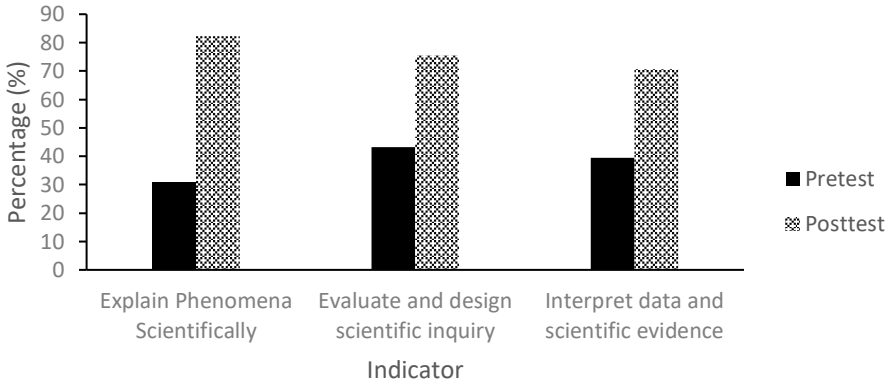

Figure 1. Improvement of Science Literacy for Each Indicator

Based on Figure 1, it can be observed that there is a significant increase in each scientific literacy indicator. The indicator of explaining scientific phenomena shows the highest growth compared to the indicators of designing and evaluating scientific investigations and interpreting scientific data and evidence. The scientific literacy indicators used are, according to [13], explaining phenomena scientifically, developing and evaluating scientific investigations, and interpreting data and evidence scientifically. The first indicator, the ability to explain phenomena scientifically, showed a significant increase from a pretest score of 30.88 to a post-test score of 82.35, with a difference of 51.47. This increase indicates that after implementing the RADEC model, students could better explain scientific phenomena through the RADEC model's emphasis on independent and group learning, expressing opinions, and applying problem-solving [43]. Additionally, this increase is due to the RADEC model encouraging students to seek information from various sources during the Read stage. Through guided reading activities, students gain a deep understanding of scientific concepts, enabling them to explain scientific phenomena better [46].

The second indicator, designing and evaluating scientific investigations, also increased from a pretest score of 43.14 to a post-test score of 75.49, with a difference of 32.25. This increase was due to the investigation activities during the Create stage. The Create stage in the RADEC model allows students to use their acquired knowledge to generate creative ideas or thoughts [47]. Students engage in active processes to design experiments, collect data, analyze results, and evaluate their findings. Research by McCormick [48] shows that students develop better critical and analytical thinking skills when they engage in activities requiring them to solve real-world problems.

The third indicator, interpreting data and evidence scientifically, showed an increase, though more minor, from a pretest score of 39.41 to a post-test score of 70.59, with a difference of 31.18. This increase was due to the use of data in the learning process and data analysis of experiments. When students answer pre-learning questions, they must interpret the data and scientific evidence they have learned. Group discussions strengthen this ability as students share views and analyze data, allowing them better to understand various interpretations of data and scientific evidence. This is consistent with the opinion of [49], who state that scientifically literate students can elaborate on various scientific concepts they have acquired, thereby building strong new understanding and knowledge that can be applied in life.

The increase in students' scientific literacy is also evident due to the implementation of the presented learning, as shown in the following Figure 2.

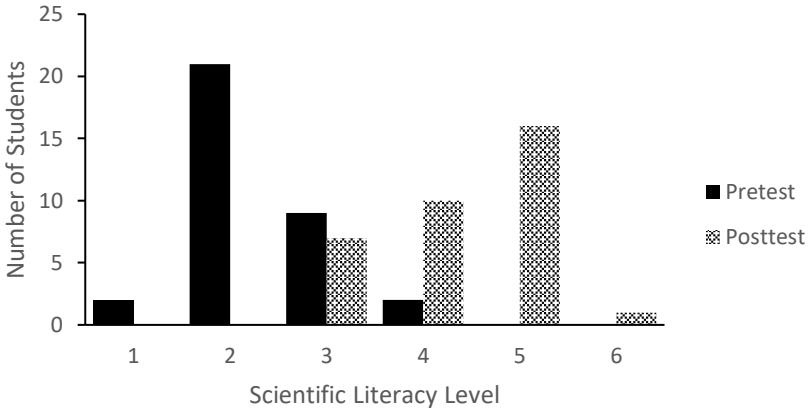

Figure 2. Level of Students' Scientific Literacy

Figure 2 depicts a diverse range of students' scientific literacy levels. Based on the pretest results, 2 students were at level 1, 21 were at level 2, and 9 were at level 3. Meanwhile, in the post-test results, 7 students were at level 3, 10 were at level 4, 16 were at level 5, and 1 was at level 6.

The increase in students' scientific literacy levels is evidenced by the pretest results, which ranged from level 1 to level 3, with the majority at level 2, indicating that students have sufficient scientific knowledge to provide explanations or draw conclusions based on simple investigations [13]. Then, in the post-test results, students' literacy levels increased to levels 3 to 5, with the majority at level 5, indicating that students can identify the scientific components of many complex life situations, apply scientific concepts and knowledge to specific situations, and compare, select, and evaluate appropriate scientific evidence to respond to life situations [13]. This shows that students' understanding and knowledge increased after learning using the RADEC model. The RADEC model can develop a conceptual understanding of science [50]. Conceptual understanding relates to scientific literacy, where good scientific literacy indicates a deep conceptual knowledge [51].

Various factors support the improvement in scientific literacy after implementing the RADEC model. These factors include the learning process and the constructivist learning environment. The RADEC model provides a systematic structure for the learning process, making students actively engaged in learning and developing the scientific skills necessary for better scientific literacy [44]. Bakar [52] states that a constructivist learning environment strongly influences scientific literacy. The learning environment significantly affects students' ability to enhance their scientific literacy [53]. The RADEC model creates a constructivist learning environment where the learning process is organized constructively, allowing students to build knowledge through direct experience and social interaction [29].

Conclusion

Based on the data analysis and discussion results, the following conclusions can be drawn. First, implementing the Read, Answer, Discuss, Explain, and Create (RADEC) model was executed well, as evidenced by an average implementation score of 98.6%, which was categorized as very good. Second, students' scientific literacy skills showed improvement after the RADEC model was implemented, as seen from the N-gain analysis, with a score of 0.60, categorized as moderate. The paired t-test analysis indicated a significant difference in improving students' scientific literacy skills before and after the learning process with the RADEC model.

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