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Improving Science Literacy in Elementary Schools Through the Application of the RADEC Model

Nadiah Talita Putri[1*], Wati Sukmawati[1]

[1]Elementary School Teacher Education Study Program, Muhammadiyah University Prof. DR. Hamka, Jakarta, Indonesia.

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Corresponding Author:
Nadiah Talita Putri
2001025164@uhamka.ac.id

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Abstract: This study evaluates the RADEC (Read, Answer, Discuss, Explain, and Create) learning method's impact on enhancing students' science literacy skills. By analyzing changes in question difficulty levels from pretest to posttest, the research assesses how effective RADEC is in improving students' comprehension of science concepts. The methodology involves administering questions before and after RADEC implementation, with statistical analysis revealing significant variations in question difficulty. Some questions became more challenging post-RADEC, indicating deeper understanding, while others remained stable or became easier, possibly due to improved familiarity or consistent teaching quality. Overall, RADEC promotes active engagement, sustains interest, and enhances understanding of science topics. The study underscores RADEC's efficacy in boosting science literacy, recommending its adoption in educational settings for optimal learning outcomes. It also highlights the need for appropriate evaluation tools in assessing students' responses to science education, offering valuable insights into effective teaching methodologies.

Keywords: Pretest-Posttest; Question Difficulty Level; RADEC Learning; Science Education; Science Literacy

Introduction

Improving science literacy is one of the main challenges in basic education in Indonesia (Sukmawati, 2023a). Science literacy, which includes the ability to understand science concepts, apply scientific knowledge in daily life, and think critically about scientific information, is essential to equip the young generation to face future global challenges. However, data shows that the science literacy of Indonesian students is still below the international average. The results of the Programme for International Student Assessment (PISA) in 2018 show that the science literacy scores of Indonesian students rank 71 out of 79 participating countries. This condition indicates the need for serious efforts to improve the quality of science learning in elementary schools, these efforts include the use of the RADEC learning model (Setiawan et al., 2020; Sukmawati et al., 2023). The RADEC (Read, Answer, Discuss, Explain, Create) learning model is one of the innovative approaches that is believed to improve students' science literacy.

This model emphasizes the active involvement of students in the learning process through reading, answering questions, discussing, explaining, and creating something related to the material being studied. The RADEC approach not only aims to improve the understanding of science concepts, but also to develop students' critical and creative thinking skills. A number of studies have shown that learning models that involve active student participation, such as RADEC, can improve learning outcomes and critical thinking skills (Pratama et al., 2020; Sukmawati, 2022; Sukmawati et al., 2023). However, although the RADEC model has great potential in improving science literacy, its application in primary schools is still limited. Many teachers have not understood or are not used to this model, so its application has not been optimal. In addition, research on the effectiveness of the RADEC model in the context of basic education in Indonesia is still limited. Most of

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the existing research is mostly conducted at the secondary or higher education level. Therefore, this study aims to fill this gap by exploring the influence of the application of the RADEC model on students' science literacy skills in elementary schools.

The problems faced in science education in elementary schools are not only related to the low science literacy of students, but also with learning methods that still tend to be conventional. Many teachers still use lecture and memorization methods, which are less effective in developing critical and creative thinking skills (Fiteriani et al., 2024). Students tend to be passive and less involved in the learning process, so they have difficulty understanding science concepts in depth and applying them in daily life (Sopandi & Handayani, 2019; Sukmawati et al., 2022b; Sukmawati et al., 2022a). More interactive and problem-based learning approaches, such as RADEC, are needed to address these issues. In addition, there is a gap between theory and practice in science education in Indonesia. Although the 2013 curriculum has mandated the use of a more active and student-centered approach to learning, in practice many teachers still find it difficult to implement it. Limited facilities and infrastructure, as well as lack of training and mentoring for teachers, are the main obstacles in the implementation of innovative learning models such as RADEC (Izzah & Sukmawati, 2022; Nurliana & Sukmawati, 2023; Sukmawati, 2023b).

Therefore, this study also aims to identify the factors that affect the successful implementation of the RADEC model in elementary schools, as well as provide recommendations to improve the effectiveness of science learning. The novelty of this study lies in its specific focus on the application of the RADEC model in primary schools, which is still rarely studied. This study will not only evaluate the influence of the RADEC model on students' science literacy skills, but will also explore how this model can be effectively implemented in elementary schools with various conditions. Thus, this research is expected to make a significant contribution to the development of science education theory and practice in Indonesia (Fikriyah & Sukmawati, 2022; Ramadhani & Sukmawati, 2022; Sukmawati et al., 2023). Overall, this study aims to make a significant contribution in improving the quality of science education in elementary schools through the application of the RADEC learning model. By exploring the influence of this model on students' science literacy, as well as the factors that influence its success, this study is expected to provide new insights that can be used to overcome various challenges in science education in Indonesia.

Method

The research method used in this study is an experimental method with a one group pretest-posttest design. This method was chosen to measure the effect of the application of the RADEC model on the science literacy ability of elementary school students. The subject of the study is 30 students in grade 4. Before and after the implementation of the RADEC model, this group of students will be given a science literacy test to measure changes in their abilities. Data collection is carried out through several stages. First, a pretest was carried out to measure students' initial science literacy skills. Furthermore, students will be given an intervention in the form of learning with the RADEC model for several weeks. After the intervention period is completed, a posttest is carried out to measure changes in students' science literacy skills after the implementation of the RADEC model. For data analysis, this study will use the stacking and racking approach of the Rasch model. The Rasch model is an effective data analysis method for measuring students' abilities based on their responses to test items (Fauziah & Sukmawati, 2023; Sukmawati, 2023a).

In the context of this study, the Rasch model will be used to calibrate science literacy test items and ensure that they have an appropriate and reliable level of difficulty. The stacking model will be used to combine pretest and posttest data so as to allow a more comprehensive analysis of changes in students' science literacy skills. Meanwhile, the racking model will be used to analyze the difficulty level of the questions. The results of quantitative data analysis with the Rasch model are expected to provide accurate information about the influence of the RADEC model on improving students' science literacy. Thus, this research is expected to make a significant contribution to the development of effective learning strategies to improve science literacy in elementary schools.

Result and Discussion

Based on Table 1, there was a significant increase in students' science literacy skills after participating in learning with the RADEC model. The average pretest score was 0.841034, which increased to 1.334138 on the posttest, indicating an increase of 0.493104. In addition, the standard deviation decreased from 0.94 on the pretest to 0.83 on the posttest, which indicates that the variation in students' scores decreased slightly after participating in the learning. This decrease in standard deviation indicates that the difference in students' science literacy skills has become more homogeneous. Looking at individual changes, many students

experienced significant improvements in their posttest scores, such as subject 2 whose score increased from 0.53 to 1.44 and subject 18 whose score increased from 1.44 to 2.24. Although there were some students who experienced a decrease in scores, such as subject 9 whose score decreased from 1.81 to 0.26, the majority of students showed a positive improvement. Some other students did not experience any change in their scores, such as subject 7 which remained at a score of 2.24.

Table 1. Changes in Science Literacy Ability

Subject	Pretest		Posttest	
	Measure	S.E.	Measure	S.E.
1	0.53	0.53	0.37	0.54
2	0.53	0.53	1.44	0.59
3	0.26	0.52	0.82	0.54
4	0.82	0.54	0.53	0.53
5	-1.45	0.58	-0.55	0.53
6	1.12	0.56	0.82	0.54
7	2.24	0.69	2.24	0.69
8	1.44	0.59	1.81	0.63
9	1.81	0.63	0.26	0.52
10	1.12	0.56	0.53	0.53
11	0.26	0.52	0.53	0.53
12	1.12	0.56	1.44	0.59
13	1.81	0.63	1.44	0.59
14	0.82	0.54	1.12	0.56
15	0.26	0.52	0.26	0.52
16	1.12	0.56	1.44	0.59
17	2.24	0.69	2.79	0.8
18	1.44	0.59	2.24	0.69
19	-0.83	0.54	0.26	0.52
20	2.24	0.69	1.44	0.59
21	-0.01	0.52	0.82	0.54
22	0.82	0.54	0.82	0.54
23	0.82	0.54	1.44	0.59
24	1.81	0.63	2.24	0.69
25	1.12	0.56	2.24	0.69
26	0.26	0.52	1.81	0.63
27	0.53	0.53	2.79	0.8
28	-0.01	0.52	1.44	0.59
29	-1.13	0.56	1.44	0.59
30	1.81	0.63	2.79	0.8
Mean	0.841034		1.334138	
S.D.	0.94054		0.835379	

Overall, the increase in the average posttest score shows that the RADEC learning model is effective in improving students' science literacy skills. The decrease in standard deviation also shows that students' science literacy skills become more uniform after learning (Mulyanti et al., 2022; Ramadhani & Sukmawati, 2022; Sukmawati & Wahjusaputri, 2018). Thus, the RADEC model succeeded in not only increasing the average ability but also reducing the disparity of ability among students. This indicates that the RADEC model can be a useful method in science teaching to improve students' science literacy comprehensively and more evenly among students. For more clarity, see Figure 1.

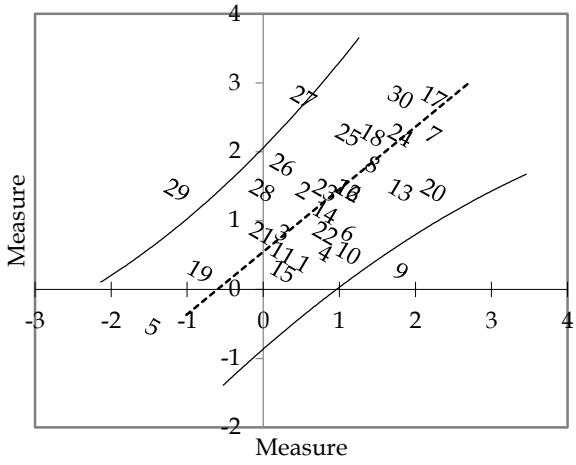

Figure 1. Changes in Science Literacy Ability of Pretest and Posttest Students

Figure 1 illustrates the relationship between pretest and posttest scores of students' science literacy skills. The X-axis shows the pretest score, while the Y-axis shows the posttest score. The dotted diagonal line on the graph is the identity line (y = x), where each point on this line has the same pretest value as the posttest, indicating no change in the student's score from pretest to posttest. The dots on the graph, represented by numbers, show the pretest and posttest scores of each student's subject. The dots above the diagonal line indicate an increase in the score from pretest to posttest, while the dots below the diagonal line indicate a decrease in the score. Most of the points are above the diagonal line, which indicates that the majority of students experienced an improvement in posttest scores compared to the pretest. Some points are right on the diagonal line, indicating no change in score, while some other points are below the diagonal line, indicating a drop in scores in certain students. In addition, there were several outliers such as subjects 29, 27, and 30 that showed significant changes, both positive and negative. For example, subject 29 had a negative pretest score that changed to a very positive posttest score, and subject 5 had a negative score on the pretest and posttest, but with a less significant increase. Overall, this graph shows the general tendency of score improvement from pretest to posttest, which indicates the effectiveness of learning with the RADEC model in improving students' science literacy skills, although there are individual variations in students' responses to such learning (Aisyah et al., 2023; Apriliana & Sukmawati, 2021; Novianti et al., 2023; Sukmawati et al., 2022c). For more details, see Figure 2.

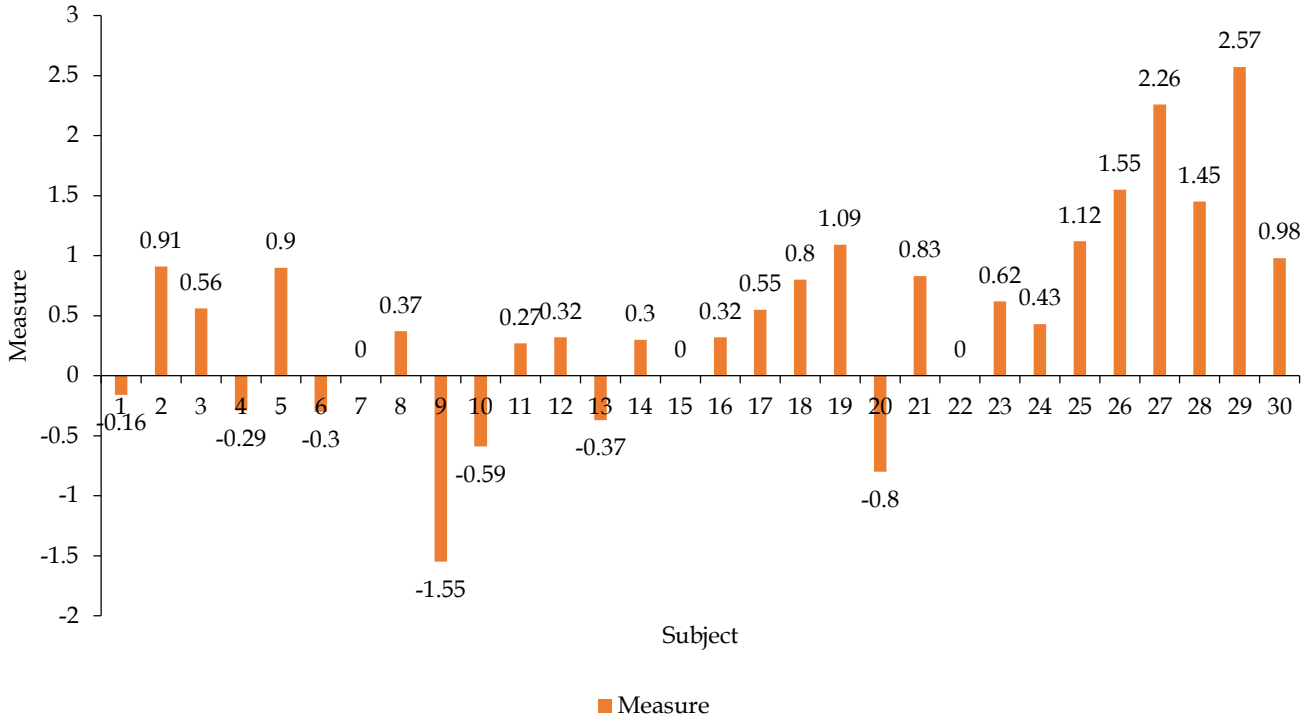

Figure 2. Changes in Students' Science Literacy Ability

Figure 2 shows the change in students' science literacy abilities for each subject. The horizontal axis (X) indicates the student's subject, while the vertical axis (Y) indicates the change in score on science literacy ability. Each bar represents the difference between the pretest and posttest scores for each student, with positive scores indicating improvement and negative scores indicating decrease. This graph shows that the majority of students have improved their science literacy skills after participating in learning with the RADEC model. Prominent examples are subject 27 with an increase of 2.26, subject 28 with an increase of 2.57, and subject 29 with an increase of 2.57. Some students experienced slight improvement, such as subjects 2, 3, and 4, with a change of about 0.9. On the other hand, there were some students who experienced a decrease in their abilities, such as subject 5 with a decrease of -0.63 and subject 11 with a significant decrease of -1.55. Overall, this graph indicates that the RADEC learning method is effective in improving science literacy skills for most students, although there are some cases where students experience a decline. Significant improvements in some students suggest that this method may provide great benefits in certain contexts, while declines in other students may be due to individual factors affecting their learning outcomes (Fitria & Sukmawati, 2022; Sukmawati, 2020, 2022; Sukmawati & Wijiastuti, 2021).

The majority of subjects showed a significant improvement in their science literacy skills after participating in learning with the RADEC model. Subjects 27, 28, and 29, for example, experienced an increase of 2.26, 2.57, and 2.57, respectively. This improvement can be explained by students' active involvement in learning, learning styles that fit the RADEC approach, and strong external motivation and support. The RADEC method, which encourages discussion, problem-solving, and the application of concepts in real-world contexts, seems to be particularly effective for students who respond well to these interactive and collaborative methods. However, there were also some subjects who experienced a decrease in their science literacy skills, such as subjects 5, 11, and 19, which experienced decreases of -0.63, -1.55, and -0.8, respectively. This decline may be due to a mismatch of learning styles with the RADEC approach, external problems such as stress or personal distractions, and a lack of adequate support from teachers or the learning environment. Subject 11, which experienced a significant decline, may face these challenges that hinder her learning process. In addition, some subjects did not show any change in their science literacy abilities, such as subjects 7, 15, and 22. This could be due to their already high initial ability, so there is not much room for further improvement, or the need for longer time to adjust to the new learning method. Students who do not experience change may require a more individualized approach or variety in teaching methods to achieve significant change. Overall, these results suggest that while the RADEC model is effective for many students, its effectiveness may vary depending on individual and

contextual factors (Izzah & Sukmawati, 2022; Sukmawati et al., 2021; Wahjusaputri et al., 2022). Significant improvements in some subjects confirmed the success of the RADEC method, while declines in other subjects indicated the need for additional adjustments or support. For students who do not experience change, an understanding of their initial abilities and adaptation to new methods is essential (Fauziah & Sukmawati, 2023; Nurliana & Sukmawati, 2023; Wanningrum & Sukmawati, 2023). Further research and a more personalized approach may be needed to optimize learning outcomes for all students.

Racking Analysis

Table 2. Changes in the difficulty level of the questions

Items	Pretest		Posttest	
	Measure	S.E.	Measure	S.E.
1	0.53	0.53	0.37	0.54
2	0.53	0.53	1.44	0.59
3	0.26	0.52	0.82	0.54
4	0.82	0.54	0.53	0.53
5	-1.45	0.58	-0.55	0.53
6	1.12	0.56	0.82	0.54
7	2.24	0.69	2.24	0.69
8	1.44	0.59	1.81	0.63
9	1.81	0.63	0.26	0.52
10	1.12	0.56	0.53	0.53
11	0.26	0.52	0.53	0.53
12	1.12	0.56	1.44	0.59
13	1.81	0.63	1.44	0.59
14	0.82	0.54	1.12	0.56
15	0.26	0.52	0.26	0.52
16	1.12	0.56	1.44	0.59
17	2.24	0.69	2.79	0.8
18	1.44	0.59	2.24	0.69
19	-0.83	0.54	0.26	0.52
20	2.24	0.69	1.44	0.59
21	-0.01	0.52	0.82	0.54
22	0.82	0.54	0.82	0.54
23	0.82	0.54	1.44	0.59
24	1.81	0.63	2.24	0.69
25	1.12	0.56	2.24	0.69
26	0.26	0.52	1.81	0.63
27	0.53	0.53	2.79	0.8
28	-0.01	0.52	1.44	0.59
29	-1.13	0.56	1.44	0.59
30	1.81	0.63	2.79	0.8
Mean	0.830667		1.302	
S.D.	0.926416		0.839374	

Based on Table 2, information was obtained regarding changes in the difficulty level of the questions based on the given table. The table shows the pretest and posttest values for each question item, along with the accompanying error standard (S.E.). From the table, it can be observed that there is a significant variation in the difficulty level of the questions from pretest to posttest. For example, item number 2 shows a considerable increase in difficulty, with the measure value increasing from 0.53 to 1.44. Meanwhile, item number 5 shows a noticeable decrease in difficulty, with the measure value initially going from -1.45 in the pretest to -0.55 in the posttest. Statistical analysis from the table shows that the average value of the measure in the pretest is 0.830667, while in the posttest it is 1.302. The standard deviation of the two groups also showed a significant difference, with a standard deviation of 0.926416 for the pretest and 0.839374 for the posttest. This suggests that there was a consistent change in the difficulty level of the questions from pretest to posttest, which could be an indication of the effectiveness of RADEC learning interventions on the difficulty level of the questions (Churiyah et al., 2020; Rosli et al., 2020), so that many students find it easier to answer questions after following the learning process using the RADEC model. For more clarity japat is seen in Figure 3.

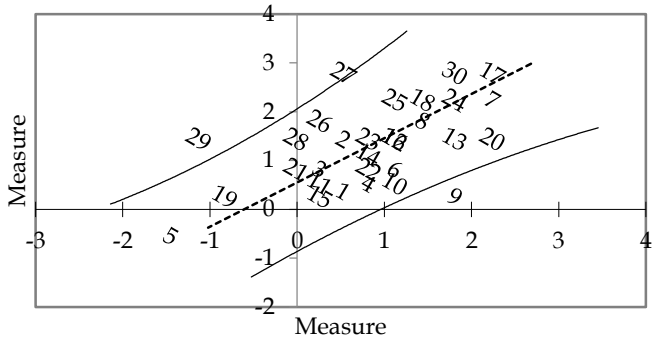

Figure 3. Graph of changes Difficulty level of questions

In the analysis of changes in the difficulty level of questions from pretest to posttest, there are several questions that show significant changes in difficulty. One example is question number 2, which has experienced a considerable increase in difficulty from pretest to posttest. In the pretest, the measure value of question number 2 was 0.53, while in the posttest, the score increased significantly to 1.44. An increase in the difficulty of this question may indicate that the material tested in question number 2 becomes more complex or challenging for the examinee in the posttest. This can be due to the addition of new material or an overall difficulty adjustment (Carl et al., 2016; Elmer & Stadtfeld, 2020; Sumintono, 2018). Further analysis needs to be carried out to understand the factors that cause the increase and its implications for the examinee's understanding of the material being tested. For more clarity, it can be seen in Figure 4.

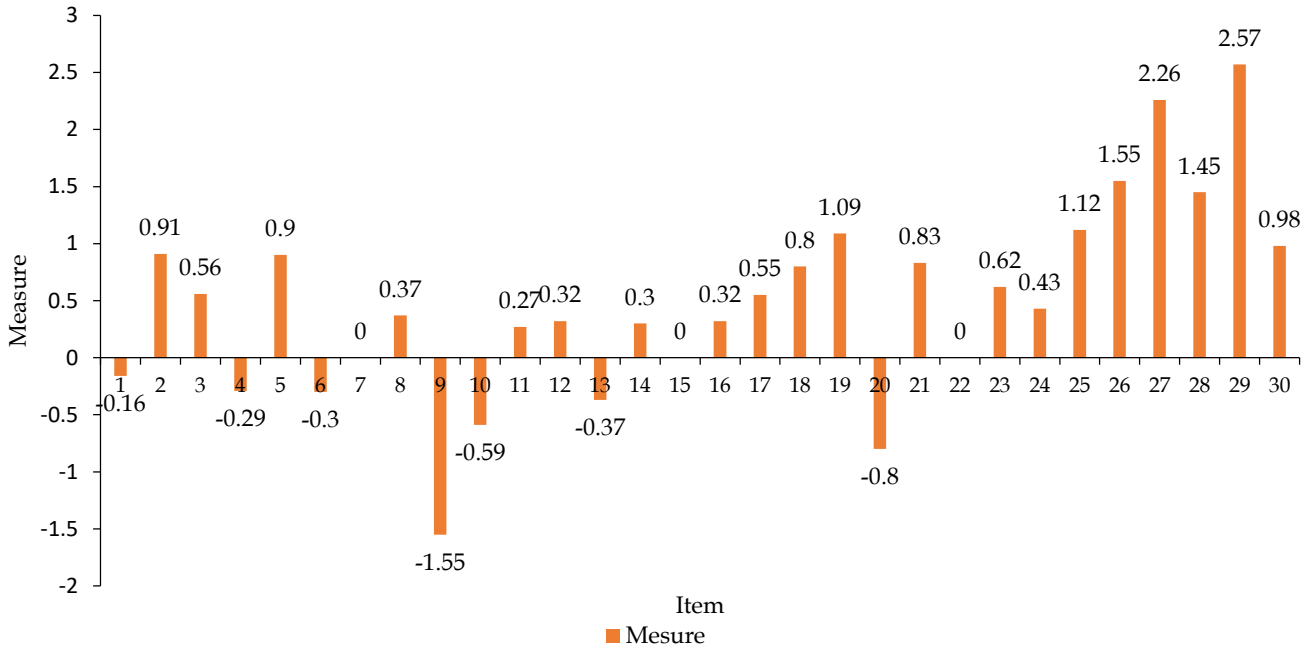

Figure 4. Changes in Question Difficulty

Figure 5. Data Collection Process

Based on the data on changes in the difficulty level of questions from pretest to posttest, it reveals a number of interesting findings and provides deeper insights into the evaluation and learning process. First, questions that have increased in difficulty, such as numbers 1, 4, 6, 9, 10, and 20, indicate the possibility of adding more complex material or changes in the preparation of questions. For example, question number 1 shows an increase from a measure value of 0.53 in the pretest to 0.37 in the posttest. This may be due to the addition of deeper sub-material or concepts to the posttest, which requires a deeper understanding of the examinee. These findings make a new contribution by underlining the importance of sustainability in the development of tests to reflect changes in curriculum understanding or increased learning needs. It can be seen in Figure 5.

Second, questions that show a fixed level of difficulty between the pretest and posttest, such as numbers 7, 15, and 22, indicate consistency in the difficulty of the questions over time. However, it should be noted that the difficulties that remain do not always reflect stagnation in the understanding of the test takers, but can also indicate consistency in the learning or understanding that the participants have gained. Further analysis needs to be carried out to understand the factors underlying this consistency, whether it comes from consistent teaching quality or unchanged characteristics of examinees. Third, the decrease in the difficulty level of the questions, such as those that occurred in numbers 2, 3, 5, 8, 11, 12, 13, 14, 16, 17, 18, 19, and 20, can be caused by various factors. For example, adjustments in the preparation of questions or materials that are easier for examinees to understand in the posttest. These declines, while not necessarily negative, require special attention to ensure that they are not caused by inaccuracies in the formulation or measurement of the questions. These findings emphasize the importance of careful evaluation of the entire evaluation process, including the design and preparation of questions, as well as a deep understanding of changes in the examinee's understanding. Overall, this study makes a valuable contribution by revealing the complex dynamics in the responses of examinees to the questions given (Lestari et al., 2022; Sopandi, 2019; Wieser & Seeler, 2018; Zulfa et al., 2021). These findings provide deeper insights into the evaluation and learning process, and highlight the need for continuous development and refinement in

evaluation instruments to reflect changes in test takers' understanding and learning.

Conclusion

This study highlights the pivotal role of RADEC (Read, Answer, Discuss, Explain, and Create) learning in enhancing students' science literacy skills. Analysis of question difficulty levels from pretest to posttest reveals that implementing RADEC significantly enhances students' understanding of science material. Most students demonstrated increased question difficulty, indicating improved comprehension through RADEC. This approach effectively stimulates student interest, fosters active engagement, and deepens understanding of science concepts. However, some questions showed unchanged or decreased difficulty, influenced by factors such as material complexity and teaching effectiveness. Overall, the study confirms RADEC's positive impact on advancing students' science literacy. It recommends continued use of RADEC in science education to optimize learning outcomes by enhancing student interest, engagement, and comprehension of science content.

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Author Contributions
For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, N.T.P contributed to the data collection process, data processing, and article writing. W.S contributed to the data processing and article writing.

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Conflicts of Interest
The authors declare no conflict of interest.

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