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Enhancing Science Literacy and Collaboration Skills Through the RADEC Learning Model in Junior High Schools

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Abstract: Collaboration and science literacy skills are key indicators in the current learning era. Collaboration trains students to actively engage and make decisions together, while science literacy equips them to think critically and face the challenges of the Industrial Revolution. However, in reality, both skills remain below average among students. This gap highlights the need for an effective learning model to address the problem. Several studies have shown that the Read, Answer, Discuss, Explain, and Create (RADEC) learning model can improve these abilities through a structured and student-centered approach. The objectives of this study are to analyze the effectiveness of the RADEC learning model in improving students' science collaboration and literacy. This research used a quasi-experimental nonequivalent control group design. The sample consisted of class VIII C (experimental) and VIII D (control), selected through purposive sampling. Data were obtained from a collaboration skills questionnaire and students' pretest and posttest scores to assess improvements in science literacy skills. The results showed that (1) the RADEC model is effective in improving students' science collaboration skills from the t-test with sig (2-tailed)-value is less than 0.05 which means that the structured RADEC model can facilitate the development of affective and cognitive aspects to create a high collaborative learning environment and (2) the RADEC model is effective in improving students' science literacy skills from the t-test with sig (2-tailed)-value is less than 0.05 which means that the RADEC model through its stages is able to build better conceptual understanding to develop students' science literacy significantly. This study concludes that the RADEC learning model is effective in improving the science collaboration skills and science literacy of junior high school students.

Keywords: RADEC, science collaboration skill, science literacy.

▪ INTRODUCTION

Natural Science Education is a fundamental concept in science that encompasses the environment and all natural events or phenomena that occur (Utomo, Narulita, & Billah, 2020). The foundation of basic science is crucial in the development of modern technology and innovation (Ke, 2020). Various activities in science learning, ranging from laboratory practicum to field learning, require students to have a high level of collaborative skills so that the learning process can be maximized (Silfia Ilma et al., 2021). The Partnership for 21st Century Skills (P21) explained that there are several skills that must be possessed in the 21st century, namely "The 4Cs," including communication skills, critical thinking skills, creative thinking skills, and working together (Septikasari & Frasandy, 2018). This is in line with the 21st-century learning approach, where the learning system focuses on emphasizing collaborative learning, so that students learn in small groups to build shared understanding (Sulaiman & Shahrill, 2015). Therefore, students are required to have good collaboration skills in order to be able to adapt effectively in various learning activities (Muniroh et al., 2021).

Collaboration skills are an ability that needs to be mastered by students in the process of working together, where the process includes the involvement of communication interactions and activeness, which can later produce a decision for the

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achievement of common goals (Riak & Hananto, 2023). Collaboration skills not only promote good group work but also encourage learners to discuss and reach decisions together without simultaneously increasing the active participation of all members (Avello & López, 2015). According to PISA (Program for International Student Assessment), collaboration skills play an important role in one's success, especially in the social sphere. Gkogkidis & Dacre (2021) added that the creation of learner collaboration encourages interaction in small groups that involves the exchange of ideas so as to foster creativity, and create new ideas expressively.

In addition to collaboration skills, the World Economic Forum (WEF) classifies 16 skills needed in the 21st century. One of the skills that is closely related to the importance of collaboration ability is students' science literacy (Dewi, Susantini, & Poedjiastoeti, 2021). According to the results of the PISA (Programme for International Student Assessment) survey, scientific literacy is defined as the ability of students to utilize scientific knowledge, analyze various types of questions, and draw conclusions based on existing facts to make informed decisions. With the ability of science literacy, a person can implement the understanding they have in order to become a provision in everyday life (OECD, 2016). Meanwhile, Fitria (2017) revealed that science literacy skills are fundamental, making it crucial to shape children's character and scientific abilities through direct interaction early on.

Science literacy skills are not only centered on reading activities, but can also be demonstrated through other activities, such as listening, writing, collecting data, and presenting information in both oral and written forms (Pitcher & Mackey, 2013). OECD PISA 2017 describes several aspects of science literacy skills, including science process skills, basic understanding, and science behavior. Science literacy skills in science concepts are influenced by the level of collaboration of students through the process of interacting and sharing insights actively (Janul & Sunendar, 2024). The development of strong science literacy skills requires close cooperation between students in solving scientific problems, enabling them to interpret scientific concepts effectively in group discussions (OECD, 2018). When science literacy indicators are instilled early, students tend to develop into dynamic individuals and are able to adapt to changing times and modern life (Roy, Sikder, & Danaia, 2025). Aisah et al. (2021) stated that literacy skills are an important prerequisite for students to adjust to the demands of the Industrial Revolution 4.0 and increase global competitiveness.

According to several literature reviews available, the level of collaboration skills among students in Indonesia remains low. Karimi & Farivarsadri (2024) found that the level of students' collaboration skills in learning projects was sometimes still in the low to medium category, with group scores ranging from one-third to half of the total expected ability. Meanwhile, observations made by Brodbeck et al. (2016) indicate that only some students play an active role; most others exhibit free-riding behavior, where only one or a few individuals contribute significantly. Du et al. (2022) added that the level of collaboration ability of students is very low, especially at the school age. In line with this, efforts are needed to develop and improve collaboration skills (Dart, Smith & Lee, 2025).

A decrease in collaboration skills in the interaction and communication of students in learning can have an impact on reducing science literacy (Prayoga & Gading, 2023). Sugianto (2022) said that students' collaborative skills in science learning are very important in improving students' scientific literacy through active interaction and sharing which will build a deeper and more contextual understanding of concepts. This is in line with Viehmann (2021) where collaboration skills in science learning create students who can exchange ideas so as to develop knowledge of scientific concepts that can increase students' science literacy skills.

PISA (Program for International Student Assessment) research from 2000 to 2022 revealed that the level of science literacy among students in Indonesia remains low. This statement is evidenced in the analysis of the PISA survey in 2015, where Indonesia ranked 62nd among 72 participating countries. In 2018, Indonesia ranked 74th among 79 total countries included. Meanwhile, in the 2022 PISA period, Indonesia's science literacy level ranked 68th and decreased by 13 points from the previous period. The statement of the Ministry of Education and Culture (2019) added that the low level of science literacy in Indonesia, according to the PISA survey data, can be seen through several aspects, including the ability to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence scientifically. From some of these facts, it can be inferred that the level of science literacy skills among students is below the standard.

The low collaboration and science literacy skills of students in Indonesia are generally caused by the learning process that has not been oriented towards improving these two aspects. In the independent curriculum, teachers have the freedom to choose a learning model used in the classroom. Therefore, a solution that can be proposed to help solve the problem of improving collaboration skills and science literacy is the Read, Answer, Discuss, Explain, and Create (RADEC) learning model. The RADEC learning model is a learning model that guides students to bring out 21st-century skills such as critical thinking, creativity, communication, and collaboration so that they can face the dynamics of the times (Burhanudin et al., 2024). This model has several stages in each learning step, namely: Read, Answer, Discuss, Explain, and Create. RADEC is more centered on awakening students' abilities in HOTS (High Order Thinking Skill) learning activities, science literacy activities, and character learning activities to strive for 21st-century skills (Nurpratiwi, Hamdu & Sianturi, 2023). This model emphasizes active, social, and reflective learning. Learners explore their initial understanding independently at the read and answer stages. The initial understanding will be explored and validated more deeply through discuss and explain stages. The existence of a strong understanding creates an innovation and a new idea that is poured in the form of a product through the create stage. Some of these stages reflect that the RADEC model belongs to the theory of constructivism. This theory adheres to the understanding that an insight is developed independently by each individual through the process of communication and social interaction (Kusumaningpuri & Fauziati, 2021).

The RADEC learning model is a student-centered learning approach that integrates conceptual understanding, collaboration, and problem-solving activities, enabling students to generate ideas or create products (Fitria & Setiyawati, 2024). In line with this, Nurpratiwi, Hamdu, and Sianturi (2023) argue that collaboration and scientific literacy skills require an active learning-oriented model, which is embodied in the RADEC framework. This is particularly evident in the "read" and "discuss" stages. The "read" stage provides students with the opportunity to independently explore knowledge from various sources relevant to the topic being studied (Sopandi, 2017). Meanwhile, in the "discuss" stage, students work in groups to find solutions to problems or questions introduced at the beginning of the lesson (Maspiroh & Sartono, 2022).

A study by Nurpratiwi, Hamdu & Sianturi (2023) showed that the RADEC model is able to train critical thinking skills, collaboration skills of students, speaking skills, and writing skills, where some of these are important indicators in the aspect of science literacy. Then in a study conducted by Putri, Ali & Ismail (2024) who applied the RADEC learning model to support the level of concept understanding and student collaboration in the concept of natural disasters, it was found that the model was successful in increasing students' concept understanding and collaboration through the stages of the RADEC model where students can seek information, understand concepts and can present the results of their group discussions in depth and meaning.

With the problems and some descriptions related to the results of other similar studies, the researcher intends to review research on the effectiveness of the RADEC learning model in improving the ability of science collaboration and science literacy of junior high school students. This research can be an update in researching the RADEC model, as most have only focused on one learning outcome variable or have not compared it directly with other active learning models. Research that specifically compares RADEC with Discovery Learning, especially in improving collaboration skills and science literacy simultaneously, is still very limited. Therefore, this research is expected to complement and update previous studies and show that the RADEC model can be applied to various aspects and concepts of learning.

▪ METHOD

Participants

This study was conducted with a population of students in grade VIII of SMP Negeri 13, Magelang City, during the 2024/2025 school year, comprising seven classes from class A to class G. The basis for sampling was determined by applying the purposive sampling method, a sampling approach that aims to obtain representative data based on a specific consideration (Sugiyono, 2016). The reasons for sampling include the same science teacher, the same number of students in each class, and the similarity of the average value of student learning outcomes. With these criteria, two classes were selected for the research sample: 32 students from class VIII C as the experimental class and 32 students from class VIII D as the control class.

Research Design and Procedures

This research is classified as a quantitative study employing a quasi-experimental design with a non-equivalent control group, utilizing an experimental class and a control class. The RADEC learning model was applied to the experimental class. Meanwhile, the control class applied the discovery learning model. In the experimental class, students will conduct pre-learning activities, specifically Read and Answer, where they are required to read a passage, then summarize and answer questions about the content of the reading text. Pre-learning activities were conducted prior to students' formal learning at school. Furthermore, in school activities, the Discuss stage involved group discussions, and the Explain stage entails presenting the results of each group's discussion. At the Create stage, students created a product in the form of an experimental design. In the control class, the Discovery activity involved group learning with stimulating activities, identifying problems, collecting data through reading or experiments, processing data systematically, verifying findings, and drawing conclusions in an outline. The research was conducted over two meetings, totaling 4 lesson hours in each class. Before giving treatment at the first meeting, students will take a pretest to measure initial ability. Then, at the end of the learning process, students take a posttest to assess the improvement in their initial ability.

Instruments

The data generated from this study include pretest and posttest scores from the collaboration questionnaire sheet and science literacy test questions. The collaboration instrument used was a questionnaire sheet on peer assessment containing 25 statements according to Greenstein's (2012) indicators, presented in Table 1.

Table 1. Collaboration skills indicators

Collaboration Skill Indicators	Indicator Description	Statements
Contribute actively	1. Always present ideas, solutions, or suggestions when speaking 2. The ideas, suggestions, or solutions presented are beneficial to the discussion.	Students provide ideas, solutions, or suggestions that are appropriate to the study discussed.
Work productively	Utilize time effectively to stay focused on the task, not be distracted, and complete the work at hand.	Students utilize time effectively and stay focused on group work.
Take responsibility	1. Understand how to plan, organize, and fulfill the tasks assigned by the teacher and hold their respective duties. 2. Regularly attend group meetings	Students often underestimate their responsibilities and tend to rely on others.
Showing flexibility	1. Accept criticism, appreciation, and suggestions 2. Flexible in cooperation	Students are reluctant to cooperate with group mates who have different backgrounds, ethnicities, races, and cultures.
Respect others	1. Respond openly to differences of opinion and appreciate others' new ideas. 2. Talking about ideas	Students respect all members of their group by exhibiting a good and polite attitude during discussions.

Analysis of the level of collaboration of students is assessed based on the questionnaire category by Ridwan (2014), where in positive statements, a score of 4 is worth “very good”, a score of 3 is “good”, a score of 2 is worth “less good”, and a score of one means “not good”. Meanwhile, the score assessment in negative statements applies the opposite value, where a score of 1 means “very good” and is followed by other scores.

Meanwhile, the science literacy instrument used consists of 15 pretest and posttest questions that have been adjusted to align with the science literacy indicators as outlined in PISA 2022. The science literacy indicators are presented in Table 2.

The validity test and reliability test are used to see the level of certainty and accuracy of the instrument. The validity test aims to determine whether or not an instrument is suitable for measuring a variable. This test was conducted by five experts

Table 2. Science literacy indicators

Science Literacy Indicators	Indicator Description	Question Items
Explain phenomena scientifically	1. Explain and recognize phenomena based on scientific knowledge appropriately. 2. Make accurate conjectures in an effort to explain scientific phenomena based on their knowledge.	The application of inclined planes on winding mountain roads is done to make the road more gentle and easy to pass. However, this can actually increase the frictional force generated between the tire wheels and the asphalt. The hypothesis that might explain this application is...
Evaluate and design scientific investigations	1. Offers a method to respond to questions through scientific clarification and experimental evaluation. 2. Design an investigation that is explored in a specific scientific review.	On the playground, Susi and Lita are playing on a seesaw that is 6 meters long. Susi and Lita weigh 56 kg and 35 kg, respectively. Their initial sitting position is at a distance of 1 m from the fulcrum. However, after climbing the seesaw, Lita could not lower the seesaw. The step that must be taken to balance the seesaw is...
Interpret data and evidence scientifically	1. Convert data from one point of view to another. 2. Make conclusions supported by evidence and logical hypotheses and judgments based on different considerations.	A manual chopper is a food ingredient-smoothing tool that works by pulling it by hand to rotate the blade inside. The working system of this tool utilizes two types of simple planes to facilitate its use. The use of this tool is considered more profitable than cutting manually with a knife. Based on this statement, the type of simple plane applied in the manual chopper is...

and analyzed through Aiken's V test. The test results showed that the value of the V coefficient of the collaboration and science literacy instrument was 0.93. Based on the V score index table, instruments analyzed by five experts using a 1-4 Likert scale can be considered valid when the V value is 0.87 or higher. The reliability test of the collaboration and science literacy instrument was conducted on 32 students. The test results were analyzed using the Cronbach-Alpha formula through the SPSS 21 program. The Cronbach's Alpha score is displayed in Table 3.

Table 3. Results of cronbach's alpha score

Variable	*Cronbach's Alpha*	R_{table}	Item Total	Category
Collaboration	0.839	0.06	25	Reliable
Science literacy	0.752	0.06	15	Reliable

Data Analysis

The data analysis technique employed the Independent Sample T-Test and N-Gain test. The steps in the research data analysis process are (1) conduct a normality test to determine whether the data obtained comes from a normally distributed population. If the data is normally distributed, then a parametric statistical test is carried out in the form of a T-Test; (2) analyzing data using N-Gain calculation. According to Wahab et al. (2021), the basis for making decisions on N-Gain scores is as follows: if $g > 0.7$, the category is high; if $0.3 \leq g \leq 0.7$, the category is medium; and if $0 \leq g \leq 0.3$, the category is low.

▪ RESULT AND DISSCUSSION

This study aims to analyze the effectiveness of the Read, Answer, Discuss, Explain, and Create (RADEC) learning model in enhancing junior high school students' science collaboration skills and scientific literacy. Collaboration skills were analyzed based on five indicators proposed by Greenstein (2012), while scientific literacy was assessed using three indicators from the PISA 2022 framework. The research findings were obtained after implementing the RADEC learning model in the experimental class (Grade VIII-C). In contrast, the control class (Grade VIII-D) received instruction through the Discovery Learning model.

Overall, the average score of the collaboration ability pretest was superior in the control class, with a score of 74.10, and the experimental class scored 73.68. In the posttest results, the highest average was obtained in the experimental class, with a score of 87.40, while the control class had a score of 80.76. Furthermore, the average score in each indicator of collaboration ability shows that the highest average score is in the experimental class.

The results of the average score of the pretest of science literacy skills showed that the control class was superior, with an average of 62.71, and the experimental class scored 61.88. Meanwhile, the average posttest results in the experimental class were 82.29, which was superior to those in the control class, with a score of 73.54. Furthermore, the average score in each indicator of science literacy ability shows that the highest average score is in the experimental class.

Based on the average score, it can be seen that both classes experienced an increase in each indicator of collaboration skills and science literacy. The higher increase was experienced by the experimental class, which applied the RADEC learning model. Although the control class that applied the Discovery Learning model experienced a smaller increase, it does not deny that both abilities can also be improved through the model applied.

The data results in the form of pretest and posttest scores from both classes were analyzed through the prerequisite test, namely the normality test. Based on the SPSS output, the significance values from the Kolmogorov-Smirnov test are higher than 0.05, indicating that the data were normally distributed. Therefore, the appropriate statistical test for this condition was the parametric test, specifically the Independent Sample T-Test, as the data sets were unpaired. The results of the T-Test analysis are presented in Tables 4 and 5.

Table 4. Independent sample t-test – collaboration skills

Data Tested	*Sig.(2-tailed)*	Alpha	Description
Pretest	0.992	0.05	No significant difference
Posttest	0.000	0.05	Significant difference

Table 5. Independent sample t-test – science literacy

Data Tested	*Sig.(2-tailed)*	Alpha	Description
Pretest	0.849	0.05	No significant difference
Posttest	0.001	0.05	Significant difference

To determine the extent of improvement before and after the treatment, the N-Gain test was conducted. The N-gain results on collaboration skills showed a greater improvement value in the experimental class, at 0.51, compared to the control class, at 0.25. Meanwhile, the N-Gain results on science literacy skills in the control class yielded a value of 0.57, indicating an increase greater than the N-Gain value in the control class, which was 0.27.

Effect of RADEC on Collaboration Skills

Based on the obtained data, the experimental class demonstrated higher collaboration skills compared to the control class. The average posttest score in the experimental class was higher (87.40) than that of the control class (80.76). Nevertheless, both classes showed an overall improvement in collaboration skills.

The results of the T-test on the pretest scores for collaboration skills indicated a Significant Difference. (2-tailed) value greater than 0.05 (sig. > 0.05), suggesting no significant difference between the average scores of the experimental and control classes prior to the treatment. This implies that both classes started from a similar baseline. However, the posttest T-test results showed a sig. (2-tailed)-value less than 0.05, indicating a statistically significant difference in the average posttest scores between the two classes after the treatment was implemented.

Based on the N-Gain analysis, a noticeable difference was observed in the improvement of collaboration skill scores between the experimental and control classes. The experimental class achieved a higher N-Gain score of 0.51, categorized as moderate, while the control class attained a lower N-Gain score of 0.25, categorized as low. The detailed N-Gain scores for each collaboration skill indicator are presented in Figure 1.

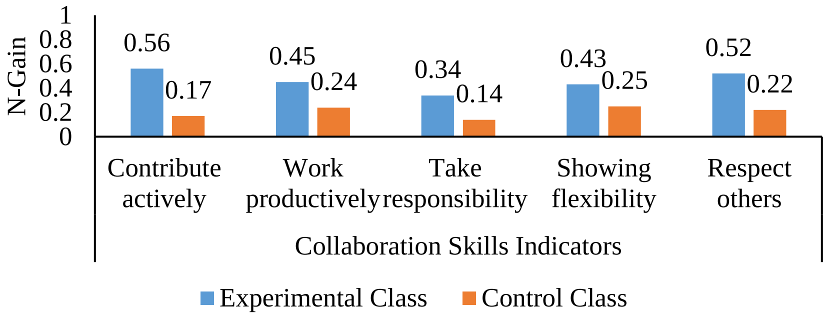

Figure 1. N-Gain analysis by indicator of students' collaboration skills

Across all five collaboration indicators, the experimental class achieved moderate N-Gain scores on each indicator, while the control class attained low N-Gain scores across all indicators. Nevertheless, both groups demonstrated improvement in each aspect of collaboration skills.

For the first indicator, active contribution, the experimental and control classes recorded N-Gain scores of 0.56 and 0.17, respectively. This improvement was primarily supported by the discuss phase in the RADEC model, during which students engaged in discussion and task delegation to solve presented problems. This process encouraged all group members to actively contribute ideas, suggestions, and responses. AR & Hardiansyah (2022) note that active participation can include asking questions, offering opinions, or answering questions. Such activities make a significant contribution to the dynamics of classroom discussions and student engagement (Mercer & Howe, 2012).

In the control class, active contribution was observed during the data processing and verification stages, where students worked in groups to solve problems in the student worksheet. However, not all students were active participants in these discussions; some remained passive and relied heavily on their higher-achieving peers.

The second indicator, working productively, showed a moderate N-Gain in the experimental class and a low N-Gain in the control class. This improvement was driven by the read and answer phases of RADEC, which were conducted outside regular class hours with limited time. The time constraints motivated students to be more productive and make efficient use of their time. In the read phase, students were expected not only to read but also to produce summaries of the material.

The answer phase helped students develop focus by applying what they had read to pre-learning questions. The read and answer stages play a crucial role in preparing students to enter the next stage, enabling the discussion, explanation, and creation process to take place more effectively (Maulida, Pratama, & Kelana, 2024). This preparation encouraged stronger classroom engagement, with students sharing ideas, posing questions, and providing responses (Kurniayati, Hardiansyah & Sukitman, 2025).

In the control class, this indicator was reflected during the stimulation and problem statement stages. However, during the second session, which followed a physical education class, many students were visibly tired or sleepy, reducing their overall productivity during the lesson.

The third indicator, taking responsibility, yielded N-Gain scores of 0.34 in the experimental class and 0.14 in the control class. Responsibility was fostered during the read, answer, and discuss phases of the RADEC model. Students were accountable for completing pre-learning tasks such as summarizing readings and answering questions. In addition, during the discussion stage, students determine the division of tasks through group discussions, ensuring that each member has a clear role and responsibility in completing a common task (Fitri & Caswita, 2023).

In the control class, responsibility was seen in the data collecting activity, where students gathered information through reading and conducting simple experiments. However, some students were reluctant to carry out the experiments and instead copied results without engaging in the process, an issue that persisted across both sessions.

The fourth indicator, demonstrating flexibility, resulted in a moderate N-Gain in the experimental class and a low N-Gain in the control class. This improvement was attributed to the create phase of RADEC, where students collaboratively designed simple experiments as solutions to given problems. This process requires learners to work intensively together, supporting and accepting ideas or responses from fellow members, thereby increasing substantive collaboration in a scientific context (Rambe, Suresman, & Firmansyah, 2025). Therefore, students will work together more often and accept every form of idea, opinion, or response given by each group member. Collaboration skills involve the ability to work both individually and collectively toward a conclusion or innovation (Kurniayati, Hardiansyah, & Sukitman, 2025).

In the control class, flexibility was observed in students' responses to randomly assigned groups. Initially, some students were unwilling to work with certain peers. A few chose to withdraw from their groups despite efforts to encourage cooperation. However, by the second session, many had begun to participate and accept their responsibilities within the group.

The fifth indicator, respecting others, showed N-Gain scores of 0.52 in the experimental class and 0.22 in the control class. This improvement was supported by the explain phase of RADEC, where students took turns presenting and explaining their group discussions to the class. This practice helped students develop the ability to listen attentively and appreciate differing perspectives. Each learner will practice listening carefully to the results and different opinions of other learners, which is an important aspect of respect for others (Parker & Thomsen, 2019). Dewi & Mailasari (2020) emphasized that this skill involves acknowledging and valuing others' ideas and opinions.

In the control class, this indicator was evident during the generalization activity, in which students collectively summarized the conclusions from their group discussions. Overall, both the experimental and control classes experienced gains across all collaboration indicators. However, the most substantial improvement occurred in the experimental class using the RADEC model. This suggests that RADEC effectively supports the development of 21st-century skills, particularly collaboration. Fitria & Setiyawati (2024) state that implementing the RADEC model provides students with opportunities to engage in discussions, design investigations, and draw conclusions, encouraging active participation throughout the learning process. Thus, the RADEC learning model is more effective in enhancing collaboration skills compared to the discovery learning model.

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The RADEC Model and Scientific Literacy Skills

Based on the data obtained, the experimental class demonstrated higher scientific literacy skills compared to the control class. The average posttest score in the experimental class was 82.29, outperforming the control class, which had an average score of 73.54. Nevertheless, both classes showed an overall improvement in scientific literacy.

The results of the T-Test on pretest scores revealed that the Sig. (2-tailed)-value was greater than 0.05, indicating no statistically significant difference in the mean scores between the experimental and control classes prior to the intervention. This suggests that both groups started from a comparable baseline. However, the posttest T-Test results showed a Sig. (2-tailed)-value less than 0.05, indicating a statistically significant difference in the average scores of the two groups after the treatment was applied.

According to the N-Gain analysis, the experimental class exhibited a greater improvement in scientific literacy, with an N-Gain score of 0.57. In contrast, the control class achieved a lower N-Gain score of 0.27. The detailed N-Gain scores for each scientific literacy indicator are presented in Figure 2.

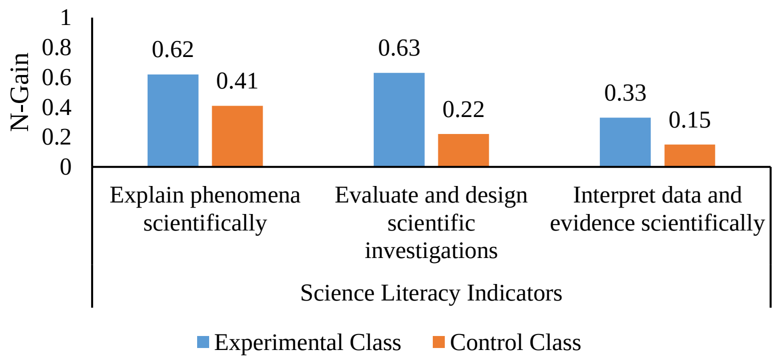

Figure 2. N-Gain analysis by indicator of students' scientific literacy skills

Across the three indicators of scientific literacy, the experimental class achieved moderate N-Gain scores in all indicators. Meanwhile, the control class achieved a moderate N-Gain in only one indicator, with the other two falling into the low category. Nonetheless, both the experimental and control classes experienced improvement across all scientific literacy indicators.

For the first indicator, explaining phenomena scientifically, both groups showed moderate N-Gain scores, but the experimental class had a significantly higher score than the control class. This improvement was driven by the read and answer stages of the RADEC model. The read phase was conducted outside regular class hours, during which students independently studied materials listed in the student worksheet and produced summaries to reflect their engagement and comprehension. This process requires a deep understanding of concepts, enabling students to effectively extract the scientific core of the text and interpret its meaning more accurately (Fatimah, Usman, & Sukemi, 2024). Therefore, learners need a deep understanding of some basic concepts that will be categorized and rephrased in writing. Fitria & Setiyawati (2024) support this, noting that reading activities help students identify key ideas, interpret scientific meaning, and facilitate conceptual understanding.

The answer phase was also done independently, where students responded to pre-learning questions related to the concepts they had read. The primary goal of this phase was to help students comprehend, recall, and apply theory and concepts to solve problems. Amelia, Imran, & Anisa (2024) state that such pre-learning questions help optimize students' conceptual understanding and enable them to articulate their knowledge in a simplified manner. The existence of this stage can also enhance concept understanding, support memory, and improve students' ability to apply theory in problem-solving, thus supporting simple explanations based on their respective understanding (Pan, Han, & Fung, 2024).

In the control class, the indicator of explaining scientific phenomena was observed during the stimulation and problem statement activities, where students were given a stimulus and tasked with identifying the problems. For the second indicator, evaluating and designing scientific investigations, the experimental class achieved a moderate N-Gain of 0.63, while the control class scored a low N-Gain of 0.22. The improvement in the experimental group was influenced by the discuss and create phases in the RADEC model. The discussion process played a crucial role in developing students' problem-solving abilities, enabling them to design solutions and assess potential risks. The discuss stage in the RADEC model strengthens students' ability to evaluate scientific questions and design investigations because, through collaborative group discussions, they question assumptions, refine draft hypotheses, and evaluate solutions together based on social interactions (Pan, Han & Fung, 2024). According to Fauziyah et al. (2021), students meet the criteria for this indicator when they can critically evaluate scientific questions and propose suitable solutions.

The create phase also contributed significantly. Students worked in groups to design experimental solutions to presented problems, which allowed them to refine and expand their prior knowledge into innovative and relevant investigations. This hands-on approach enabled students to directly apply scientific concepts and techniques. Through the create stage, learners actively assess the truth of the hypothesis by reflecting on the data generated, improving indicators of the ability to evaluate and design scientific investigations (Huang, 2022). As noted by Astutik et al. (2019), experimentation allows students to evaluate the validity of hypotheses based on the data generated.

In the control class, this indicator was represented in the data collecting and data processing activities, where students gathered and analyzed information from readings or simple experiments to address problems in the student worksheet. However, some students failed to participate actively in data collection and relied on their peers for assistance.

In the third science literacy ability indicator, the N-Gain results in the experimental class and control class were 0.33 and 0.15, respectively. The increase in this indicator occurred due to explaining the syntax in the RADEC learning model in the experimental class. Learners in this stage explain and describe the results of the discussions they have had and agree to draw conclusions in outline in turn. The explain stage requires learners to explain the results of the previous discussion using words that are strung together as a whole. This shows that they have a meaningful form of understanding.

The ability to interpret data and evidence scientifically in the control class is evident in verification and generalization activities, where students present the results of solving problems in the LKPD and summarize what they have learned in the lesson in an outline. The striking difference between the explain and verification stages in the Discovery Learning model in this study lies in the opportunity for students. In the explanation stage, all groups have the same opportunity in the process of presentation, question, and answer discussion. Meanwhile, during the verification stage, only representatives of two groups had the opportunity to present and discuss, as the limited learning time allowed.

The purpose of this stage is to establish a common understanding of the concept and material being studied. Syam, Imran & Amal (2024) added that the RADEC stage is based on constructivism learning theory, namely exploring previously acquired knowledge and then interpreting it. The relationship between constructivism theory and the RADEC model is in the process of internalization and reconstruction of students through the presentation of the results of the discussion obtained. This theory adheres to the understanding that an insight is developed independently by each individual through the process of communication and social interaction (Kusumaningpuri & Fauziati, 2021). This aligns with the stages in the RADEC model, which emphasize active, social, and reflective learning. Learners explore initial understanding independently at the read and answer stages. This initial understanding will be explored and validated more deeply through discuss and explain stages. The existence of a strong understanding creates an innovation and a new idea that is poured into the form of a product through the create stage.

Overall, both the experimental and control classes demonstrated improvement in all scientific literacy indicators. However, the most substantial progress occurred in the experimental class using the RADEC model. This suggests that the RADEC learning model effectively supports students in developing scientific literacy through structured stages that enhance both knowledge and skills. This aligns with Suardi, Bancong, & Ruki (2025), who state that RADEC is a viable alternative learning model for improving students' scientific literacy. Therefore, the RADEC model is more effective in enhancing scientific literacy than the Discovery Learning model.

Research Limitations

Some limitations that need to be emphasized in this study are (1) the findings in this study only cover the results in one school, so it is limited in generalizing; (2) the possibility of the Hawthorne effect on learners, and (3) the potential influence of teacher enthusiasm for new learning models. The diversity of learner characteristics, learning styles, cultures, and environments within schools may influence the output of the RADEC model, which requires further research (Cohen, Manion, & Morrison, 2018). Therefore, the limitations of the research sample have the potential to reduce external validity and affect the applicability of the results to other contexts (Hassan, 2024).

The second limitation is the potential for the Hawthorne effect, where the improvement in the ability of students in the experimental class is not the result of the application of the learning model, but because they realize that there is a special or new treatment as a research sample, which raises a positive view of the learning outcomes (Nikolopoulou, 2022). This awareness causes the emergence of a motivation that is different from the intrinsic motivation of students in normal conditions. Therefore, there is a change in behavior that does not represent a natural response to the treatment given (McCambridge, Witton, & Elbourne, 2014). In the educational context, the Hawthorne effect is considered one of the serious threats to external validity due to active triggered by special attention from researchers or teachers (Nikolopoulou, 2022). With this, the results of the study need further attention because the improvement in the experimental class does not necessarily guarantee the long-term effect of a model implemented.

The last limitation of the study is the influence of teachers' enthusiasm for the new learning model. The RADEC learning model applied in the lesson is considered to affect teachers' enthusiasm when teaching. The new learning model is considered to increase the enthusiasm and attitude of teachers towards learning, thereby creating a difference in the quality of learning implementation, even when the same teacher teaches. Some of these claims can trigger factors that support the increase in learning outcomes and students' abilities. In line with Rosenthal & Jacobson (1968), teachers' enthusiasm and expectations for the RADEC model can influence teaching unconsciously (the observer-expectancy effect or Pygmalion effect), where teachers' expectations of learners can alter classroom interactions and student learning outcomes.

▪ CONCLUSION

Based on the results of the research and discussion presented, it is concluded that the RADEC learning model is effective in improving the ability of science collaboration and science literacy of junior high school students. The application of the RADEC model encourages students to be more active in learning activities that are oriented towards critical thinking activities, collaborative discussions, and creating a product. This demonstrates that the RADEC learning model is a relevant and effective approach to addressing the challenges of education in a complex era, particularly in enhancing junior high school students' science collaboration and science literacy skills.

This research contributes to educational practice by offering an adapted learning model in science learning. However, some limitations of this study include the Hawthorne effect, which affects student performance due to awareness of special treatment, as well as the study's limited scope, which is a consideration for generalizing the results. Therefore, further research on a large scale is needed to see the consistency of the results of this study.

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