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STEM Learning Using the RADEC Model on Elementary School Students' Electrical Materials in Improving Students' Science Literacy Skills

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Abstract: This study aims to identify the potential to improve the science literacy of elementary school students through the application of the RADEC learning model based on the STEM approach on electrical materials. This study uses a pre-experimental design in the form of a one-group pretest-posttest design without a control group. The subjects consisted of 21 grade V students in one of the public elementary schools in Indonesia. Data was collected through science literacy tests administered before and after learning. The results of the analysis using paired t-tests showed a significant increase in students' science literacy scores after the intervention ($t(20) = 10.46$, $p < 0.001$), with an average pretest score of 1.44 and a posttest of 4.11, as well as an average gain of 2.67 (SD = 0.80). All participants showed an increase in scores. These findings indicate that the integration of STEM approaches in the RADEC model has the potential to improve students' understanding of science concepts. However, because the study design did not involve a control group, it cannot be concluded with certainty that the improvement was entirely due to the intervention. Other factors such as additional learning experience or the effect of test repetition can affect the results. Further research with a quasi-experimental design is recommended to test effectiveness more robustly.

Keywords: Electric learning; Elementary school students; RADEC model; Science literacy; STEM approach

Introduction

Technological advances and globalization have brought major changes in various aspects of life, including the world of education (Wang et al., 2021). The demand for quality human resources who are able to think critically, communicate effectively, work together in teams, and have high creativity is increasing. Therefore, 21st century education emphasizes the importance of mastering high-level thinking skills that include the 4Cs: critical thinking, communication, collaboration, and creativity (Febianti et al., 2024; Hartomo et al., 2024; Lestari et al., 2024). Science education, particularly at the elementary school level, plays an important role in shaping these skills, because through science students not only understand scientific concepts, but also learn how to apply them in real life.

One of the relevant and important science concepts to be taught from an early age is the concept of electricity. Electricity is part of everyday life that are close to the student experience, such as the use of lights, electronic devices, and various household devices. Understanding electricity not only helps students understand the phenomena around them, but also serves as a foundation for the formation of strong science literacy.

However, the reality on the ground shows that science (Natural Sciences) learning in elementary

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schools still faces various obstacles (Aulia et al., 2024; Latifah et al., 2024; Sukmawati & Sari, 2024). Based on the results of observations in one of the elementary schools, science learning is still dominated by conventional lecture methods and only relies on package books as the main source. This approach causes students to tend to be passive, less motivated, and have difficulty understanding concepts in depth (Fuadi et al., 2020). They are also not accustomed to associating theory with practice or solving contextual problems related to everyday life (Yuliati, 2017). In fact, science learning should encourage students' active participation, arouse curiosity, and develop critical thinking and problem-solving skills.

To answer these challenges, it is necessary to implement innovative, contextual, and fun learning approaches and models (Fitria et al., 2024; Sukmawati, 2021; Sulistiani et al., 2024; Wahjusaputri et al., 2022). One relevant approach is the STEM (Science, Technology, Engineering, and Mathematics) approach, which is a learning approach that integrates four main disciplines in an integrated manner to equip students to solve real problems in a collaborative and creative way. The STEM approach encourages applicative cross-disciplinary learning and encourages students to think critically and innovatively (Suwardi, 2021).

For the implementation of STEM approaches to be effective, a learning strategy that is student-centered and encourages their active involvement is needed. The learning model that matches this characteristic is RADEC (Read, Answer, Discuss, Explain, Create), which is a learning model that requires students to read, answer questions, discuss, explain, and create based on the material learned. According to Widiari et al. (2023), the RADEC model is able to improve high-level thinking skills and provide solutions to conventional learning problems in Indonesia. Widiari et al. (2023) also states that this model builds a deep understanding of concepts, while (Subayani, 2022) affirms the importance of students' active involvement in every stage of RADEC to create a meaningful learning experience.

The STEM and RADEC approaches have a strong fit in the context of 21st century learning (Muttaqiin, 2023). Both emphasize the integration of knowledge, real problem-solving, collaboration, and creativity. Although each of these approaches has been shown to be effective separately in various studies, studies that integrate STEM approaches with RADEC models simultaneously, particularly in science learning on electrical materials in elementary schools, are still limited. This shows that there is a research gap that can be used as a basis for learning innovation.

Therefore, this study is designed to examine the application of science learning by integrating STEM approaches and RADEC models to improve the science literacy of grade V elementary school students. Science literacy in this study includes the ability to understand scientific concepts, relate concepts to real-life contexts, and think logically and critically about science issues in the surrounding environment (Izzati et al., 2019; N. T. Putri et al., 2024; Sukmawati, 2020). It is hoped that the results of this research can contribute to the development of innovative and contextual science learning strategies, as well as become a practical reference for teachers in creating learning that is meaningful, relevant, and in accordance with the demands of 21st century education.

Method

This study uses a pre-experimental method with a one-group pretest-posttest design, which is a design that involves one group without a control group and measurements are taken before and after the treatment is given (Suryana et al., 2021). This design was chosen because of the limitations of the research situation that did not allow for comparisons, although methodologically it had weaknesses in controlling external variables that might affect the results of the study (C. A. Putri et al., 2023). This study aims to observe changes in students' science literacy skills after participating in learning using the STEM approach combined with the RADEC model.

The subjects of the study were 21 students in grade V of SD Duren Tiga 13 who were selected purposively based on their readiness to participate in learning. The purposive selection is carried out so that the subjects involved can provide a representative picture of the ability of students who are ready to participate in learning with the RADEC model. The number of subjects as many as 21 students is considered sufficient to obtain valid data and provide a real picture of the conditions of the class in the context of the research. The instrument used is a science literacy ability test that has been validated through expert judgment by several experts in the field of learning and science literacy (Muthi'ah et al., 2023; Saputri et al., 2024; Sukmawati et al., 2024, 2024). This validation is important to ensure that the test can accurately measure science literacy ability according to the set indicators. In addition, the reliability of the instrument was tested using Cronbach's alpha, and the results showed an adequate level of consistency, so that the instrument could be trusted to accurately measure science literacy ability in both pretest and posttest (Setyaedhi, 2024).

Data collection is carried out through the implementation of science literacy tests given to students before learning begins (pretest) and after learning is completed (posttest). Analysis of test result data using the stacking method with the help of the

Winsteps application, a Rasch model-based approach that helps to produce valid and reliable measurements of student abilities (Hanatan et al., 2023). To support the results of the logit analysis obtained through the Winsteps application (stacking feature), an inferential statistical test was carried out using a paired sample t-test through the SPSS application. This method allows researchers to assess changes in science literacy abilities quantitatively and objectively after students follow learning with the RADEC model.

The implementation of learning follows the stages of the RADEC model which consists of five main phases, namely Reading (reading material), Answering (answering questions), Discussing (group discussion), Evaluating (evaluation of learning outcomes), and Creating (making products related to electrical materials) (Suriani et al., 2024). At the Reading stage, students are given the opportunity to read and understand electrical matter well. The Answering stage requires students to answer questions related to the material to test their initial understanding. Furthermore, in the Discussing stage, students conduct group discussions to exchange ideas and deepen their understanding of the concepts learned. The Evaluating stage is carried out to measure student learning outcomes individually and in groups. Finally, in the Creating stage, students create creative products that are relevant to electrical materials, such as posters or simple models, as a tangible manifestation of their understanding of the material. The RADEC model applied is part of STEM-based learning that emphasizes the development of critical thinking, creative, and science literacy skills in an integrated manner (Fauziah et al., 2023).

After the implementation of learning, students' science literacy ability is measured again through a posttest test. Pretest and posttest data were analyzed descriptively and inferentially to see if there was a significant improvement in science literacy skills. Descriptive analysis describes the development of the average score of science literacy ability, while inferential analysis is used to test the hypothesis of whether the RADEC model has a positive influence on students' science literacy abilities (Ifdaniyah et al., 2024; Kusnadi et al., 2023; Sukmawati et al., 2024; Wahjusaputri et al., 2024). With this approach, researchers can conclude the effectiveness of STEM-based learning using the RADEC model on electrical materials in grade V of SD Duren Tiga 13.

Overall, this study is expected to provide a clear picture of the application of the RADEC model as an effective STEM-based learning model in improving the science literacy skills of elementary school students. The results of this research can be a reference for teachers in designing more interactive and meaningful learning, as well as the basis for the development of similar learning models in other schools (M. N. Fitria et al., 2022; Istiqomah et al., 2023; Novianti et al., 2023; Ramadhani et al., 2022). With quasi-experimental methods and systematic analysis, this research also contributes to the development of educational science, especially in the context of strengthening science literacy through STEM-based learning and the RADEC model.

Result and Discussion

The results of descriptive statistical analysis showed that there was an increase in the average score from pretest to posttest. The average pretest score was 71.40 with a standard deviation of 11.63, while the average posttest score increased to 95.20 with a standard deviation of 4.79. The number of participants in both measurements was 21 people. In addition, the standard error mean decreased from 2.60 in the pretest to 1.07 in the posttest, indicating that the posttest scores were more consistent among the participants. These findings indicated an improvement in performance after the treatment was administered, characterized by an increase in average scores and a decrease in score variations.

Table 1. Paired Sample Statistics

Pair 1	Mean	N	Hours of deviation	Std. Error Mean
Pretest	71.400	20	11.62755	2.600000
Posttest	95.2000	20	4.78594	1.07017

Table 2. Paired Samples Correlations

	N	Correlation	Itself
Pretest & Posttest	20	.233	.323

The results of Pearson's correlation analysis between pretest and posttest values showed that the correlation value (r) was 0.233 with N = 20 and the significance value (Sig.) was 0.323. A positive correlation value indicates a one-way relationship between pretest and posttest scores, but this relationship is relatively weak. In addition, the significance value was greater than 0.05 ($p > 0.05$), which means that there was no statistically significant relationship between pretest and posttest results.

The results of the paired sample t-test between the pretest and posttest scores showed a significant difference statistically (Atthoriqoh et al., 2024). The mean difference between the pretest and posttest was -23.80 with a standard deviation of 11.50 and a standard error of the mean of 2.57. The 95% confidence interval for the average difference is between -29.18 to -18.42, which does not include zeros, indicating a noticeable difference. The t-count value was -9.258 with a degree of freedom (df) = 19, and a significance value (Sig. 2-tailed) of 0.000 ($p < 0.05$), indicating that the difference between the pretest and posttest values was statistically significant.

Table 3. Paired Samples Test

	Mean	Std Dev	Std. Error Mean	95% CI Lower	95% CI Upper	t	df	Sig. 2 (tailed)
Pair1 Pretest - posttest	-2.38000E1	11.49645	2.57068	-29.18051	-18.41949	-9.258	19	.000

Table 4. Analysis of Post-test and Pretest Results

Pre-test	Post-test	Pre-test	Information
0.08	1.56	1.48	increase
1.87	5.27	3.4	increase
2.64	5.27	2.63	increase
1.87	5.27	3.4	Increase
2.22	5.27	3.05	increase
1.56	5.27	3.71	Increase
1.02	5.27	3.71	increase
1.02	3.17	2.15	increase
0.77	3.17	2.4	increase
1.28	2.64	1.36	increase
1.56	3.17	1.61	increase
2.22	2.64	0.42	Increase
2.22	3.99	1.77	Increase
1.02	3.17	2.15	Increase
0.53	3.17	2.64	Increase
1.56	3.17	1.61	Increase
0.53	5.27	4.74	Increase
0.77	2.64	1.87	Increase
1.87	3.17	1.3	Increase
-0.36	5.27	5.63	Increase
-0.36	5.27	5.63	Increase

This study aims to determine the effectiveness of STEM learning using the RADEC model in improving the science literacy skills of elementary school students on electrical materials. Quantitative results showed an increase in scores from pretest to posttest in all participants (Fauziah et al., 2023; Nurliana et al., 2023; Sukmawati et al., 2022, 2023).

Table 4 shows the pretest and posttest scores of 21 students. All students experienced a positive gain score, with the difference in improvement ranging from 0.42 to 5.63. The highest increase was achieved by students number 20 and 21 with an increase in scores of 5.63 points.

To visualize this data, an identity line plot graph (Figure 1) was used. Each point in the graph represents the pretest (X-axis) and posttest (Y-axis) scores of each student. All data points are above the identity line, which means that all students experience an increase in scores after learning.

Descriptive statistical analysis showed that the average pretest score was 71.40 (SD = 11.63), and increased in the posttest to 95.20 (SD = 4.79) from a total of 20 respondents. The standard error mean value decreased from 2.60 to 1.07, which indicates that the posttest results were more consistent between participants.

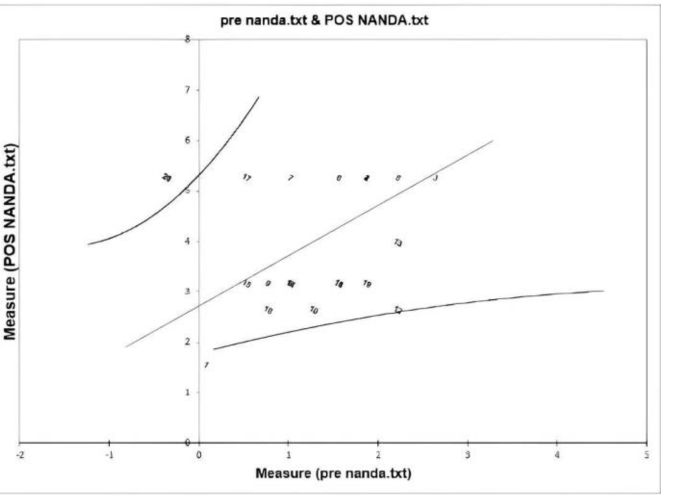

Figure 1. Pre-test-posttest analysis chart arrangemen

Inferential statistical analysis using paired sample t-test showed a statistically significant difference. The mean difference value was -23.80 (SD = 11.50), with t-count = -9.258, df = 19, and significance value $p < 0.001$. These results confirm that the difference in pretest and posttest scores is significant.

The results of the study show that STEM-based learning with the RADEC model is effective in improving the science literacy of elementary school students. This is reflected in the increase in the average score of pretest to posttest, from 71.40 to 95.20. The decrease in the standard deviation from 11.63 (pretest) to 4.79 (posttest), as well as the standard error mean from 2.60 to 1.07, indicates an increase in the consistency of learning outcomes between students. This shows that students not only experience an increase in overall performance, but also an equal distribution of understanding between individuals.

However, the results of Pearson's correlation analysis between pretest and posttest scores showed a value of $r = 0.233$ with $p = 0.323$. This correlation was weak and not statistically significant ($p > 0.05$). This means that students with high pretest scores don't necessarily get high posttest scores anyway, and vice versa. This interpretation is important because it confirms that the improvement of learning outcomes does not depend on the student's initial ability. In other words, the learning carried out has a positive effect on all groups of students' initial abilities, including those at low levels.

The most important results of the inferential analysis were obtained from the paired sample t-test which showed an average difference of -23.80 with a standard deviation of 11.50 and a standard error of 2.57. The 95% confidence interval is between -29.18 to -18.42, which does not include zero, signaling a noticeable difference. The t-count value = -9.258 with the degree of freedom (df) = 19, and the p-value = 0.000 ($p < 0.05$), indicating that the increase in the value from pretest to posttest was statistically significant.

These findings reinforce that the RADEC model is effective in driving real improvements in learning outcomes, not just accidental improvements or measurement biases (Sugiarti et al., 2024). This effectiveness reflects that the learning structure consisting of Read, Answer, Discuss, Explain, and Create allows students to actively engage, build collaborative understanding, and apply concepts into real-life products or problem-solving (Nurpratiwi et al., 2023).

The tendency of all students to experience an increase in scores, including students with low pretest scores (e.g. students number 20 and 21), confirms that this approach is able to reach various characteristics of students in an inclusive manner. In fact, in students with high initial scores such as student number 3 (pretest 2.64), there is still an increase, although not as large as other students. This shows that RADEC not only has an impact on weak students, but also provides added value for students who already have a stronger knowledge base.

This discovery is in line with a study by (Hanatan et al. (2023) who found that project-based learning in the STEM approach is able to increase active participation, knowledge integration, as well as the development of critical thinking and problem-solving skills. RADEC, as an implementive model, has visibly succeeded in directing students to develop science literacy skills through contextual and applicative approaches. This is also reflected in the findings of this study, where students' active involvement is key in improving their science literacy skills.

The application of the STEM-based RADEC model not only has a positive impact on improving numerical scores, but also creates a learning atmosphere that allows students to experience the process of scientific thinking, solve real problems, and collaborate meaningfully. The absence of students who experience a decline in scores indicates that this approach has the potential to be used more widely, especially in the face of 21st-century educational challenges that emphasize collaboration, critical thinking, and science literacy (Suryana et al., 2021).

Figure 2. Learning activity on electrical energy using the STEM and RADEC approach

Conclusion

This study shows that STEM-based learning with the RADEC model has the potential to improve the science literacy skills of elementary school students on electrical materials. This is shown by a statistically significant increase in pretest to posttest scores based on the results of the paired sample t-test. These findings indicate that the learning approach applied is able to encourage students' understanding of science concepts better. Nonetheless, the design of the study using a single group without a control group limits the generalization of the findings. Therefore, the results of this study need to be interpreted carefully, and it is recommended to conduct further studies with a stronger experimental design and involving a larger sample count.

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All research activities, data collection, processing, and publication writing is a contribution from CAR. Writing a research proposal, instrument validation, learning data processing using RACH, and article writing is a significant contribution of WS.

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