The Effectiveness of the RADEC Model in Improving Students' Literacy and Critical Thinking in Geography Learning at Senior High School

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Abstract: This study aims to analyze the effectiveness of the RADEC (Read, Answer, Discuss, Explain, Create) learning model in improving students' literacy and critical thinking skills in geography learning at the senior high school level. The need for this research arises from the consistently low literacy and higher-order thinking performance of Indonesian students in PISA and AKM, as well as the limited implementation of RADEC in geography. This study employed a one-group pretest–posttest quasi-experimental design involving 16 eleventh-grade students from SMA Negeri 3 Tebing Tinggi Barat, Riau Province. The instruments consisted of a literacy test based on AKM indicators and a critical thinking test adapted from Facione's framework, which measured Interpretation, Analysis, and Evaluation. Data were analyzed using descriptive statistics, N-gain calculations, and paired-samples t-tests. The results showed a significant improvement ($p < 0.05$) in both variables, with N-gain scores of 0.40 for geographic literacy and 0.36 for critical thinking, categorized as moderate. These findings indicate that the RADEC model enhances students' literacy and critical thinking through structured stages involving reading comprehension, answering tasks, collaborative discussion, explanation, and the creation of learning products. The study provides empirical evidence for the application of RADEC in geography learning and highlights its relevance to the Merdeka Curriculum.

Keywords: Critical thinking; Geography learning; Literacy; RADEC model; Senior high school

Introduction

The literacy and critical thinking skills of Indonesian students remain pressing educational concerns. Various international assessments such as PISA (Programme for International Student Assessment) consistently indicate that Indonesian students' literacy and critical thinking performance is below the OECD average. The average reading score for Indonesian students in PISA was 359 points. Indonesian students' achievements in reading show that the majority of students are below the minimum proficiency level set by PISA 2022 (PISA 2022 Results Factsheets Indonesia PUBE, 2023).

Similarly, the results of the national Minimum Competency Assessment (AKM) show that students' reading literacy at the secondary level is still relatively low, reinforcing the need for pedagogical innovation to enhance students' basic literacy and higher-order thinking skills (Samala et al., 2024). This situation may stem from a learning approach that prioritizes outcomes rather than analytical and reflective thinking processes,

making students less accustomed to analyzing, evaluating, and reflecting on the information they encounter. Moreover, curriculum changes emphasizing competency-based learning demand a stronger foundation in literacy and critical thinking as essential 21st-century competencies. According to Halim (2022), critical thinking skills will make individuals more sensitive to change, more adaptive, and better able to generate brilliant ideas amid the rapid pace of science and technology. Therefore, strengthening these abilities has become an educational priority that requires empirical exploration. Critical thinking has been identified as an important general skill that contributes to academic and career success in the twenty-first century (Shaw, 2020).

Literacy is closely related to critical thinking. The results of (Trisna Ayu Putri & Agusdianita, 2024) literature study reveal that literacy plays a significant role in improving students' critical thinking skills. The higher the literacy skills of students, the higher their level of critical thinking. Meanwhile, Oktariani & Ekadiansyah (2020) states that literacy activities carried out by individuals, such as reading or listening to information or stories, enable individuals to find ways to solve problems. Individuals will then analyze the problems, which will ultimately shape their critical character or personality. Based on these findings, it can be emphasized that strengthening literacy not only serves as a means of obtaining information, but also as a foundation that strengthens the process of reasoning and decision making. Thus, developing students' literacy is a strategic step to foster more mature, systematic, and relevant critical thinking skills in line with the demands of 21st-century learning.

Literacy and critical thinking remain key educational themes, and in recent years, research has increasingly linked these competencies to the use of innovative learning models. One model that has been proven to improve literacy and critical thinking relevant to the demands of 21st-century learning is the RADEC (Read, Answer, Discuss, Explain, Create) learning model. The research by Ulum et al. (2025) states that the RADEC model is an innovative learning development that is relevant to the needs of 21st-century education, one of which is to improve critical thinking skills. This study is in line with (Pramita & Yulkifli, 2023)findings, which prove that the use of RADEC-based modules can improve 21st-century skills in junior high school students. Numerous studies demonstrate its effectiveness in improving various aspects of literacy and thinking skills. For instance, (Sulastyana & Shafwatul Anam, 2023) found that RADEC combined with flipbook media improved students' reading comprehension, while (Ifdaniyah & Sukmawati, 2024)

reported gains in science literacy among fifth-grade students. Furthermore, the study (Lestari et al., 2023) designed a RADEC model oriented towards ESD that effectively improves environmental literacy. Damariswara & Andri Aka (2024) emphasized that the integration of RADEC with the TPACK approach can strengthen basic literacy, while (Guslisnawati et al., 2024) showed that STEM-based RADEC improved mathematical literacy and (Sofira et al., 2025) found that RADEC can improve science literacy at the junior high school level. Based on these studies, it can be seen that this research was conducted at the elementary and middle school levels with a primary focus on literacy in mathematics and science subjects.

In addition to contributing to literacy enhancement, the RADEC learning model has also been proven effective in developing critical thinking. Jumanto et al. (2024) state that RADEC can improve the critical thinking skills of elementary school students, a finding that is also in line with the research of Fiteriani et al. (2025); Pratama et al. (2019); Pratiwi & Helsa (2025). These results are supported by Muthmainnah et al. (2024), who prove the effectiveness of RADEC-based E-modules in training critical thinking skills in elementary schools. The same findings are found in the literature review by Purwanto & Yanuarto (2025), which concludes that the RADEC model offers a structured and effective approach to developing critical thinking in basic education. Fatimah et al. (2024) found that RADEC also improves high school students' critical thinking skills in colloid material. Overall, this series of findings confirms that RADEC is not just an alternative learning model but an approach that consistently has a positive impact on the development of critical thinking skills at various levels of education. However, research on the application of RADEC at the high school level, especially in geography learning, is still limited. This condition opens up space for further research to explore in greater depth the effectiveness of RADEC in the context of subject matter and student characteristics at the secondary education level.

Therefore, this study aims to contribute to the scientific knowledge on improving literacy and critical thinking among high school students, particularly in geography lessons. Geography learning requires students to interpret spatial data, analyze environmental issues, and make informed decisions based on evidence—competencies that are inherently tied to literacy and critical thinking. As (Prastiyono et al., 2023) emphasized, geography education plays a strategic role in developing students' critical awareness and responsibility toward sustainable development. Therefore, investigating the effectiveness of RADEC in geography learning offers a new and necessary

perspective on applying this model within the social sciences.

This study aims to fill that gap by analyzing the effectiveness of the RADEC learning model in improving literacy and critical thinking skills among senior high school students in geography learning. Specifically, this research seeks to answer three questions: (1) Does the implementation of RADEC increase students' critical thinking scores? (2) Does it improve students' literacy performance? and (3) What is the magnitude of the effect (N-gain) of RADEC on these two variables? The findings of this study are expected to contribute empirical evidence supporting the adaptation of the RADEC model to geography education and provide pedagogical implications for enhancing 21st-century learning outcomes.

Method

This study employed a quantitative approach with a one-group pretest–posttest quasi-experimental design. Previous studies (Oktavia & Sukmawati, 2025) also used a research design without a control group in the application of RADEC to improve science literacy. This design was chosen to measure the effectiveness of the RADEC learning model in improving students' literacy and critical thinking skills. In this design, students were given a pretest before the implementation of the RADEC model and a posttest after the completion of the treatment, so that the difference in scores could be compared to determine learning improvement. To ensure that the research procedure is easier to understand, the overall sequence of the pretest, treatment, and posttest stages is summarized in the flowchart presented below.
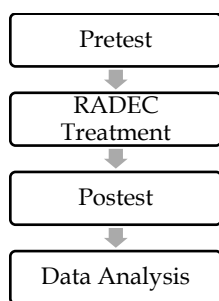
Pretest

↓

RADEC Treatment

↓

Postest

↓

Data Analysis

Figure 1. Research Procedure Flowchart

To provide clearer illustration of the intervention process, documentation of the RADEC learning activities during classroom implementation is presented in Figure 2. Figure 2 shows the Explain Process in the RADEC model, where students express their understanding of geographical concepts verbally as an indicator of literacy and critical thinking development.

This study was conducted at a senior high school in Meranti Islands Regency, Riau Province, namely SMA

Negeri 3 Tebing Tinggi Barat, with 16 participants from grade XI. The subjects were selected purposively based on considerations of academic homogeneity and suitability with the geography material taught in that semester. Data were collected through validated literacy and critical thinking tests. The literacy test was developed based on the Minimum Competency Assessment indicators, while the critical thinking test referred to the indicators proposed by Seventika et al. (2018). Both tests consisted of multiple-choice and essay items administered in two stages: a pretest prior to the RADEC model implementation and a posttest afterward.

Figure 2. The Explain process in the RADEC model

The data were analyzed using descriptive statistics (mean, standard deviation), N-Gain calculations (normalized gain) to assess the effectiveness of score improvement from pretest to posttest, and paired-samples t-tests to test the significance of score differences before and after treatment. The N-gain formula for each student is written as follows:

$$g_i = \frac{Post_i - Pre_i}{100 - Pre_i} \qquad (1)$$

Pre_i and $Post_i$ are the initial and final scores in percentage form. The g value is then interpreted into categories of low ($g < 0,3$), medium ($0,3 \leq g < 0,7$), and high ($g \geq 0,7$). Furthermore, the data collected from the pretest and posttest were analyzed using statistical software to ensure accuracy and objectivity. Meanwhile, the paired t-test is calculated by considering the difference in scores $d_i = Post_i - Pre_i$, the average differenced, and the standard deviation of the

differences $\bar{d}$, and the standard deviation of the difference s_d. The test statistic is formulated as:

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} \qquad (2)$$

With degrees of freedom (df) = n-1 Hypothesis decisions are made by comparing the calculated t value with the table t value, or by using the significance value (p-value) at a 95% confidence level (α = 0,05). If p < 0,05, the increase in score is considered significant. The paired t-test is the appropriate statistical method for a single-group pretest-posttest research design because it allows for the comparison of the means of two measurements from the same subject. All data processing was performed using SPSS statistical software version 27. The results of the analysis show that the SPSS application facilitates faster and more accurate data processing, supporting the findings of previous studies that emphasize its effectiveness (Riani, 2022).

Result and Discussion

The analysis was conducted on 16 eleventh grade students. The students' literacy and critical thinking scores on the pretest and posttest were analyzed using descriptive statistics, N-gain, and paired t-tests. The mean pretest scores, posttest scores, and N-gain values were then presented to provide an overview of the changes that occurred after the implementation of the RADEC learning model. The results of the pretest and posttest on literacy and critical thinking are presented in the following table 1:

Table 1. Results of the Pretest and Posttest on Literacy and Critical Thinking

Variable	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	N-Gain (Mean)
Literacy	16	57.3	15.9	74.4	10.3	0.40
Critical Thinking	16	58.1	16.8	73.1	9.4	0.36

The descriptive results of students' literacy and critical thinking skills are presented in Table 1. The mean literacy score increased from 57.3 in the pretest to 74.4 in the posttest, while the mean critical thinking score increased from 58.1 to 73.1. These descriptive results indicate a positive change after the implementation of the RADEC learning model.

The increase in score from the pretest to the posttest was quite consistent. The literacy increased from a mean of 57,3 to 74,4, while critical thinking skills increased from average of 58,1 to 73,1. The N-gain value was in the moderate category, indicating the effectiveness of the RADEC model in improving both variable, with a significance level of 5% (Prastiyono et al., 2023). This paired t-test helps determine whether the difference in the mean between the pretest and posttest scores is statistically significant, so it can be concluded whether the learning model applied has a real impact on improving student abilities (Hendratmoko et al., 2024).

To determine whether the improvement was statistically significant, a paired-samples t-test was conducted (Table 2).

Table 2. Paired T-Test

Variable	t	df	Sig. (p)	Description
Literacy	6.27	15	0.000	Significant
Critical Thinking	5.94	15	0.000	Significant

The results showed significant differences between the pretest and posttest scores for both literacy ($t(15) = 6.27$, $p < 0.001$) and critical thinking ($t(15) = 5.94$, $p < 0.001$). These findings confirm that the improvement was statistically meaningful. A comparison of average literacy and critical thinking scores can be seen in the following figure 2.
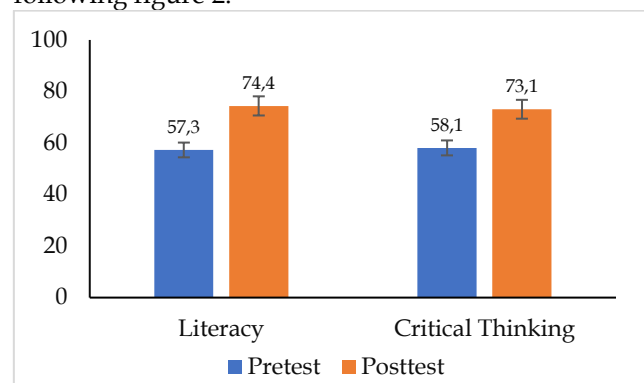

Figure 2. Comparison of Mean Literacy and Critical Thinking

Figure 2 shows an increase in the mean scores for students' literacy and critical thinking from pretest to posttest. For the literacy variable, the mean score increased from 57,3 to 74,4. While for the critical thinking variable, it increased from 58,1 to 73,1. This increase indicates that the application of the RADEC model has a positive impact on students' understanding of literacy and critical thinking skills. In line with research (Yulianti et al., 2022), there was an increase in students' critical thinking skills before and after treatment using the RADEC learning model. In general, the graph trend shows a clear difference between the initial and final scores, reinforcing the finding that learning with the RADEC model is effective in improving student learning

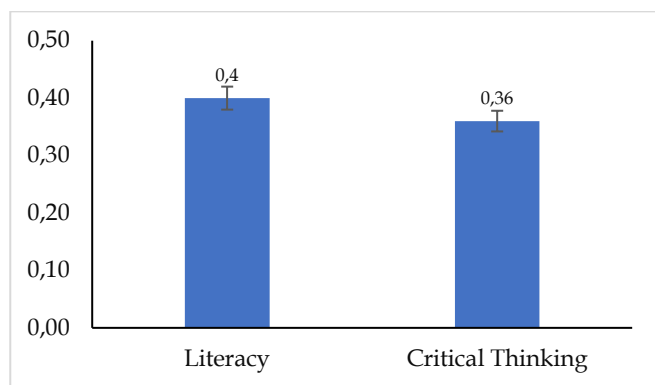outcomes. The mean N-gain scores for literacy and critical thinking can be seen in the following figure 3.

Figure 3. The N-gain Scores for Literacy and Critical Thinking

The normalized gain (N-gain) values are shown in Table 2. The N-gain score for literacy was 0.40, while the N-gain for critical thinking was 0.36. Based on the Hake classification, both values fall within the moderate category. This indicates that while students experienced meaningful improvement, the increase was not yet at a high level ($g \geq 0.70$). The moderate N-gain values suggest that students benefited from the RADEC model but still require additional cycles of structured learning activities to achieve higher improvements. This is in line with research by Karlina et al. (2020) which found that students' critical thinking skills improved moderately through the RADEC model. Meanwhile, the significant t-test results indicate that the increase observed was not due to chance but due to the structured learning intervention.

The results show that the RADEC model contributed to an improvement in students' literacy and critical thinking skills. Although the N-gain values for both variables were in the moderate category, the paired-samples t-test confirmed that the improvement was statistically significant. This combination suggests that students experienced substantial and reliable learning progress, although the magnitude of improvement was not high. Such patterns are common in classroom-based interventions where cognitive skills develop gradually over time. Teachers must demonstrate critical thinking skills frequently and explicitly (Mohamed Nor & Sihes, 2021)

The structure of the RADEC model provides a strong pedagogical explanation for these findings. The Read stage exposes students to textual and visual geographical information, helping them activate prior knowledge and build foundational literacy. During the Answer and Discuss stages, students engage in collaborative reasoning, which supports the development of critical thinking through argumentation, question evaluation, and evidence-based justification. The Explain stage strengthens students' ability to articulate their understanding, while the Create stage requires students to apply concepts to produce geographic solutions or interpretations, further reinforcing both literacy and critical thinking competencies.

These findings are consistent with previous research indicating that structured discussion, guided reading, and reflective explanation contribute to improved literacy and critical thinking. However, in contrast to many earlier studies that focused on science or mathematics literacy, this study provides empirical evidence of RADEC's effectiveness in geography learning, particularly in enhancing students' ability to interpret spatial information and analyze environmental problems.

These findings are in line with research Kamal et al. (2023) which proves that the application of the RADEC learning model can develop literacy from an early age. Then Sukmawati & Wahjusaputri (2024) that proves the effectiveness of RADEC in improving high school students' science literacy, as well as research (Setiawan et al., 2022)which states that the RADEC model can increase student engagement and begin to foster critical thinking skills in science learning in elementary schools. Similarly, research Fatikhin et al. (2024) shows that the application of the RADEC model can improve the critical thinking skills of junior high school students. However, its effectiveness is highly dependent on teachers' competence in facilitating higher-order thinking processes and repeated practice so that students become skilled in analyzing, evaluating, and communicating scientific ideas. Therefore, RADEC learning model mentoring activities are needed to encourage teachers to develop skills in training students' critical thinking skills (Lestari et al., 2021).

The results of this study make an important contribution to the development of innovative teaching materials in line with the demands of the Merdeka Curriculum and the dimensions of the Pancasila Student Profile, particularly in developing students' critical skills in a systematic and contextual manner. The Merdeka Curriculum emphasizes learning that not only focuses on knowledge transfer, but also the development of comprehensive competencies that include cognitive, affective, and psychomotor aspects (Jannah et al., 2025). Overall, the results strengthen the claim that the RADEC model is a viable pedagogical approach for enhancing literacy and critical thinking in geography. This conclusion is supported by both descriptive trends and inferential statistical evidence, showing that RADEC enables students to engage more deeply with geographic concepts through structured, cognitively oriented learning sequences.

This supports the argument that constructivist-based active learning strategies are more effective than traditional approaches in building 21st-century competencies. Teachers can strategically use various digital tools and innovative teaching methods to foster and nurture critical thinking skills in their students (Kumari, 2024). In general, the RADEC learning model is effective in developing critical thinking skills in order to meet educational development in the era of the Super Smart Society 5.0 (Lasari et al., 2023). The development of critical thinking skills can be nurtured through education, with teachers playing an important role (Pradana et al., 2024).

Therefore, the implementation of the RADEC model needs to be continuously encouraged in the education curriculum to equip students with adaptive and solution-oriented skills amid the complexity of global issues (Pratama et al., 2019). However, further research is needed to investigate contextual factors that may influence the effectiveness of the RADEC model implementation in various learning environments and its potential adaptability to accommodate diverse student learning styles. The novelty of this study lies in the application of the RADEC model in the context of geography learning at the high school level using a quantitative approach through a one-group pretest–posttest design. Most previous studies have focused on science or social studies subjects at the elementary and middle school levels, so this study contributes to expanding the scope of RADEC application to the field of geography education. Thus, the results of this study not only enrich the empirical evidence regarding the effectiveness of RADEC, but also contribute to the development of innovative learning theories that support the strengthening of literacy and critical thinking skills in the field of geography.

The practical implication of this study is that geography teachers can utilize RADEC as an alternative learning model that is in line with the Merdeka Curriculum. The application of RADEC not only helps students understand geographical phenomena, but also develops critical thinking and literacy skills that are important for facing global challenges. From a policy perspective, the results of this study can be used as input for schools and education agencies to provide training to teachers on the application of innovative learning models based on literacy and higher-order thinking skills. However, this study has limitations. First, the sample size was only 16 students, so the results of this study cannot be generalized widely. Second, this study only measures the short-term impact of RADEC implementation without looking at the sustainability of its effects in the long term. Third, the instruments used are limited to AKM-based literacy tests and Facione

critical thinking indicators, so they do not cover the more complex dimensions of geospatial literacy.

Further research is recommended to involve a larger sample, utilize a stronger experimental design (e.g., control groups), and integrate RADEC with digital technology-based learning to examine its effectiveness in the context of 21st-century learning. For example, the integration of AI-based RADEC models is an innovative step to improve the effectiveness of science learning in elementary schools to provide personalized learning experiences and improve student literacy (Sukmawati & Wahjusaputri, 2024), Or the AR-assisted RADEC model represents an evolution in pedagogical approaches that encourage students to think critically and interact with virtual objects interactively (Maisarah & Rusnilawati, 2025).

Conclusion

This study demonstrates that the RADEC learning model effectively improves senior high school students' geographic literacy and critical thinking skills. The results of the paired-samples t-test indicate a significant difference between pretest and posttest scores for both literacy and critical thinking ($p < 0.05$), while the N-gain values of 0.40 and 0.36 fall within the moderate category. These findings confirm that RADEC facilitates structured cognitive engagement through its sequential stages—reading to build initial understanding, answering to process information, discussion for reasoning development, explanation to strengthen conceptual articulation, and creation to apply geographic concepts meaningfully. The effectiveness of RADEC aligns with constructivist principles and supports the development of 21st-century competencies emphasized in the Merdeka Curriculum and the Pancasila Student Profile. Practically, this model can serve as an alternative strategy for geography teachers to enhance students' analytical and interpretive abilities in understanding spatial and environmental issues. However, this study has limitations, including its small sample size and the absence of a control group, which restrict broader generalization. Future research should employ stronger experimental designs, larger samples, and incorporate digital-supported RADEC approaches to explore long-term impacts and further strengthen literacy and critical thinking outcomes in geography learning.

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