



## THE EFFECTIVENESS OF THE RADEC LEARNING MODEL ON GRADE IX STUDENTS' LEARNING OUTCOMES IN SOLID GEOMETRY

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### Article Info

#### Article history:

Received Feb 10, 2026

Revised Feb 17, 2026

Accepted Feb 20, 2026

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#### Keywords:

Effectiveness

RADEC Learning Model

Learning Outcomes

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### ABSTRACT

This study aimed to examine the effectiveness of the RADEC (Read, Answer, Discuss, Explain, and Create) learning model on the learning outcomes of Grade IX students in solid geometry. The research employed a quantitative approach using a quasi-experimental design with a pretest–posttest control group. The population consisted of ninth-grade students at a junior high school in Palu, and the sample was selected using cluster random sampling. Data were collected through essay-type tests to measure students' learning outcomes and observation sheets to assess the implementation of the learning model. Data analysis was conducted using the independent sample t-test and N-Gain analysis at a significance level of 0.05. The results showed that the Sig. (2-tailed) value was 0.001, indicating a statistically significant difference in learning outcomes between the experimental and control classes. The average N-Gain score in the experimental class was 0.56, which falls into the moderate category and is higher than that of the control class. These findings indicate that the RADEC learning model is effective in improving students' learning outcomes in solid geometry and can serve as an alternative instructional approach in mathematics education.

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### How to Cite:

Afni, N., Nasir, R., Idris, M., & Pathuddin. (2026). The Effectiveness of The RADEC Learning Model on Grade IX Students' Learning Outcomes in Solid Geometry. *JME: Journal of Mathematics Education*, 11(1), 78-87.

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## 1. INTRODUCTION

The Independent Curriculum emphasizes the development of students' understanding of mathematical concepts and their ability to apply these concepts in problem-solving contexts. In mathematics learning, geometry plays a crucial role because it involves reasoning about shapes, sizes, positions, and relationships between objects. One of the essential competencies in geometry learning is spatial ability, which supports students in visualizing and manipulating three-dimensional objects. However, despite the curricular emphasis, many students still experience difficulties in understanding spatial geometry, particularly solid geometry topics at the junior high school level.

Spatial ability refers to the capacity to mentally represent, manipulate, and transform objects in space, including understanding their shapes, dimensions, positions, and interrelationships. This ability is closely associated with visualization skills, which are fundamental for comprehending solid figures, connecting nets to complete three-dimensional forms, and identifying the elements of geometric solids. Students with limited spatial ability often encounter conceptual difficulties when solving geometry problems, leading to misunderstandings and incorrect application of formulas. Consequently, weak spatial ability may contribute to low mathematics learning outcomes, especially in geometry-related content.

Field observations and interviews with mathematics teachers reveal that students frequently struggle to visualize solid figures accurately. These difficulties often result in conceptual misunderstandings of geometric objects. For example, when students were given a contextual problem involving a rectangular prism-shaped storage box with specific dimensions and asked to determine the minimum surface area required to cover it, many students incorrectly applied the formula for the surface area of a cube. Instead of using the correct formula for a rectangular prism,  $L = 2(pl) + 2(pt) + 2(lt)$ , students treated the object as if all its edges were equal. This type of error indicates a fundamental misunderstanding of solid geometry concepts and weak visualization skills, as illustrated by students' written work. Such conceptual errors are critical because they directly affect students' performance in mathematics assessments.

Learning outcomes represent the competencies achieved by students after participating in the learning process, encompassing cognitive, affective, and psychomotor domains. In mathematics education, learning outcomes are commonly reflected in students' conceptual understanding, problem-solving ability, and accuracy in applying mathematical procedures. Previous studies have shown that inadequate conceptual understanding and low engagement in learning activities often result in unsatisfactory learning outcomes (Erawati & Desi, 2022). Therefore, improving students' spatial ability and conceptual understanding is essential to enhance their learning outcomes in solid geometry.

One factor contributing to students' difficulties is the learning process itself, which is often perceived as monotonous and less engaging. Traditional teacher-centered approaches tend to limit students' active participation and opportunities to explore concepts independently. This condition suggests the need for innovative learning models that actively involve students in constructing knowledge, encourage interaction, and promote higher-order thinking skills. One learning model that has the potential to address these challenges is the RADEC (Read, Answer, Discuss, Explain, and Create) learning model.

The RADEC learning model is designed to foster independent learning, active participation, and meaningful discussion. In the Read stage, students independently explore learning materials from various sources guided by pre-learning questions prepared by the

teacher. This stage aims to build initial understanding and activate prior knowledge. In the Answer stage, students respond to the pre-learning questions based on the information they have gathered, encouraging individual accountability. The Discuss stage allows students to collaborate in groups to compare, clarify, and refine their answers, thereby promoting interaction and peer learning. In the Explain stage, students present and justify their ideas, while other students are encouraged to ask questions or provide feedback. Finally, in the Create stage, students produce a product, such as a model, design, or creative solution related to the learning material, enabling them to apply and extend their understanding (Sopandi et al., 2021)

The characteristics of the RADEC learning model are particularly relevant to geometry learning, especially in developing spatial and visualization skills. During the Answer and Discuss stages, students engage with representations of solid figures, nets, and diagrams, which helps them understand the relationships among geometric elements. Furthermore, the Create stage provides opportunities for students to manipulate and visualize three-dimensional objects directly, such as constructing solid models or designing nets. These activities support deeper conceptual understanding and strengthen spatial reasoning, which is essential for mastering solid geometry concepts.

A growing body of research has demonstrated the effectiveness of the RADEC learning model in improving various aspects of student learning. Previous studies have reported positive effects of RADEC on learning outcomes, critical thinking skills, higher-order thinking skills, and student engagement across different subjects and educational levels (Magfirah et al., 2024; Nurmitasari et al., 2023; Yulianti et al., 2023). In mathematics education, the RADEC model has been shown to significantly improve students' learning outcomes compared to conventional instructional approaches (Ishak et al., 2025; Kurnia et al., 2025). Moreover, research by Rara & Waworuntu (2023) highlights that RADEC promotes active learning and meaningful understanding through structured discussion and creative tasks. These findings indicate that RADEC is a promising learning model for enhancing students' understanding and achievement.

Despite the positive findings from previous studies, research focusing specifically on the effectiveness of the RADEC learning model in improving learning outcomes in solid geometry at the junior high school level remains limited. Most existing studies emphasize general learning outcomes or other mathematical topics, leaving a gap in the literature regarding its application to spatial geometry. Therefore, this study aims to examine the effectiveness of the RADEC learning model on Grade IX students' learning outcomes in solid geometry. The results of this study are expected to contribute to the development of more effective and appropriate instructional strategies in mathematics education, particularly in geometry learning.

## 2. METHOD

This study employed a quasi-experimental research method because the researchers were not able to randomly assign individual students to experimental and control groups. The research design used was a pretest–posttest control group design, which allows for the comparison of learning outcomes before and after the implementation of different learning models. In this design, both groups were administered a pretest, followed by instructional treatment, and then a posttest. The research design is presented in table 1.

**Table 1. Research Design**

Group	Pretest	Treatment	Posttest
Experimental	O <sub>1</sub>	X <sub>1</sub>	O <sub>2</sub>
Control	O <sub>3</sub>	X <sub>2</sub>	O <sub>4</sub>

In this study, X<sub>1</sub> represents the implementation of the RADEC (Read, Answer, Discuss, Explain, and Create) learning model, while X<sub>2</sub> represents the direct learning model.

The population of this study consisted of 224 ninth-grade students at a junior high school. The sampling technique used was cluster random sampling, in which intact classes were randomly selected. Two classes were chosen as research samples: one class was assigned as the experimental group, and the other as the control group.

The data collected in this study were quantitative data in the form of students' learning outcome scores. The primary data source was the results of pretest and posttest administered to students in both the experimental and control classes. In addition, observational data were collected to monitor the implementation of the RADEC learning model during the learning process and to ensure that the treatment was conducted according to the planned instructional procedures.

The research instruments consisted of:

1. an essay test comprising three items used to measure students' learning outcomes in solid geometry,
2. learning modules,
3. student worksheets, and
4. observation sheets used to assess the implementation of the RADEC learning model.

To ensure the appropriateness of the instruments, expert validation was conducted by experts in mathematics education. The validation process focused on content validity, clarity of language, and alignment of the instruments with the research objectives. The instruments were revised based on the validators' suggestions before being used in the study.

Data analysis was conducted using inferential statistical techniques. Prior to hypothesis testing, prerequisite tests consisting of normality and homogeneity tests were performed to ensure that the data met the assumptions for parametric testing. After these assumptions were satisfied, an independent sample t-test was used to examine differences in learning outcomes between the experimental and control groups. The significance level was set at 0.05. The decision criteria were that if the significance value (p-value) was less than or equal to 0.05, the null hypothesis (H<sub>0</sub>) was rejected.

The hypotheses tested in this study were formulated as follows:

**H<sub>0</sub>:** There is no difference in learning outcomes between students taught using the RADEC learning model and those taught using the direct learning model in solid geometry.

**H<sub>1</sub>:** There is a difference in learning outcomes between students taught using the RADEC learning model and those taught using the direct learning model in solid geometry.

To determine the effectiveness of the RADEC learning model, an N-Gain score analysis was conducted. The N-Gain score was calculated to measure the improvement in students' learning outcomes from pretest to posttest using the following formula:

$$\text{N-Gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}}$$

Note: Ideal Score  $\neq$  Pretest Score

The effectiveness criteria based on the average N-Gain score were classified as follows:

- **High:**  $0.70 < \text{N-Gain} \leq 1.00$
- **Moderate:**  $0.30 < \text{N-Gain} \leq 0.70$
- **Low:**  $\text{N-Gain} \leq 0.30$

The RADEC learning model was considered effective if the average N-Gain score fell within the moderate or high category.

### 3. RESULTS AND DISCUSSION

#### 3.1. Results

This section presents the findings of the study based on descriptive statistics, prerequisite tests, hypothesis testing, N-Gain analysis, and observation results of the implementation of the RADEC learning model.

##### **Descriptive Statistics of Pretest and Posttest Scores**

The descriptive analysis was conducted to describe students' initial and final learning outcomes in both the experimental and control classes. The pretest was administered before the treatment to determine students' initial ability in solid geometry, while the posttest was administered after the treatment to measure learning outcomes.

The results showed that the mean pretest scores of the experimental and control classes were relatively similar. This indicates that both groups had comparable initial abilities prior to the implementation of the learning models. After the treatment, the mean posttest score of the experimental class increased substantially and was higher than that of the control class. The increase in the experimental class was more pronounced compared to the control class.

In addition to the mean scores, the distribution of students' scores also showed improvement. In the experimental class, the number of students achieving higher score intervals increased after the implementation of the RADEC learning model. Meanwhile, in the control class, although there was an improvement, the increase was not as substantial as that observed in the experimental class.

These descriptive findings indicate that students who were taught using the RADEC learning model experienced greater improvement in learning outcomes compared to students who were taught using the direct learning model.

##### **Prerequisite Tests**

Before conducting the hypothesis test, prerequisite tests were carried out to ensure that the data met the assumptions required for inferential statistical analysis.

##### **Normality Test**

The normality test was conducted to determine whether the posttest data from both classes were normally distributed. The results of the normality test showed that the significance values (Sig.) for both the experimental and control classes were greater than

0.05. Therefore, it can be concluded that the posttest data in both groups were normally distributed.

### **Homogeneity Test**

The homogeneity test was conducted to determine whether the variances of the two groups were equal. The results of the homogeneity test showed that the significance value was greater than 0.05. Thus, the variances of the experimental and control classes were homogeneous.

Since the data met the assumptions of normality and homogeneity, the independent sample t-test could be applied to test the research hypothesis.

### **Hypothesis Testing**

Hypothesis testing was conducted using the independent sample t-test to determine whether there was a significant difference in learning outcomes between students taught using the RADEC learning model and those taught using the direct learning model.

The results of the independent sample t-test showed that the significance value (Sig. 2-tailed) was less than 0.05. Based on the decision criteria, if  $\text{Sig.} \leq 0.05$ , then  $H_0$  is rejected and  $H_1$  is accepted. Therefore,  $H_0$ , which states that there is no difference in learning outcomes between students taught using the RADEC learning model and those taught using the direct learning model, was rejected.

This result indicates that there is a statistically significant difference in learning outcomes between the two groups. Students who were taught using the RADEC learning model achieved significantly higher posttest scores than students who were taught using the direct learning model.

### **N-Gain Analysis**

To determine the effectiveness of the RADEC learning model in improving students' learning outcomes, the N-Gain score was calculated for both classes.

The results of the N-Gain analysis showed that the experimental class obtained a higher average N-Gain score compared to the control class. Based on the N-Gain classification criteria, the improvement in both classes fell into the moderate category. However, the experimental class demonstrated a greater increase in learning outcomes than the control class.

This finding indicates that the RADEC learning model was more effective in improving students' understanding of solid geometry concepts compared to the direct learning model.

### **Observation of the Implementation of the RADEC Learning Model**

Observation data were collected to evaluate the implementation of the RADEC learning model during the learning process in the experimental class. The observation results showed that the implementation of each stage of the RADEC model—Read, Answer, Discuss, Explain, and Create—was carried out according to the lesson plan.

Students were observed to actively participate during the learning activities. In the Read stage, students engaged in independent reading activities. In the Answer stage, students attempted to respond to guiding questions. During the Discuss stage, students actively exchanged ideas within their groups. In the Explain stage, several students presented their solutions in front of the class. Finally, in the Create stage, students produced learning-related products such as geometric models.

Overall, the observation results indicate that the RADEC learning model was implemented effectively and that students were actively involved throughout the learning process.

### 3.2. Discussion

The findings of this study indicate that the implementation of the RADEC (Read, Answer, Discuss, Explain, and Create) learning model has a positive and significant effect on Grade IX students' learning outcomes in solid geometry. This conclusion is supported by both descriptive and inferential statistical analyses, which consistently show that students taught using the RADEC learning model achieved higher posttest scores and greater learning gains than those taught using direct instruction.

The descriptive analysis revealed that the average pretest scores of the experimental and control classes were relatively similar, indicating that both groups had comparable initial abilities before the treatment was administered. This similarity is an important prerequisite for experimental research, as it ensures that differences observed in the posttest results can be attributed primarily to the instructional treatment rather than to pre-existing differences between groups. After the learning intervention, however, the experimental class demonstrated a substantially higher average posttest score compared to the control class. This result suggests that the RADEC learning model provides more effective support for students in mastering solid geometry concepts than the direct learning model.

These descriptive findings were further reinforced by inferential statistical analysis. The results of the independent sample t-test showed a statistically significant difference between the posttest scores of the experimental and control classes. This indicates that the learning outcomes achieved by students who learned through the RADEC learning model were significantly better than those achieved by students who learned through direct instruction. From a pedagogical perspective, this finding highlights the effectiveness of learning models that actively engage students in the learning process and encourage them to construct their own understanding through structured stages of learning.

In addition to hypothesis testing, the analysis of N-Gain scores provided further evidence of the effectiveness of the RADEC learning model. Although both the experimental and control classes were classified in the moderate category of learning improvement, the experimental class achieved a higher average N-Gain score than the control class. This result indicates that students in the experimental class experienced greater improvement in learning outcomes from pretest to posttest. The higher N-Gain score suggests that the RADEC learning model not only improves final achievement but also enhances the overall learning process by facilitating deeper conceptual understanding.

The effectiveness of the RADEC learning model can be explained by examining its pedagogical structure and how each stage supports meaningful learning. The Read stage plays a critical role in preparing students for classroom learning by encouraging them to explore learning materials independently before formal instruction. Through guided reading activities, students develop initial familiarity with key concepts and terminology related to solid geometry. This early exposure helps reduce cognitive load during classroom learning and enables students to participate more actively in subsequent learning activities. Moreover, this stage aligns with the emphasis on literacy and independent learning within the Indonesian educational context, where students are expected to develop the ability to access and process information from various sources (Rafsanjani et al., 2023).

The Answer stage further strengthens students' conceptual readiness by requiring them to respond to pre-learning questions based on their independent reading. This stage encourages students to reflect on what they have learned and to identify gaps in their understanding. By answering questions prior to classroom discussion, students are trained to take responsibility for their own learning and to develop curiosity about the material

being studied. This process helps students construct a basic conceptual framework that serves as a foundation for deeper understanding during collaborative activities.

The Discuss stage is particularly important in facilitating conceptual clarification and knowledge construction. During group discussions, students have opportunities to exchange ideas, compare solutions, and negotiate meaning with their peers. In the context of solid geometry, discussion activities allow students to articulate their understanding of geometric properties, surface area, volume, and the relationships among elements of three-dimensional figures. Because students in the RADEC model have already engaged with the material during the Read and Answer stages, discussions tend to be more focused and productive. This finding is consistent with previous research showing that discussion-based learning environments promote active engagement and enhance students' understanding of mathematical concepts (Yulianti et al., 2023).

Compared to direct instruction, where guided practice is often limited to teacher-led problem solving, the RADEC learning model places greater emphasis on student preparedness and peer interaction. Students who learn through RADEC are better equipped to participate in discussions because they have already developed preliminary understanding prior to class. This advantage contributes to more meaningful interaction and more effective problem-solving during group activities. Similar conclusions were reported by Magfirah et al., (2024) who found that students taught using the RADEC learning model demonstrated greater readiness and maturity in discussion activities compared to those taught using conventional approaches.

The Explain stage further reinforces learning by requiring students to communicate their understanding to others. When students explain their solutions and reasoning in front of the class, they engage in metacognitive processes that help consolidate their understanding. Explaining concepts aloud requires students to organize their thoughts, use appropriate mathematical language, and justify their reasoning. This stage also allows teachers to identify misconceptions and provide clarification when necessary. Research has shown that explanation activities play a crucial role in verifying students' understanding and strengthening conceptual mastery (Magfirah et al., 2024). In the context of solid geometry, explaining solutions to problems involving surface area and volume helps students internalize abstract concepts through verbalization.

The Create stage distinguishes the RADEC learning model from many traditional instructional approaches by emphasizing creativity and application. In this stage, students are encouraged to produce tangible products related to the learning material, such as constructing nets and three-dimensional models of cubes and rectangular prisms using recycled materials. These activities allow students to directly manipulate and visualize geometric objects, which is particularly beneficial for developing spatial ability. By creating models, students are able to connect abstract mathematical formulas with concrete representations, thereby enhancing conceptual understanding. This hands-on approach supports meaningful learning and contributes to improved learning outcomes.

Observational data collected during the implementation of the RADEC learning model further support these findings. Students in the experimental class were observed to participate actively in learning activities, collaborate effectively with peers, and demonstrate enthusiasm during discussion and creation stages. Active participation is a key factor in successful learning, as it enables students to engage cognitively and emotionally with the material. This observation is consistent with findings reported by Nurmitasari et al., (2023), who noted that the RADEC learning model promotes active exploration, discussion, and application of concepts, leading to improved learning outcomes.

The results of this study are also consistent with previous research that highlights the effectiveness of the RADEC learning model across different subjects and educational

levels. Rara & Waworuntu (2023) reported significant improvements in student learning outcomes after the implementation of the RADEC learning model, while Ishak et al., (2025) found that students taught using RADEC achieved higher learning outcomes than those taught using direct instruction in mathematics. These findings collectively suggest that the structured, student-centered nature of the RADEC learning model supports meaningful learning and contributes to improved academic achievement.

Overall, the findings of this study demonstrate that the RADEC learning model is effective in improving students' learning outcomes in solid geometry. The combination of independent learning, structured discussion, explanation, and creative application enables students to develop deeper conceptual understanding and stronger spatial reasoning skills. These results underscore the importance of implementing innovative learning models that actively engage students and support meaningful learning processes in mathematics education.

## CONCLUSION

Based on the results of the independent sample t-test and N-Gain analysis, it can be concluded that the RADEC learning model has a statistically significant effect on improving ninth-grade students' learning outcomes in solid geometry. Students who were taught using the RADEC learning model achieved higher posttest scores and greater learning gains compared to those who were taught using the direct learning model. The structured stages of RADEC encourage students' active engagement, independent preparation, collaborative discussion, conceptual explanation, and creative application, which contribute to deeper conceptual understanding. Therefore, the RADEC learning model can be considered an effective alternative instructional approach for improving mathematics learning outcomes, particularly in geometry topics.

## ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to the school principal, mathematics teachers, and ninth-grade students who participated in this study for their cooperation and support. Appreciation is also extended to all parties who contributed to the completion of this research.

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