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RADEC Learning Model: Practicum to Enhance Students' Science Process Skills on Temperature and Heat

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ABSTRACT

This study aims to analyze the implementation of the RADEC learning model with practicum method in enhancing students' science process skills on temperature and heat material. The method used in this research is quasi-experiment with nonequivalent control group design. The study was conducted at MA Negeri 1 Tasikmalaya with a research population of 263 students across 8 classes of XI MIPA. Purposive sampling technique was used to select the sample, resulting in XI MIPA 5 as the experimental group and XI MIPA 3 as the control group. To measure students' science process skills, pretest and posttest in the form of reasoned multiple-choice questions were administered, totaling 12 items representing 6 basic science process skill indicators on temperature and heat material. Data analysis techniques included expert validation, instrument testing, analysis of science process skills mastery, analysis of learning model feasibility, N-Gain analysis, prerequisite tests, and hypothesis testing. The hypothesis testing results using t-test at a significance level ($\alpha = 0.05$) showed that after the implementation of the RADEC learning model with practicum method, $t_{observed} > t_{critical}$, specifically $3.43 > 1.67$, thus rejecting H_0 and accepting H_a . Therefore, with 95% confidence level, it can be concluded that the application of the RADEC learning model with practicum method effectively enhances students' science process skills on temperature and heat material. From this research, the RADEC learning model with the practicum method can be the choice of learning model applied in Physics learning and as a means of practicing for students in improving science process skills.

INTRODUCTION

Science process skills aim to build scientific concepts by investigating natural phenomena around us [1]. Through science process skills, students can solve problems and draw conclusions to develop

thinking skills and build knowledge [2]. Therefore, science process skills are crucial to emphasize in learning Physics [3].

The researcher conducted a preliminary study involving interviews with Physics teachers and administered questionnaires as well as an initial science process skills test to 67 students. Based on the interviews with the XI MIPA Physics teacher at MA Negeri 1 Tasikmalaya, it was found that the common teaching method is conventional, utilizing lectures and learning resources such as Student Worksheets (LKS) and textbooks from a particular publisher. Additionally, the teacher rarely uses the practicum method in teaching, as the Physics laboratory was recently separated from the Biology laboratory, leading to the reorganization of equipment, with some of it not functioning properly due to infrequent use. This aligns with the questionnaire results from the 67 students, where 86.56% stated that the teacher teaches Physics through lectures and rarely uses the practicum method. Consequently, most students are not actively engaged in learning, leading to a lack of familiarity with using science process skills in Physics education.

Based on the preliminary study involving an initial test of students' science process skills, the test results data are as follows.

Table 1. Initial Test Results of Students' Science Process Skills (Preliminary Study)

| No | Indicator | Percentage (%) | Category |
|----------------|---------------|----------------|-----------------|
| 1 | Observing | 51,85 | Very Low |
| 2 | Measuring | 43,21 | Very Low |
| 3 | Classifying | 29,63 | Very Low |
| 4 | Predicting | 59,26 | Very Low |
| 5 | Communicating | 53,09 | Very Low |
| 6 | Concluding | 40,74 | Very Low |
| Average | | 49,76 | Very Low |

An alternative solution to improve science process skills in Physics learning is to apply the Read-Answer-Discuss-Explain-Create (RADEC) learning model with the practicum method. According to Sopandi et al [4], RADEC learning model can meet the demands of the 2013 curriculum, including the competency skills that students must possess. The RADEC learning model is suitable for developing students' science process skills with its systematic RADEC syntax, which consists of Read-Answer-Discuss-Explain-Create. It has several characteristics: (1) the RADEC learning model consistently encourages students to actively engage in the learning process; (2) the RADEC learning model encourages students to learn independently; (3) the RADEC learning model always connects what students know with the material being studied; (4) the RADEC learning model links the material being studied with real life or contemporary issues; (5) the RADEC learning model consistently provides opportunities for students to actively ask questions, discuss, propose investigation plans, and conclude the material being studied; (6) the RADEC learning model offers students the opportunity to study the material in depth through pre-learning tasks [5]. The effectiveness of the RADEC learning model has been proven by Wahyuni et al [6] that the science process skills and science learning outcomes of fifth-grade students at UPT SPF SDN Parang Tambung I Makassar in the experimental class, implementing the RADEC learning model, are higher than those of the control class using the discovery learning model.

To achieve maximum learning objectives, the implementation of a learning model needs to be supported by the selection of appropriate teaching methods. Based on the earlier issues, the researcher intends to combine the RADEC learning model with the practicum method. Practicum is a crucial part of science education as it helps students learn process skills and practical skills, and is an effective method to achieve learning objectives [7]. Practical activities are closely related to science process skills, as through practical activities, students become accustomed to following processes and making observations that can develop their science process skills.

The success of using the practicum learning method has been demonstrated in several previous studies [8]. In the study by Lestari et al [9], students' science process skills improve with the use of a direct practicum-based learning model, categorized as good. Similar research was conducted by Royani et al [10], by applying a direct practicum-based learning model, the results showed that there is an influence of the direct practicum-based learning model on students' critical thinking abilities and science process skills. The application of the direct practicum-based learning model is categorized as good.

The selection of appropriate learning materials is crucial in efforts to enhance science process skills. One of the topics covered in Physics education for 11th grade is temperature and heat. Based on interviews with Physics teachers, temperature and heat are essential topics as they serve as a foundation for students to understand the next topic, which is the kinetic theory of gases. Additionally, according to Hara et al [11], in their research at SMA Negeri 12 Kota Kupang, it was found that students still struggle to articulate concepts related to temperature and heat accurately. Additionally, the topic of temperature and heat includes sub-topics that require practical implementation in each session, making it suitable for gradually training students' science process skills [12]. Based on the previous discussion, the researcher is interested in conducting research on temperature and heat material by applying the Read-Answer-Discuss-Explain-Create (RADEC) learning model combined with the practicum method at MA Negeri 1 Tasikmalaya in the XI MIPA class.

METHOD

This research focused on class XI MIPA students at MA Negeri 1 Tasikmalaya. This research utilizes quasi-experimental method, which is a development of true experimental method known for its challenging implementation. This method includes a control group that cannot control external variables that may affect the overall research implementation [13]. The sample used in this research was determined using purposive sampling, a technique for selecting samples based on specific considerations [14]. The experimental and control classes were not chosen randomly. After analyzing the average values and standard deviations of the eight classes, it was determined that class XI MIPA 5 would be the experimental class and class XI MIPA 3 would be the control class, as they had similar average values and small standard deviations.

The research design used in this study is a non-equivalent control group design. Each experimental group and control group was given a pretest, then after being given treatment in the experimental class using the RADEC learning model and in the control class using a commonly applied learning model in schools, namely direct instruction, a post-test was administered. In this study, there are two variables: the independent variable and the dependent variable. The independent variable in this study is the RADEC learning model, while the dependent variable is the students' science process skills.

The data collection techniques used in this research were observation and testing. Three observers directly observed the learning activities. The test conducted was a multiple-choice test of science process skills to measure the students' science process skills. The final score of the students' science process skills is presented as a percentage value. These percentage values will be interpreted into categories as shown in Table 2.

Table 2. Nonequivalent Control Group Design

| Percentage (%) | Category |
|----------------|---------------|
| 81 – 100 | Very good(A) |
| 61 – 80 | Good (B) |
| 41 – 60 | Enough (C) |
| 21 – 40 | Less (D) |
| 0 – 20 | Very less (E) |

Two data analyses will determine how the RADEC learning model influences science process skills.

The first data analysis was carried out to test the hypothesis through a series of tests: normality, homogeneity, and t-tests. The second data analysis is to determine the increase in critical thinking skills using N-Gain analysis through equation (1).

$$N\text{-Gain}(g) = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}} \quad (1)$$

The N-Gain category can be found in Table 3

Table 3. N-Gain Analysis

| Range | Category |
|--------------------|----------|
| $g < 0,3$ | Low |
| $0,3 \leq g < 0,7$ | Moderate |
| $g \geq 0,7$ | High |

RESULTS AND DISCUSSIONS

After the trial was conducted and the results were known, it was continued by collecting data on the initial ability of students' science process skills through a pretest in the experimental class (students of class XI MIPA 5) and the control class (students of class XI MIPA 3). The pretest results are described in Table 4.

Table 4. Statistical Data on Pretest Results for Science Process Skills

| Class | n | Score | | | Average | Variance | Standard Deviation |
|--------------|----|--------|---------|-------|---------|----------|--------------------|
| | | Lowest | Highest | Ideal | | | |
| Experimental | 33 | 15 | 26 | 48 | 20,83 | 4,28 | 2,07 |
| Control | 33 | 13 | 24 | 48 | 19,86 | 6,66 | 2,58 |

In Table 4, it is shown that each of the experimental and control classes, consisting of 33 students each, obtained varied pretest scores. The average score for the experimental class was 20.83, while the control class had an average score of 19.86. These results indicate that the average pretest score in the experimental class was higher compared to the control class.

Next, to determine the variability of the pretest score data from the experimental and control classes, variance calculations were performed. The variance of the control class was greater than that of the experimental class, with 6.66 in the control class and 4.28 in the experimental class. This indicates that the pretest score data in the control class were more varied than in the experimental class. Then, standard deviation calculations were performed to determine the data distribution in both classes. The standard deviation of the control class was greater than that of the experimental class, with 2.58 in the control class and 2.07 in the experimental class. This indicates that the pretest score data in the control class were more evenly distributed than in the experimental class.

The experimental class implemented the RADEC learning model, while the control class used the conventional learning model (direct instruction) commonly used in schools. Based on the post-test results after applying the learning model to the experimental and control classes with temperature and heat material, the obtained data are described in Table 5.

Table 5. Statistical Data on Posttest Results for Science Process Skills

| Class | n | Score | | | Average | Variance | Standard Deviation |
|--------------|----|--------|---------|-------|---------|----------|--------------------|
| | | Lowest | Highest | Ideal | | | |
| Experimental | 33 | 35 | 46 | 48 | 41,32 | 6,15 | 2,48 |
| Control | 33 | 32 | 43 | 48 | 39,11 | 5,21 | 2,28 |

In Table 5, it is presented that the average posttest score in the experimental class was 41.32, while the average posttest score in the control class was 39.11. These results indicate that the average posttest score in the experimental class was higher than that in the control class. When comparing the average scores of the students by comparing the pretest results (before treatment) with the posttest results (after treatment), it can be seen that there was an improvement in the students' mastery of science process skills.

The diversity of post-test score data from the experimental class and the control class is known from the variance of each class. The variance of the post-test score data in the experimental class is 6.15, while the variance of the post-test score data in the control class is 5.21. This indicates that the data in the experimental class is more varied than in the control class. Additionally, the spread of the post-test score data is obtained from the calculation of the standard deviation in the experimental class and the control class. The standard deviation of the experimental class is greater than that of the control class, which is 2.48 in the experimental class and 2.28 in the control class. This shows that the post-test score data in the experimental class is more evenly distributed than in the control class.

After collecting data on the pretest and post-test results of students from both the experimental and control classes, the prerequisite tests, which include the normality and homogeneity tests, are performed first. The Chi-Square test is used for the normality test to assess the normal distribution of the research data. The results of this normality test are presented in Table 6.

Table 6. Chi-Square Normality Test Results

| Class | Data | $\chi^2_{observed}$ | χ^2_{table} | Conclusion | Conclusion of the Analysis |
|--------------|--------|---------------------|------------------|-------------------|---|
| Experimental | N-Gain | 14,45 | 16,7 | H_0 is accepted | The sample has been taken from a population that is normally distributed. |
| Control | N-Gain | 16,21 | | H_0 is accepted | |

The Chi-Square calculation was conducted using Microsoft Excel 2019. The obtained result of the calculation in the experimental class yielded $\chi^2_{observed}$ value of 13.01, and in the control class, it was 16.21. Since both $\chi^2_{observed}$ values in the classes are smaller than the χ^2_{table} critical value, H_0 is accepted, and H_a is rejected. With the description of H_0 stating that the samples were taken from populations that are normally distributed, it is concluded that all data groups are normally distributed.

The homogeneity test was performed to ascertain if the data groups being examined had equal variances. This was done using the Fisher test with Microsoft Excel 2019, applying a significance level of 5%. The data analyzed comprised the post-test scores from both the experimental and control classes. The results of this homogeneity test are shown in Table 7.

Table 7. Homogeneity Test Results (Fisher)

| Class | N | Variance (S^2) | $F_{observed}$ | α | F_{table} | Conclusion |
|--------------|----|--------------------|----------------|----------|-------------|-------------------|
| Experimental | 33 | 0,0074 | 1,16 | 0,05 | 1,83 | H_0 is accepted |
| Control | 33 | 0,0064 | | | | |

From the results of the Fisher test calculation, the variance of the N-Gain data in the experimental class is 0.0074, and in the control class, it is 0.0064. Thus, the obtained $F_{observed}$ is 1.16. With α being 0.05, F_{table} for $F_{0,05(32,32)}$ is 1.83. Since the calculated $F_{observed}$ is smaller than the critical F_{table} , H_0 is accepted, and H_a is rejected. Therefore, it is concluded that all data groups have the same variance, or are homogenous.

After completing the prerequisite tests (normality test and homogeneity test), it was determined that the data from both samples were normally distributed and had homogeneous variances. Consequently, hypothesis testing could proceed using the t-test. The analysis results from the t-test are presented in Table 8.

Table 8. t-test Result

| Data | N-Gain for the experimental and control classes |
|----------------------------|--|
| T_{observed} | 3,43 |
| A | 0,05 |
| T_{table} | 1,67 |
| Conclusion | H_a is accepted |
| Conclusion of the Analysis | The implementation of the Read-Answer-Discuss-Explain-Create (RADEC) learning model with the practical method can enhance the science process skills of students in temperature and heat material. |

From Table 8, it is shown that the result of hypothesis testing using the t-test with a significance level ($\alpha = 0.05$) yields $t_{\text{observed}} > t_{\text{table}}$, which is $3.43 > 1.67$. Therefore, H_0 is rejected, and H_a is accepted. This means that at a confidence level of 95%, it can be concluded that the implementation of the Read-Answer-Discuss-Explain-Create (RADEC) learning model with the practical method enhances the science process skills of students in temperature and heat material.

The post-test data results from the experimental and control classes can be explained in more detail by calculating the average percentage of post-test scores per indicator. This percentage is derived from the post-test results, which consist of 12 multiple-choice questions covering six indicators of basic science process skills. The calculation results are in Table 9.

Table 9. Comparison of the Percentage of Science Process Skills from Posttest Results

| SPS Indicator | Experimental Class | | Control Class | |
|----------------|--------------------|-------------|---------------|-------------|
| | Percentage | Category | Percentage | Category |
| Observing | 97% | Very High | 92% | Very High |
| Measuring | 89% | High | 85% | High |
| Classifying | 83% | High | 81% | High |
| Predicting | 81% | High | 80% | High |
| Communicating | 84% | High | 76% | High |
| Concluding | 83% | High | 75% | High |
| Average | 86% | High | 82% | High |

In Table 9, it is shown that the level of mastery of science process skills among students in the experimental class after the implementation of the RADEC learning model with the practical method was as follows: observing 97%, measuring 89%, classifying 83%, predicting 81%, communicating 84%, and concluding 83%. The average level of mastery of science process skills among students in the experimental class after the treatment was 86%, which falls into the high category.

Table 9 also shows that the level of mastery of science process skills of students in the experimental class before the application of the Direct Instruction learning model with the practicum method was 92% for observing, 85% for measuring, 81% for classifying, 80% for predicting, 76% for communicating, and 75% for concluding. The average level of mastery of science process skills of students in the control class after treatment was 82%, which falls into the high category. From this data, it can be seen that after treatment, the mastery of science process skills in the experimental class was 4% higher compared to the control class, both being in the high category.

The results of the N-Gain calculation for the mastery of science process skills per indicator in the experimental and control classes are presented in Table 10.

Table 10. Normalized Gain (N-Gain) Analysis Results

| Indicators of Science Process Skills | Class | | | |
|--------------------------------------|--------------|-------------|--------------|-----------------|
| | Experimental | | Control | |
| | N-Gain Score | Category | N-Gain Score | Category |
| Observing | 0,93 | High | 0,84 | High |
| Measuring | 0,79 | High | 0,72 | High |
| Classifying | 0,71 | High | 0,66 | Moderate |
| Predicting | 0,69 | Moderate | 0,66 | Moderate |
| Communicating | 0,71 | High | 0,62 | Moderate |
| Concluding | 0,74 | High | 0,64 | Moderate |
| N-Gain Score Average | 0,76 | High | 0,69 | Moderate |

From the six N-Gain scores of science process skill indicators examined, the average for the experimental class was 0.76, categorized as high, and 0.69 for the control class, categorized as moderate. The average N-Gain score per science process skill indicator in each class is the same as the average N-Gain score per student. With the average N-Gain score of the experimental class being greater than that of the control class, it indicates that the implementation of the Read-Answer-Discuss-Explain-Create (RADEC) learning model with the practical method can enhance students' science process skills in temperature and heat material more effectively than the Direct Instruction learning model with the practical method.

The science process skills investigated in this research encompass six basic skills according to Funk as cited in Dimiyati & Mudjiono [15] include six basic skills: observing, classifying, measuring, predicting, communicating, and concluding. After treatment in both sample classes, in the experimental class, the observation skill reached 97%, categorized as very high, while in the control class, it reached 92%, also categorized as very high.

In the experimental class, the observation skill was trained during the "read" syntax (reading). In the first session, a picture of the phenomenon of expansion on railway tracks was presented, and in the second session, a picture of heat transfer in an uninsulated heated pan, as shown in Figure 1, was presented.

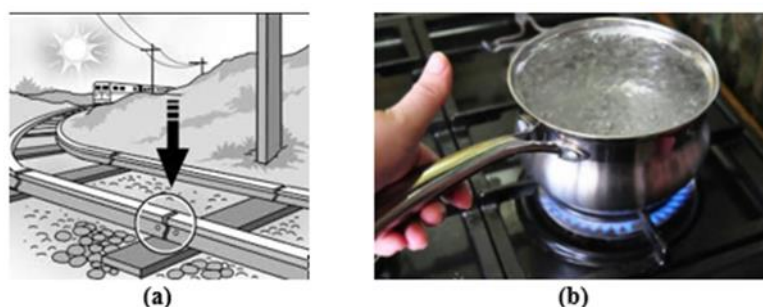


Fig 1. (a) Expansion Phenomenon on Railway Tracks (b) Heat Transfer Phenomenon in Pans without Insulators

After observing the presented pictures, students are given the opportunity to express their observations, and the teacher poses questions as a segue to the next syntax, such as "How does the process of expansion occur?" This syntax aims to train students in extracting information about the upcoming material from their worksheets. Then, the teacher checks the students' reading results through the process of observing the pictures presented to build the students' observation skills. The activities in the "read" syntax in the experimental class are depicted in Figure 2.



Fig 2. *Activity Syntax Read*

Furthermore, the measuring skill in the experimental class reached 89%, categorized as high, while in the control class it reached 85%, also categorized as high. The measuring skill achieved the same category in both the experimental and control classes. This occurred because both classes conducted the same activity, which was a practical session using the same objectives and materials. According to Sampurna & Nindhia [16] similar activities yield similar or nearly similar results. However, there is a difference in the treatment of students in the experimental class, where they are guided by the teacher to design the practical session independently, while in the control class, the teacher provided a list of materials and equipment, as well as the steps of the practical session to be carried out.

The measuring skill in the experimental class was trained during the "answer" syntax, by applying the practical method. In this syntax, students are directed to design and conduct the practical session directly in the laboratory. During this syntax, the teacher guides and directs the students in determining the tools and materials, as well as the steps of the practical session to be carried out. This practical session is conducted to answer the questions given in the "read" syntax and to train the students' measuring skills.



Fig 3. *Syntax Answer Activities (practicum)*

The classification and prediction skills are trained during the "discuss" syntax. The achievement of mastery in classifying by students reached 83% in the experimental class, categorized as high, and 81% in the control class, also categorized as high. As for the prediction skill, in the experimental class, it reached 81%, categorized as high, and 80% in the control class, also categorized as high.

In the "discuss" syntax, students are directed to discuss the results of the practical session from the "answer" syntax with their groupmates. This discussion is aimed at answering several questions presented in the student worksheet (LKPD) related to the practical session results.

The mastery achievement of students in the communication skill reached 84% in the experimental class, categorized as high, and 76% in the control class, categorized as fair. The communication skill of students in the experimental class was trained during the "explain" syntax. In this syntax, the teacher requests a group of students, predetermined by the teacher based on the results of the

discussion syntax, to present their group discussion results in front of the class. Other groups of students pay attention to their classmates' presentations and provide questions/statements regarding their classmates' presentation. Then, the teacher reinforces the students' presentation results and explains the material to be conveyed during that session. The activities in the "explain" syntax in the experimental class are depicted in Figure 5.



Fig 4. Syntax Discuss Activity



Fig 5. Syntax Explain Activity

The mastery achievement of students in the concluding skill reached 83% in the experimental class, categorized as high, and 75% in the control class, categorized as fair. The concluding skill of students in the experimental class was trained during the "create" syntax. In this syntax, the teacher directs and guides the students to create a practical report on a folio paper. Then, the students create their practical reports according to the systematic guidelines determined by the teacher. The systematic report includes objectives, materials and methods, experimental procedures, observation data, data analysis, and conclusions. In the final part of the report, the conclusion is presented, where students learn to draw conclusions from the practical results and discussions conducted in the previous syntaxes. The activities in the "create" syntax in the experimental class are depicted in Figure 6.



Fig 6. Syntax Create Activity

In administering the treatment in the experimental and control classes, both conducted the same practical session with different approaches. In the control class, students were directly guided to

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conduct the practical session at the beginning of the learning process, unlike the experimental class, where the learning activities began with the requirement to read first in the "read" syntax. Additionally, in the control class, the practical session conducted by students involved directly providing them with the experimental procedures without them having to independently design it, as in the experimental class. Furthermore, after the practical session in the control class, students did not independently create practical reports; instead, they only listened to the teacher's explanation regarding the learning material and the results of the practical session that had been conducted.

Various activities carried out in all the syntaxes of the RADEC learning model with the practical method provide opportunities for students to actively participate during the learning process. This is in line with one of the characteristics of the RADEC learning model as expressed by Handayani et al [5] which is that the RADEC learning model consistently encourages students to actively engage in the learning process. With active involvement from students, it facilitates the process of improving students' science process skills.

The RADEC learning model emphasizes reading and discussion activities. Reading activities emphasized in the "read" syntax can help students acquire information and knowledge about science. According to Pohan [17] with the "read" syntax, students' reading comprehension abilities will be trained, and students' information or insights will be expanded before receiving the subject matter. However, in this research, there are limitations in providing reading sources for students, resulting in the less-than-optimal improvement of students' science process skills, as seen in the predicting indicator with an N-Gain Score of 0.69, which is stated as the indicator of science process skills with the lowest improvement based on the data in Table 10.

The practical activities in the implementation of the RADEC learning model in the experimental class provide opportunities for students to conduct scientific investigations. Scientific investigations are carried out to help develop students' science process skills. The enthusiasm of students in carrying out the practical sessions is very good, thus assisting in the development of science process skills. This is in line with what Widyarti et al [18] mentioned, that with practical activities, students find their learning enjoyable, thereby increasing their enthusiasm for learning, making them more active, and improving their skills.

CONCLUSION AND SUGGESTION

Based on the research findings and the discussion of the data processing results, it is concluded that the implementation of the Read-Answer-Discuss-Explain-Create (RADEC) learning model with the practical method can improve students' science process skills in temperature and heat material. This is demonstrated by the results of hypothesis testing using the t-test with a significance level ($\alpha = 0.05$), where $t_{observed} > t_{table}$ specifically $3,43 > 1,67$ thus rejecting H_0 and accepting H_a .

Based on the research conclusions presented, the author suggests that future studies continue to investigate integrated science process skill indicators and provide opportunities for students to design a simple tool in the "create" syntax. Additionally, it is recommended to extend the duration and increase the variety of reading sources available to students in the "read" syntax to enhance students' insights and knowledge about the learning material.

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