



The Impact of RADEC Learning Model on Mathematical Communication Ability: An Experimental Study on High School Students in Palu City

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ABSTRACT: The low mathematics learning outcomes of high school students in Palu City are caused by the weak mathematical communication skills of high school students. Therefore, a learning model is needed that can improve students' mathematical communication skills. The RADEC learning model was chosen to be implemented in mathematics learning in the classroom. This research method is a quasi-experimental method with an intact group comparison design. The population of the study was all grade X high school students in Palu City, totaling 3656 students, while the sample was 186 students in the experimental class and 186 students in the control class. Sampling used a purposive random sampling technique. The instruments used were initial ability tests and mathematical communication ability tests. Data were analyzed using t-test statistics and two-way ANOVA test statistics. The results showed that the RADEC learning model had a higher impact on the mathematical communication skills of high school students in Palu City, with a significance level of $p = 0.000$. The average score of mathematical communication skills of students who follow the RADEC learning model is 76.70 on a scale of 0-100, while participants who follow Direct Instruction are 62.35. The RADEC learning model does not provide different impacts based on students' initial abilities, so this model can be implemented in classes with heterogeneity in students' initial abilities.

KEYWORDS: Instruction, Mathematical Communication, Direct, RADEC Learning Model.

INTRODUCTION

Mathematics is a subject taught in schools. One of the main purposes of studying mathematics in schools is as a means of communication. Mathematics is a universal language that is widely used to communicate ideas, concepts, facts, and information clearly and precisely (Hodiyanto, 2017). As a means of communication, mathematics is widely used in various fields, such as science, technology, business, economics, and others (Siregar, 2018).

Although it is recognized that studying mathematics has many benefits, student learning outcomes in mathematics subjects in schools are still low (Ardilla et al., 2023; Yanti et al., 2020). The results of a study by (Abaskue et al., 2022) showed that students' mathematics learning outcomes in the even semester of 2019/2020 were in the very low category. The mathematical communication skills of public high school students in Palu City averaged 39.63 out of 100 (Inayah, 2016).

The difficulties experienced by students in mathematics subjects, especially in mathematical communication, include students' lack of understanding when reading texts, resulting in errors in solving mathematical problems, students' errors in interpreting interrogative sentences, students' dislike of long question sentences or in the form of story problems so that students only guess and do not use the thinking process and cannot find keywords from a mathematical problem or question (Restiani et al., 2023).

There are several factors that influence learning outcomes, generally divided into two, namely internal factors of students and external factors of students (Elastika et al., 2021). Internal factors such as motivation, IQ, SQ, AQ, interest, self-confidence, and self-management. External factors such as school curriculum, school facilities and infrastructure, parental attention, teacher competence (Nafis et al., 2019), learner cognitive style, self-regulated learning, and working memory (Wang & Kao, 2022), use of models, methods, and learning strategies by teachers (Sartika et al., 2018).

Learning models that do not provide many learning activities for students will have a negative impact on students' written and oral communication skills so that their learning outcomes are low, but on the contrary, if the learning model applied in the classroom provides ample opportunities for students to carry out learning activities, it will have a major impact on communication skills and learning outcomes of students. One of the learning models that provides extensive learning opportunities for students is the Read, Answer, Discussion, Explain, and Create learning model which is then abbreviated as the RADEC learning model. The



RADEC learning model was introduced by Wahyu Sopandi at an International conference in Kuala Lumpur, Malaysia in 2017. The RADEC learning model can improve the quality of the learning process and outcomes of students (Chairunnisa & Sukardi, 2022; Sopandi, 2017). The RADEC learning model can develop students' knowledge, attitudes, and skills in the 21st century (Sopandi et al., 2021). The RADEC learning model was developed according to the characteristics of students in Indonesia (Sopandi & Handayani, 2019). So the RADEC learning model can be an option in efforts to improve learning outcomes such as problem-solving skills, communication skills or critical and creative thinking skills of students.

In addition to the use of learning models, curriculum changes are also an effort by the government to improve the quality of education (Barlian et al., 2022; Tampubolon et al., 2022). The implementation of the Independent Curriculum (Kurma), starting in 2022, aims to catch up with Indonesian students in terms of literacy and numeracy skills, and students have the skills to live in the 21st century. The learning applied in the independent curriculum is differentiated learning. Differentiated learning is a process of teaching and learning activities that pay attention to students based on their abilities, what students like/are interested in learning, and meet the characteristics of students in carrying out the learning process. Because it is undeniable that in a class there are individuals who have diverse abilities. Some have high, medium, and low academic abilities. Some have an auditory, visual, or kinesthetic learning style, and some have an interest/like to learn in nature, or there are also students who like to learn in the classroom. To be able to implement differentiated learning, a learning model is needed as a structured platform or framework in realizing the desired learning objectives. The learning model that can be applied is the RADEC Model. According to Pohan et al. (2020) the RADEC learning model can be used as a learning solution for education in Indonesia.

The RADEC learning model through its syntax (Read-Answer-Discussion-Explain-Create) can be combined with differentiated learning strategies. Because in the Read phase, students can be facilitated with teaching materials that are in accordance with auditory, visual, and kinesthetic learning styles. While in the Discussion phase, students can be given the responsibility to discuss learning materials according to their abilities, not forcing students to work on/discuss learning materials that exceed their abilities. The RADEC learning model with differentiated learning strategies can develop aspects of 21st century skills, namely critical, creative and problem-solving thinking skills can be developed through reading (Read) and discussion (Discussion) activities. Communication skills are developed through discussion activities (Discussion) and presentations (Explain). Collaboration skills can be developed through discussion and creation activities. Based on the description in the background, the formulation of the problem in this study is whether there is a significant impact of the RADEC learning model with differentiated learning strategies on the mathematical communication skills of high school students in the city.

METHOD

The research conducted is an experimental research type with an intact group comparison design. This study involved two groups, namely the experimental group and the control group. The experimental group implemented learning with the RADEC learning model with a differentiated learning strategy, while the control group implemented learning with a direct instruction model.

The population of this study was all grade X SMA students in Palu City registered with DAPODIK in 2023, totaling 3656, spread across 126 study groups. The research sample of 372 people was taken from 3 schools, namely SMA Negeri 4 Palu, SMA Model Terpadu Madani Palu, and SMA Al-Azhar Palu. Sampling used a purposive random sampling technique.

The data in this study were data on students' mathematical communication skills and data on students' initial abilities. Students' mathematical communication data were collected using a written mathematical communication ability test and initial ability data were collected using an open essay test. Indicators and guidelines for scoring mathematical communication skills are as in Table 1.

Table 1. Indicators and Guidelines for Scoring Mathematical Communication Skills

Indicator	Score	Description
1). Using mathematical ideas or writing down their thoughts to find solutions, the right way to present their ideas in solving existing problems,	0	Not using mathematical ideas
	1	Using mathematical ideas but not quite right
	2	Using mathematical ideas correctly
2) Interpreting mathematical ideas in the form of images, or mathematical models,	0	No interpretation
	1	Interpreting but not quite right



	2	Interpreting correctly
3). Using representations to express mathematical concepts in writing,	0	No representation
	1	There is a representation but not quite right
	2	Representing correctly
4) Interpreting solutions found through writing,	0	No interpretation of the solution
	1	There is an interpretation of the solution but it is wrong
	2	Interpreting the solution correctly
5) Writing solutions using mathematical terms or notations appropriately to present their ideas in solving existing problems,	0	No solution written
	1	There is a solution but it is wrong
	2	Writing the solution using mathematical terms correctly

The data were analyzed using two analysis techniques, namely descriptive statistics and inferential statistics. The descriptive statistics used were mean, maximum value, minimum value, median, and standard deviation. Meanwhile, to test the research hypothesis, two-way ANOVA and prerequisite test analysis were used, namely data normality test and the data homogeneity test.

RESULTS

The results of the students' mathematical communication ability test can be seen in Table 2.

Table 2. Descriptive Statistics of Mathematical Communication Ability Data of Experimental Class and Control Class

Statistics	Experiment Class	Control Class
Many Data	186	186
Minimum score	48 (Skala 0 – 100)	38 (Skala 0 – 100)
Maximum score	100 (Skala 0 – 100)	90 (Skala 0 – 100)
Mean	76,70	62,35
Standard deviation	11,398	12,696

Based on Table 2, it can be seen that the amount of mathematical communication ability data in both class groups is 186 students each. The minimum score of the mathematical communication ability of students in the experimental class is 48 (Scale 0 - 100), while the control class is 38 (Scale 0 - 100). The maximum score of the mathematical communication ability of students in the experimental class is 100 (Scale 0 - 100), while the control class is 90 (Scale 0 - 100). The average score of the mathematical communication ability of students in the experimental class is 76.70 (Scale 0 - 100), while the control class is 62.35 (Scale 0 - 100). The standard deviation of the mathematical communication ability data of students in the experimental class is 11.980, while the control class is 12.696. Based on Table 2, it can be concluded that the impact of the RADEC learning model on the mathematical communication skills of high school students in Palu City is greater than the impact of direct instruction models. The average score of the mathematical communication skills of students who follow the RADEC learning model is 76.70. This score is greater than the average score of the mathematical communication skills of students who follow the direct instruction model, which is only 62.35.

Furthermore, to draw more general conclusions, hypothesis testing was carried out for both groups of communication ability data. Before the research hypothesis was tested, the data was first tested for normality and homogeneity.

Table 3. Normality Test of Mathematical Communication Ability Data for Experimental Class and Control Class

Class	Many Data	Kolmogorov-Smirnov Test		
		Statistics	Df	Sig.
Experiment	186	0,064	186	0,063
Control	186	0,064	186	0,060

Based on Table 3, it can be seen that in the sig. column, the significance of the RADEC learning model (experimental class) is 0.063 and the significance of the direct instruction model is 0.060. Because these values are greater than $\alpha = 0.05$, the hypothesis H0 is accepted. This means that both groups of data are normally distributed.



Furthermore, a data homogeneity test was carried out to test the two groups of data, namely the experimental class and the control class, whether they have the same variance (homogeneous). The statistics used are the Levene test. The calculation results obtained values as in Table 4.

Table 4. Homogeneity Test of Students' Mathematical Communication Skills Based on Learning Models

Variable	Based	Levene Statistics	Df1	Df2	Sig.
Mathematical Communication	Mean	1,147	1	370	0,285

Based on Table 4, the sig value is obtained as 0.285. The sig value is greater than the value of $\alpha = 0.05$. So, H_0 is accepted or H_1 is rejected. Showing that the two groups of data are homogeneous, meaning that the data on the mathematical communication skills of students taught using the RADEC learning model and the data on the mathematical communication skills of students taught using the direct instruction model are homogeneous.

After the two prerequisite tests have been met, the next step is to test the research hypothesis. The statistics used are one-way ANOVA. The calculation results using the help of the SPSS application are as shown in Table 5.

Table 5. Hypothesis Test Using ANOVA Research Hypothesis

	Sum of Squares	Dk	Mean Square	F	Sig.
Between Groups	19163,710	1	19163,710	124,898	0,000
Within Groups	56771,118	370	153,435		
Total	1873900,0	371			

Based on Table 5, the significance (sig) obtained is 0.000, so that H_0 is rejected or H_1 is accepted. So there is a significant impact of the RADEC learning model with differentiated learning strategies on the mathematical communication skills of high school students in Palu City. To find out more details about the impact of the RADEC learning model, students are grouped based on the results of diagnostic tests or initial ability tracking tests of high school students in Palu City. Students are grouped into 3 groups, namely the gifted student group, the average student group, and the challenged student group. The results of the analysis of the mathematical communication ability data test of students in the experimental class and control class based on the initial ability or diagnostic test of students can be seen in Table 6.

Table 6. Results of Descriptive Statistical Analysis of Mathematical Communication Ability Data in the Experimental Class and Control Class Based on Initial Ability Groups

Statistics	Experiment Class			Control Class		
	Gifted	Average	Challenged	Gifted	Average	Challenged
Many Data	60	66	60	60	66	60
Minimum score	50	48	52	38	40	38
Maximum score	100	98	96	90	90	84
Mean	78,57	75,48	76,17	63,17	62,33	61,537
Standard deviation	12,174	12,285	11,405	12,874	12,471	13,181

The results of the data analysis of students' mathematical communication skills show that for the group of students (gifted) who followed the RADEC learning model, they obtained a mean of 78.57 with the highest score of 100 (on a scale of 0 - 100), while gifted students who followed the direct instruction model obtained a mean of 63.17 with maximum score of 90. For the group of average students who followed the RADEC learning model, they obtained a mean of 75.48 with maximum score of 98, while average students who followed the direct instruction model obtained a mean of 62.33 with maximum score of 90.



For the group of challenged students who followed the RADEC learning model, they obtained a mean of 76.17 with maximum score of 96, while challenged students who followed the direct instruction model obtained a mean of 61.537 with the maximum score of 84. From the three groups of students, it appears that there are differences in mathematical communication skills due to differences in the learning that is followed. Students who follow the RADEC learning model always have higher communication skills than students who follow the direct instruction model. Based on the data, information was obtained that the impact of the RADEC learning model was higher than the impact of the direct instruction model based on the initial ability group of students.

Furthermore, general conclusions about communication skills based on initial abilities were drawn by testing the research hypothesis "there is a significant impact of the RADEC learning model with a differentiated learning strategy reviewed from the initial abilities of students on the mathematical communication skills of high school students in Palu City".

Table 7. Normality Test of Mathematical Communication Skills Data for Experimental Classes and Control Classes Based on Initial Ability

Class and Group Initial Ability	Many Data	Kolmogorov-Smirnov Test		
		Statistics	Degrees of Freedom (Df)	Sig.
Gifted Group Experimental Class	60	0,081	60	0,200
Average Group Experimental Class	66	0,077	66	0,200
Challenged Group Experimental Class	60	0,096	60	0,200
Gifted Group Control Class	60	0,091	60	0,200
Average Group Control Class	66	0,084	66	0,200
Challenged Group Control Class	60	0,108	60	0,081

Based on Table 7, it can be seen that in the experimental class (the class of students who follow the RADEC learning model) the gifted group has a sig = 0.200 greater than $\alpha = 0.05$, so that the data of the experimental class students in the gifted group are normally distributed. For the experimental class, the average group has a sig = 0.200 greater than $\alpha = 0.05$, so that the data of the experimental class students in the average group are normally distributed. For the experimental class, the developing group has a sig = 0.200 greater than $\alpha = 0.05$, so that the data of the experimental class students in the developing group are normally distributed. Based on Table 7, it can also be seen that in the control class (the class of students who follow the Direct instruction model) the gifted group has a sig = 0.200 greater than $\alpha = 0.05$, so that the data of the control class students in the gifted group are normally distributed. For the control class, the average group has sig = 0.200, which is greater than $\alpha = 0.05$, so that the data of students in the control class, the average group is normally distributed. For the developing control class, the average group has sig = 0.081, which is greater than $\alpha = 0.05$, so that the data of students in the developing control class are normally distributed.

Furthermore, a data homogeneity test was carried out using the Levene test, the calculation results of which are as in Table 8.

Table 8. Homogeneity Test of Student Communication Skills Data Reviewed from Initial Ability

Variabel	Based	Statistik evene	Df1	Df2	Sig.
Komunikasi	Mean	0,494	5	366	0,781

Based on Table 8, it can be seen that the degree of freedom of the group (Df1) is 5, and the overall degree of freedom (Df2) is 366, so that the sig is 0.373. Because the significance is greater than $\alpha = 0.05$, the data on students' communication skills reviewed from the initial abilities for the three data groups are homogeneous. After the two prerequisite tests have been met, the next step is to test hypothesis 4. To test the research hypothesis, a statistical hypothesis or test hypothesis is put forward, which contains two hypotheses, namely H_0 and H_1 , as follows.

H_0 : There is no significant impact of the RADEC learning model with differentiated learning strategies reviewed from the initial abilities of students on the mathematical communication skills of high school students in Palu City

H_1 : There is a significant impact of the RADEC learning model with differentiated learning strategies reviewed from the initial abilities of students on the mathematical communication skills of high school students in Palu City

The statistics used to test the hypothesis are the Two-Way ANOVA test. The calculation results are stated in Table 9.



Table 9. Results of the ANOVA Test of Students' Communication Skills Reviewed from Initial Abilities

Source	Sum of Squares	DF	Mean Square	F	Sig
Group	320,752	2	160,376	1,041	0,354
Learning Model	19232,102	1	19232,102	124,876	0,000

Based on Table 9, it can be seen that the significance in the "group" row is 0.354. This value is greater than 0.05 so that the hypothesis H_0 is accepted or H_1 is rejected. This condition indicates that there is no significant impact of the learning model in terms of the initial abilities of students on the mathematical communication skills of high school students in Palu City. In another row, namely in the "Learning Model" row, the significance obtained is 0.000, which means that there is a difference in the impact of the two learning models without looking at the division of student groups. To analyze the data, a two-way ANOVA was used; the results of the calculation of the significance of the initial ability were 0.238, while the significance of the learning model was 0.000. Because $sig > 0.05$, then the hypothesis stating that there is a significant impact of the RADEC learning model with differentiated learning strategies reviewed from the initial abilities of students on the mathematical communication skills of high school students in Palu City "is rejected. So there is no significant impact of grouping students' initial abilities on communication skills in the RADEC learning model. Grouping students based on diagnostic test results does not differ significantly in the RADEC learning model.

DISCUSSION

The results of the study indicate that there is a significant impact of the RADEC learning model with differentiated learning strategies on the mathematical communication skills of high school students in Palu City. The results of this study are in line with the statement that students who follow the RADEC learning model are able to obtain 21st century competencies such as critical thinking, creativity, collaboration, and communication (Maspiroh & Sartono, 2022). The RADEC learning model can improve communication skills (Febriyanti et al., 2023)

The RADEC learning model (Read, Answer, Discuss, Explain, Create) has a positive effect on students' communication skills through various structured mechanisms in each stage. Here is how the RADEC model affects communication skills:

1. Interactive Stages

Each stage in the RADEC learning model is designed to encourage active interaction among students, especially in the steps

- a. Read: students read the material that is the basis for the discussion, which helps them understand the context and information to be discussed.
- b. Answer: students answer questions related to the material, facilitating the expression of their thoughts.
- c. Discuss: Group discussions allow students to exchange ideas and perspectives, strengthening their listening and speaking skills (Rahmawati, 2022; Widodo et al., 2024).

2. Development of Speaking and Listening Skills

The RADEC model directly improves students' speaking skills through:

- a. Explain: At this stage, students are asked to explain the results of the discussion to their friends, this activity trains their public speaking skills and strengthens their understanding of the material.
- b. Collaborative Learning: Through discussion and group work, students learn to listen to others' opinions and respond in a constructive way (Nugraheny, 2021; Nurwendah et al., 2023; Rahmawati, 2022).

3. Improvement of Social Skills

Group learning in the RADEC model helps students develop social skills because;

- a. Students learn to communicate effectively and work together in groups. Communication skills are important skills to face challenges in the real world (Vitriasari, 2023; Widodo et al., 2024).
- b. Discussion and presentation activities encourage students to be more confident in expressing their opinions.

The results of the descriptive statistical analysis showed that the three groups of students who followed the RADEC learning model always had higher communication skills than students who followed the direct instruction model. Meanwhile, the results of the inferential statistical analysis stated that there was a significant difference in the impact of the RADEC learning model on the mathematical communication skills of high school students in Palu City. So it is concluded that the RADEC learning model has a higher impact than the direct instruction model on the mathematical communication skills of high school students in Palu City.



Furthermore, the results of the inferential statistical analysis of the comparison of the impact of the RADEC learning model with the direct instruction model based on students' initial abilities obtained a significance of 0.238. Because the significance is greater than 0.05, it is concluded that there is no significant impact of grouping students based on initial abilities on the communication skills of high school students in Palu City. These results are in line with research stating that the PBL learning model does not affect mathematical communication skills based on initial abilities (Qonaah et al., 2019), and research stating that the learning model does not affect students' mathematical understanding based on initial abilities (Davita et al., 2020). students so that this model can be implemented in classes that have heterogeneity in terms of students' initial abilities.

CONCLUSION

Based on the results and discussion, it can be concluded that the RADEC learning model with a differentiated learning strategy has a higher impact than the direct instruction model. The average score of mathematical communication skills of senior high school students in Palu city who participated in RADEC learning was 76.70 on a scale of 0 - 100, while the average score of mathematical communication skills of senior high school students in Palu city who participated in direct instruction was 62.35 on a scale of 0 - 100. No significant impact of the RADEC learning model was found based on students' initial abilities.

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