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The Effectiveness of the MBKM-Aligned Research-Based Learning Model in Enhancing Students' Problem-Solving Skills

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ABSTRACT

This study investigates the effectiveness of the MBKM-based Research-Based Learning (RBL) model in enhancing students' problem-solving skills in Madrasah Ibtidaiyah (MI) science instruction. The RBL model engages students in research-oriented activities to foster critical, analytical, collaborative, and innovative thinking. The study involved 58 students from the PGMI Study Program using a quantitative quasi-experimental design with a nonequivalent control group. One experimental and one control class were used, with data collected through observation, tests, and documentation. The objectives were to assess: (1) students' problem-solving abilities prior to the implementation of the RBL model, and (2) the model's effectiveness following its application. Data analysis included validity and reliability checks, tests of normality and homogeneity, and hypothesis testing using one-way ANOVA. Prior to the intervention, average problem-solving scores were comparable between the experimental (44.14) and control groups (44.83), indicating baseline equivalence. After implementing the RBL model, one-way ANOVA results showed a significant improvement in the experimental group's problem-solving skills ($F = 55.238$, $p < 0.001$), indicating a positive effect of the intervention. Despite its promising results, the study is limited by its small sample size, short duration, and specific focus on MI science content within the PGMI program, which may limit broader generalizability. Nonetheless, the findings support the effectiveness of the MBKM-aligned RBL model in improving students' problem-solving skills.

Keywords: *Research-Based Learning; Merdeka Belajar Kampus Merdeka; problem-solving skills; elementary science education*

ABSTRAK

Penelitian ini menyelidiki efektivitas model *Research-Based Learning* (RBL) berbasis MBKM dalam meningkatkan keterampilan pemecahan masalah siswa dalam pembelajaran IPA Madrasah Ibtidaiyah (MI). Model RBL melibatkan siswa dalam kegiatan berorientasi penelitian untuk menumbuhkan pemikiran kritis, analitis, kolaboratif, dan inovatif. Penelitian ini melibatkan 58 siswa dari Program Studi PGMI dengan menggunakan desain quasi-eksperimental kuantitatif dengan kelompok kontrol nonequivalent. Satu kelas eksperimen dan satu kelas kontrol digunakan, dengan data dikumpulkan melalui observasi, tes, dan dokumentasi. Tujuannya adalah untuk menilai: (1) kemampuan pemecahan masalah siswa sebelum penerapan model RBL, dan (2) efektivitas model

setelah penerapannya. Analisis data meliputi pemeriksaan validitas dan reliabilitas, uji normalitas dan homogenitas, dan pengujian hipotesis menggunakan ANOVA satu arah. Sebelum intervensi, skor pemecahan masalah rata-rata sebanding antara kelompok eksperimen (44,14) dan kelompok kontrol (44,83), yang menunjukkan kesetaraan awal. Setelah menerapkan model RBL, hasil ANOVA satu arah menunjukkan peningkatan yang signifikan dalam keterampilan pemecahan masalah kelompok eksperimen ($F = 55{,}238$, $p < 0{,}001$), yang menunjukkan efek positif dari intervensi. Meskipun hasilnya menjanjikan, penelitian ini terbatas oleh ukuran sampel yang kecil, durasi yang singkat, dan fokus khusus pada konten sains MI dalam program PGMI, yang dapat membatasi generalisasi yang lebih luas. Meskipun demikian, temuan ini mendukung efektivitas model RBL yang selaras dengan MBKM dalam meningkatkan keterampilan pemecahan masalah siswa.
Kata-kata Kunci: Pembelajaran Berbasis Riset; Merdeka Belajar Kampus Merdeka; keterampilan pemecahan masalah; pendidikan sains dasar

1. INTRODUCTION

Education, as a vehicle for transformation, must be capable of shaping individuals who are both contributive and innovative in responding to the rapid advancement of science, technology, and industry. The urgency of implementing research-based learning emerges as a new formulation within the *Merdeka Belajar–Kampus Merdeka* (MBKM) framework in higher education. Moreover, the changes in the MBKM curriculum demand output in learning. MBKM has a mission to realize Outcomes-Based Education (OBE) based learning, which is clearly illustrated in the graduate profile, learning process, and evaluation at the *Merdeka Belajar* level.

One of the pressing issues in today's educational landscape, despite the adoption of the MBKM curriculum, is the weak implementation of learning processes by educators in several institutions. The learning process applied so far has not been able to accommodate the development of students' problem-solving. The implementation of the learning process that takes place in the classroom is still focused on developing students' ability to memorize information, compelling students merely to recall and record information rather than encouraging them to interpret and apply it in real-life contexts (Kallet 2014).

The development of the MBKM curriculum in the PGMI study program marks an initial step toward restoring educational quality and fostering excellence among students in alignment with the competencies outlined in the Pancasila Student Profile (Aprima and Sari 2022). The MBKM curriculum grants lecturers the autonomy to select instructional tools, design learning innovations, and implement project-based learning (Dewi 2023). Based on the analysis, the research-based learning model is considered effective for realizing students' Science skills in problem solving through module development with scientific methods (Ulum 2022). Science, as one of the sciences that is closely related to nature and physics, demands systematic research and trials that determine success in learning (Rahmadina, Rohmani, and Haryadi 2024). Similarly, the findings of (Wahyuningtyas and Widiyono 2024) explain that students' critical thinking skills in Science learning can be enhanced through the development of appropriate learning models. The STEM-based Discovery Learning model, for example, has been shown to effectively sharpen critical thinking skills and foster students' character in science education.

The reconstruction of research-based learning is not a new concept in the field of education. According to (Arora, Saxena, and Gangwar 2018) Research-based learning models conceptually have the potential to enhance students' problem-solving skills. The importance of more in-depth and consistent innovation in research-based learning is emphasized in the findings of a study conducted by (Khuana, Khuana, and Santiboon 2017). The importance of deeper and more consistent innovation in research-based learning, as demonstrated by the research conducted by (Brew and Saunders 2020) through semi-structured interviews, it was found that the implementation of the research-based learning model is one of the effective strategies that teachers can apply in the learning process. This strategy incorporates research through direct experiences for students, making the learning environment active, innovative, and professional. However, this study specifically aims to evaluate the effectiveness of the MBKM-based Research-Based Learning model in the context of science learning in the PGMI study program.

The reconstruction of research-based learning is not a new concept in the field of education. According to (Arora et al. 2018), research-based learning models conceptually have the potential to enhance students' problem-solving skills. However, this study specifically aims to evaluate the effectiveness of the MBKM-based Research-Based Learning model in the context of science learning in the PGMI study program.

Initial observations conducted at PGMI in the Science course showed the following: (1) students' science teaching have not been fully integrated with students' daily lives, lacking contextualization and failing to prioritize higher-order cognitive processes (Higher Other Thinking Skills); (2) the lack of readiness of lecturers in presenting learning tools such as syllabus, strategies, lesson plans, including relevant teaching materials; (3) students are less enthusiastic about learning to experiment, which contains challenges and fulfills strong curiosity; (4) students' ability to explore Science materials is still low, students like to rely on lecturers' explanations to obtain and formulate information; (5) students still have difficulty completing written assignments and / or exams related to the ability to think, analyze arguments, evaluate and make conclusions; and (6) students are unable to collaborate / link between the context of information contained in the teaching material and their environmental conditions.

To address these issues, the implementation of a Research-Based Learning (RBL) model is proposed. This RBL model is one of the alternatives developed by the constructivism school. Research-based Learning is a learning model that leads to analysis, synthesis, and evaluation activities and increases students' abilities in terms of assimilation and application of knowledge. Research-Based Learning can change the learning atmosphere to be more active and collaborative among students, a model that accommodates the needs of students in developing new ideas, honing creativity, and creating a product from the learning process carried out.

The Research Based Learning-based learning model represents a pedagogical reform in higher education aimed at improving instructional quality and producing graduates who are prepared to meet the demands of scientific and technological advancement, as well as the complexities of the modern industrial world. This model also supports the development of 21st-century competencies, known as the 6Cs, which include communication, collaboration, critical thinking, creative thinking, computational thinking, and compassion, which must be achieved by students in order to be able to compete competitively in the world arena nationally and internationally (Monika, Julia, and Nugraha 2022).

The Research-Based Learning learning model presents learning content, creativity of learning resources, and strengthening student analysis in honing problem-solving skills, analyzing, and evaluating a problem. The teaching system is authentic problem solving with a viewpoint of problem formulation, problem solving, and communicating the benefits of research results. The results of research by Cut Erra Rismorlita et al found that research-based learning is able to increase social interaction, formulate new ideas, develop creativity and innovation, and find problem solutions or problem-solving in learning (Rismorlita et al. 2021).

The Research-Based Learning (RBL) model provides students with opportunities to develop metacognitive skills and foster critical thinking. It encourages them to make predictions, identify causal factors, and present constructive arguments. This Research-Based Learning Model has a contextualization to produce students who: (1) are able to understand basic concepts and strong methodologies in understanding material conceptually; (2) are able to solve problems creatively, logically, and systematically; (3) have a scientific attitude in seeking truth, are open, and honest in integrating; and (4) students have communication, technical, and analytical skills that are qualified to adapt, work in groups, and compete scientifically (Usmeldi 2016).

Furthermore, the operational demands of the RBL model align with the objectives and evolving framework of the *Merdeka Belajar* curriculum, which aims to develop students with higher-order thinking skills through structured phases of analysis, synthesis, and sound decision-making. These processes are expected to culminate in the creation of innovative products and discoveries that emerge from meaningful learning experiences. Freire (2000) emphasized that research-based learning transforms monotonous educational systems into critical and humanistic environments by promoting scientific inquiry and structured, purposeful thinking (Freire 2000).

Science is one of the courses well-suited to cultivating problem-solving skills through analysis and evaluation. As a core subject within the PGMI study program, Science focuses on the factual examination of natural phenomena and requires empirical evidence obtained through experimentation. The learning process in science thus necessitates the use of research-based strategies to process scientific knowledge and support informed decision-making through direct application and testing.

The implementation of the Research-Based Learning (RBL) model in science courses within the PGMI study program supports the objectives of the *Merdeka Belajar-Kampus Merdeka* (MBKM) curriculum transformation, particularly its emphasis on Outcome-Based Education (OBE). OBE focuses on achieving learning outcomes that equip students with real-world competencies to face practical challenges beyond the academic environment. In line with the statement from the Ministry of Education and Culture, the MBKM curriculum aims to foster the development of learning models that enhance students' creativity, independence, and innovation (Kemdikbud 2022). In this context, RBL serves as a relevant and strategic pedagogical approach to support higher education curriculum transformation through active student engagement in scientific research activities that effectively develop their creativity.

Moreover, the integration of the Research-Based Learning (RBL) model specifically fosters the enhancement of students' creativity by actively involving them in the processes of exploration, analysis, and the production of scientific works that are contextual and relevant to real-life situations. This approach encourages students not only to receive knowledge passively but also to engage in critical thinking, develop original ideas, and create unique innovative solutions. Continuous research activities stimulate creative problem-solving skills and strengthen students' learning independence. As a result, the learning process becomes more meaningful and consistent with the principles of Outcome-Based Education, which emphasize the acquisition of authentic competencies and preparedness for real-world challenges. Therefore, the RBL model not only strengthens students' academic abilities but also cultivates the creative and independent characteristics essential for navigating the complexities of the modern world (Ulum 2022).

Furthermore, the Research-Based Learning (RBL) model significantly supports the development of students' critical thinking skills through in-depth exploration and analysis in the creation of scientific work. It addresses students' learning needs by offering relevant and autonomous learning experiences, aligned with the principles of *Merdeka Belajar–Kampus Merdeka* (MBKM) (Sudaryanto, Widayati, and Amalia 2020) and Outcome-Based Education (OBE), which emphasizes creativity, independence, and innovation. Thus, RBL serves as an effective approach for developing critical thinking skills while optimally fulfilling students' learning requirements (Inocian and Inocian 2016).

The RBL learning model can answer the needs of MBKM curriculum development so that there is synchronization between the learning process and the applied curriculum. Applicatively, the research-based learning model is a contextual, scientific, and constructivist-based model that is processed through direct and real learning in applying the values of students' daily lives to learning content (Fadriati 2016). Science learning applications are presented through direct experiments independently and collaboratively, so that students are trained to conduct various applied research, and the learning process presents learning experiences and meaningfulness (Direktorat 2019).

Critical thinking involves the capacity to argue rationally in pursuit of truth. According to Facione, critical thinking ability is self-regulation in deciding (judging) something to produce interpretation, analysis, evaluation, and inference as a basis for making a decision (Freire, Paulo., Illich, Ivan, Fromm 2006). Critical thinking is a logical consequence of brain-based learning that involves the ability to think in responding and presenting arguments (Utomo 2017). Critical thinking skills in students must be trained continuously in order to be able to reveal the truth of information through a series of experimental activities in determining a decision to accept, deny, or reject (Llyod and Bahr 2010). The results of Fajrul's research state that students who are accustomed to being given critical thinking skills early in the curriculum have the ability to solve learning faster, because the thinking process gives students the experience to process, analyze, and find solutions directly based on cases of daily life that are scientifically observed (Bahri, 2019).

The implementation of the RBL model aligns with the broader goals of the MBKM curriculum, particularly in cultivating an independent, productive, innovative, and adaptive learning environment that keeps pace with developments in science, technology, and the industrial world (*Dunia Usaha dan Dunia Industri*, or DUDI). Furthermore, the application of the RBL model is consistent with the objectives of the National Education System Law No. 20 of 2003, Article 3, which states: "National education functions to develop abilities and shape the character and civilization of a dignified nation in order to make the nation's life more intelligent, aimed at developing the potential of participants. educate to become human beings who have faith and are devoted to God Almighty, have noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens (Sulaiman 2017).

Therefore, the application of the Research-Based Learning Model to MI Science content aims to restore the learning process to its fundamental purpose, enhancing students' problem-solving abilities and learning outcomes. The implementation of RBL has demonstrated significant differences in science learning achievements between students who are supported by critical thinking activities and those who are not. Apart from that, the research-based learning model is effective in developing active, engaging, and intellectually stimulating learning environments, where students are encouraged to innovate and create. This research-based Learning Model is able to facilitate the needs of students in the PGMI study program in strengthening MI Science learning values in the implementation of the MBKM curriculum.

2. METHOD

a. Research Design, Participants, and Sampling

The approach used in this research is quantitative with an experimental method (Quasi Experiment). The quantitative type used to reveal the data in this research is Quasi-Experimental Design with the Nonequivalent Control Group Design type, which uses one control class and one experimental class.

The technique used in determining the sample in this research is purposive sampling, a type of non-probability sampling where participants are selected based on specific characteristics that align with the research objectives rather than by random selection. This sampling method was chosen because it allows the researcher to focus on classes that have similar characteristics and are relevant to the study, ensuring that the sample accurately reflects the population targeted for the Research-Based Learning (RBL) model implementation. The samples were taken from two classes: class III A (Experimental) with 29 students and class III B (Control) with 29 students, making a total of 58 students. The research process began with administering a Pre-Test, followed by providing treatment to the experimental group using the Research-Based Learning model, and concluded with a Post-Test to evaluate the learning outcomes resulting from the application of this model.

b. Instruments and Data Collection

The data collection methods used in this study included observation, documentation, and testing. The observation was conducted directly by the researcher, who prepared an observation instrument in advance. The components observed focused on the alignment between the learning scenario and the RBL (Research-Based Learning) syntax. The RBL aspects were observed through a series of learning activities, beginning with the preliminary stage, such as formulating a general question. In the core learning activities, the observed components included: overview of research literature, defining the question, planning research activities, clarifying methods/methodologies, undertaking investigation, analyzing data, interpretation and consideration of results, and report and presentation of results. Finally, the closing activity observed was reflection.

Documentation was used to collect data related to activities during the implementation of the Research-Based Learning (RBL) model. This included documentation of the RBL implementation process, the study program profile, student data, learning support documents (such as lesson plans or RPS), and records of student involvement throughout the learning process.

The test was used to measure the extent of differences in students' problem-solving abilities before and after the implementation of the Research-Based Learning (RBL) model. The test consisted of written multiple-choice questions that were validated by experts and empirically tested prior to their use. The blueprint for the Problem-Solving Test Instrument in the MI Science material was developed based on Sub-CPMK 4: Specifically, analyzing the functions of plants. This included several indicators: the ability to explain plant descriptions (3 sub-indicators), accuracy in analyzing plant parts and their functions (3 sub-indicators), accuracy in describing plant cell structures (4 sub-indicators), accuracy in analyzing plant growth and development (3 sub-indicators), and accuracy in distinguishing plant classifications (2 sub-indicators). This instrument was designed to ensure that the assessment aligned with the intended learning outcomes and provided valid and reliable measurement of students' competencies.

c. Data Analysis Procedures

The procedure carried out before implementing the RBL learning model involved a data testing process, which included validity testing of the test items, reliability testing, analysis of difficulty level, and discriminating power. The stages conducted in the requirement testing for this research are explained as follows.

Before the test items were administered to students, they were first validated. The results of the empirical validity test were calculated using the product-moment correlation at a significance level of 5% (0.05) with the assistance of SPSS version 25. The analysis showed an R-table value of 0.443. Out of 30 test items examined, 25 were found to be valid. Based on these results, the test items were deemed appropriate for use. Instrument reliability testing aims to determine the degree of consistency of a measuring tool to be used. After calculating the reliability coefficient, the results were interpreted based on predetermined reliability criteria to assess the level of consistency of the instrument. The classification of reliability levels adopted in this study is presented in Table 1.

Table 1. Reliability Criteria

Reliability Coefficient (r11)	Criteria
$r11 \leq 0{,}20$	Very Low
$0{,}20 < r11 \leq 0{,}40$	Low
$0{,}40 < r11 \leq 0{,}60$	Medium
$0{,}60 < r11 \leq 0{,}80$	High
$0{,}80 < r11 \leq 1{,}00$	Very high

Source: (Haris 2008)

The trial involving 30 students produced a reliability coefficient (Cronbach's Alpha) of 0.894, calculated using SPSS version 25. This result suggests that the instrument has a high level of internal consistency. The complete reliability statistics are shown in Table 2.

Table 2. Reliability Statistics

Cronbach's Alpha	N of Items
. 894	30

Based on the values in the table, the instrument has a very strong coefficient, as the alpha value of 0.894 is greater than 0.60. Therefore, the test items are considered reliable. Furthermore, to ensure the quality of the test items, an analysis of their difficulty level was conducted. This analysis aims to evaluate each item based on how easy or difficult it is for students to answer, with an ideal test consisting of a balanced mix of easy, moderate, and difficult items. The criteria used to determine the difficulty level of each item are outlined in Table 3.

Table 3. Difficulty Level Categories

P value	Category
0,00 - 0,30	Difficult
0,31 - 0,70	Moderate
0,71 – 1,00	Easy

Source: (Sulistyorini 2009)

Based on the data analysis conducted, the results showed that out of the total 30 test items administered, 2 items were classified as difficult, 26 items as moderate, and 2 items as easy in terms of difficulty level.

The discrimination power of test items aims to improve the quality of each question and to determine how well each item can distinguish between students who understand the material and those who do not. Items with a discrimination index of ≥ 0.30 are considered good, while those with an index < 0.30 are considered poor. Based on the discrimination analysis calculated with the assistance of SPSS in this study, out of 30 items, 22 questions fell into the very good category, 3 questions were categorized as fair, 1 question was classified as poor, and 4 questions were deemed unacceptable.

After the requirement tests were conducted, the research process began with administering a pre-test, followed by providing treatment to the experimental group using the Research-Based Learning model, and then continued with a post-test to assess the achievements of the learning process using this model. Meanwhile, the data analysis techniques used in determining a final decision or hypothesis for this research are the normality test, homogeneity test, and hypothesis testing using one-way ANOVA.

3. RESULTS AND DISCUSSION

The This research was conducted in response to several identified problems: (1) the low problem-solving ability of students in the Elementary Science (IPA) learning process; (2) the lack of research-based activities integrated into student learning; (3) the limited experience of students in exploring research articles and integrating them into the learning process; (4) the need to equip students with specific problem-solving competencies in science-related content, including: (a) formulating general questions, (b) defining research questions, (c) planning and clarifying research methods/methodologies and conducting investigations, and (d) analyzing data; (5) students' insufficient understanding of science problems in elementary science subjects; (6) the lack of comprehensive experience in designing plans to solve specific problems; (7) the absence of opportunities for students to design actions for analyzing problems emerging in science learning; and (8) the need to develop students' skills in conducting cross-checks by comparing and reviewing decisions made during problem-solving processes (Looking Back).

Based on this context, an analysis was conducted to determine the Pre-Test scores of students in both the experimental and control classes. Student responses were scored by assigning a value of 1 for each correct answer and 0 for each incorrect one. The total scores were then calculated, converted into percentages, and classified into categories. This analysis aimed to identify students' initial abilities as well as their strengths and weaknesses in answering problem-solving questions prior to the implementation of the Research-Based Learning model. The results of the Pre-Test analysis are illustrated in Figure 1, which shows the average scores of students in both the experimental and control classes before the intervention was carried out.

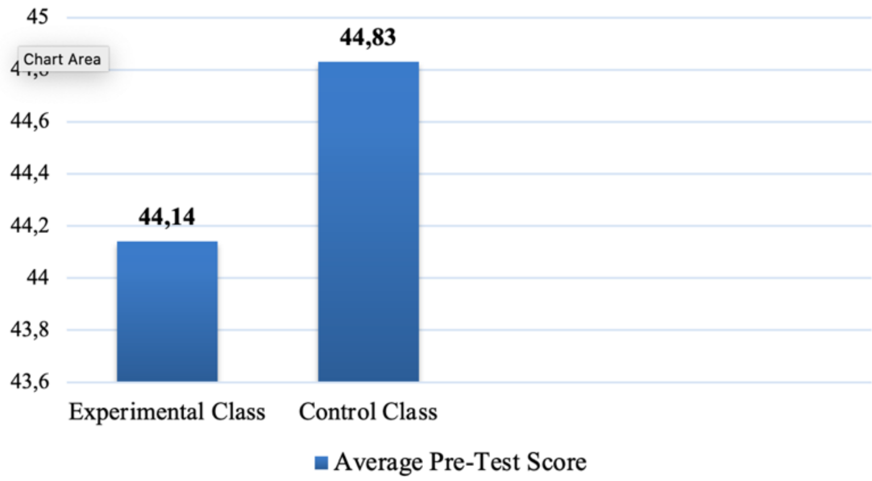

Figure 1. Average Pre-Test Score of Experimental and Control Classes

Based on Figure 1 above, it can be seen that the problem-solving ability of students in the experimental class showed an average score of 44.14 and the control class 44.83, both categorized as low, before the use of the Research-Based Learning model. These results indicate that the initial problem-solving abilities of students in both classes were relatively similar. Based on this data, the researcher determined that the Research-Based Learning model would be applied as an experimental treatment in Class III A (the experimental class), which had the lower average score.

After conducting the Pre-Test in both classes, the research-based model was implemented in the experimental class (PGMI Study Program, Class A, Semester III) during the Science (IPA) MI course. A Post-Test was then administered in both the experimental and control classes to assess students' final problem-solving abilities. The Post-Test results were used to compare the improvement in problem-solving skills between students who received the intervention and those who followed conventional instruction.

Figure 2 presents a comparison of the average Post-Test scores between the experimental and control classes, showing the impact of the Research-Based Learning model on students' problem-solving performance.

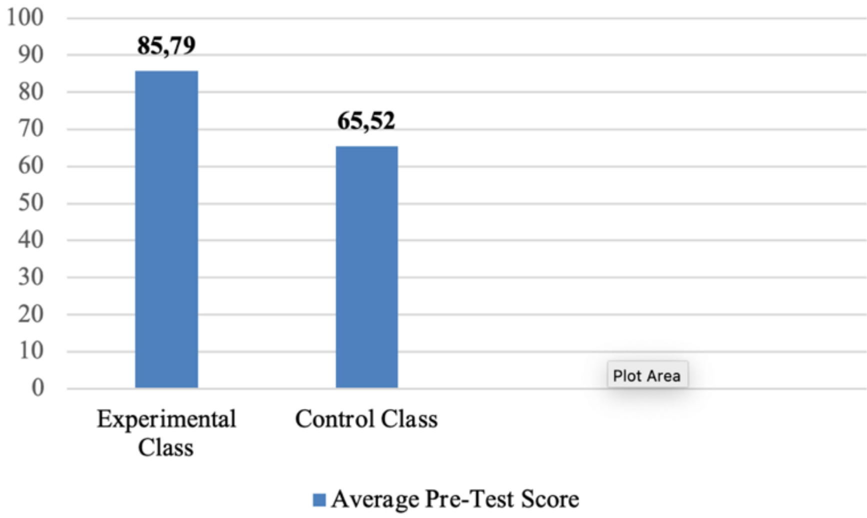

Figure 2. Average Posttest Scores of Experimental and Control Classes

Based on Figure 2 above, it can be seen that the problem-solving ability of students in the experimental class showed an average score of 85.79, while the control class reached only 65.52 after the implementation of the Research-Based Learning model. This indicates that the application of the Research-Based Learning model had a positive impact on enhancing students' problem-solving abilities compared to the conventional learning model used in the control class. To further analyze the distribution of student performance, the frequency distribution of the Post-Test scores in both classes, experimental and control in the Science (IPA) MI course is presented in Table 4.

Table 4. Frequency Distribution of Post-Test Results of Problem-Solving Ability of Experimental and Control Class Students

No.	Skor	Kelas Eksperimen		Skor	Kelas Kontrol	
		Fi	%		Fi	%
1	64-70	5	17,4	56-59	2	6.9
2	71-77	0	0,00	60-63	7	24.1
3	78-84	8	27,59	64-67	7	24.1
4	85-91	4	13,79	68-71	7	24.1
5	92-98	8	27,59	72-75	3	10.3
6	99-105	4	13,79	76-79	3	10.3
Jumlah		29	100	Jumlah	29	100
Mean		85.79		Mean	65.52	
Median		88.00		Median	64.00	
Mode		80		Mode	68	
Std. Deviation		11.493		Std. Deviation	5.699	
Range		37		Range	21	
Minimum		64		Minimum	56	
Maximum		100		Maximum	76	

Based on Table 4 above, it can be seen that the students' problem-solving abilities in the MI Science (IPA) subject taught using the Research-Based Learning model (experimental class) were higher than those in the control class, which was taught using conventional methods. This is supported by the standard deviation values: the experimental class had a higher standard deviation of 11.49 compared to 5.69 in the control class, indicating a wider but more representative distribution of scores around the mean. The average score in the experimental class was 85.79, with the highest score reaching 100 and the lowest 64, resulting in a score range of 37. These results suggest that the scores in the experimental class better reflect the characteristics of the population.

To ensure that the data met the assumptions for further parametric analysis, a normality test was conducted. The Shapiro-Wilk test was used to assess whether the data were normally distributed. If the significance value (Sig.) is greater than 0.05, the data can be considered normally distributed; conversely, if the value is less than 0.05, the data are not normally distributed. The results of the normality test conducted using SPSS version 25 are presented in Table 5.

Table 5. Results of the Normality Test of Students' Problem-Solving Abilities

Tests of Normality

	Kelas	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Posttest	Eksperimen	.135	29	.191	.901	29	.010
	Kontrol	.157	29	.067	.932	29	.062

a. Lilliefors Significance Correction

Based on Table 5 on the analysis of normality test data, it is known that the results of the Post-Test normality test of the problem-solving ability of students in the experimental class are 0.010 and for the control class it is 0.062 which is also greater than the alpha value (α = 0.005) which shows that the research data from the Post-Test results of the problem-solving ability of students in the experimental class and control class are both normally distributed.

To proceed with further statistical analysis, a homogeneity test was also conducted to determine whether the variances between the two classes are homogeneous. This test is essential to ensure that the samples used in the study originate from populations with equal variance. The homogeneity test was performed using SPSS version 25, and the results are presented in Table 6.

Table 6. Results of the Homogeneity Test of Problem-Solving Ability

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
LagY	Based on Mean	6.334	1	55	.015
	Based on Median	5.166	1	55	.027
	Based on Median and with adjusted df	5.166	1	52.090	.027
	Based on trimmed mean	6.271	1	55	.015

Based on Table 6 above, the results of data analysis in Table 4.3 show that the significant value for the variable of students' problem-solving ability is 0.015. If each significant value is compared with the alpha value (α = 0.05), it can be concluded that the data on students' problem-solving ability is homogeneous.

After confirming that the data were both normally distributed and homogeneous, a one-way ANOVA test was conducted to determine whether there were significant differences in students' problem-solving abilities before and after the application of the MBKM-based Research-Based Learning model. The ANOVA test was performed using SPSS version 25, and the results are presented in Table 7.

Table 7. One-Way ANOVA Test of Problem-Solving Ability

ANOVA

LagY

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5266.065	1	5266.065	55.238	.000
Within Groups	5243.409	55	95.335		
Total	10509.474	56			

Based on the data in Table 7 above, it can be seen that the results of the One-Way Anova test show that there is a significant difference between students' problem-solving abilities before and after being given treatment using the Research-Based Learning

learning model implemented, where the results were obtained ($F = 55.238$, $p = 0.00$). This shows that the treatment of using the Research-Based Learning learning model based on MBKM on the MI Science (IPA) material in the PGMI Study Program is effective in improving students' problem-solving abilities.

a. Students' Problem-Solving Ability Before Using the Research-Based Learning Model

Based on the results of the Pre-Test conducted on the experimental and control classes, it shows that students in the experimental and control classes initially have the same problem-solving abilities, where the average Pre-Test results in the experimental class were only obtained at 44.14 with a less category, and the control class 44.83 with a less category. This means that before using the Research-Based Learning learning model, students did not have adequate abilities in terms of problem solving.

Based on the results of the Pre-Test, the researcher then conducted an experiment using the Research-Based Learning model, which was predicted to be effective in improving students' problem-solving abilities. At the time of the Post-Test, the problem-solving abilities of the experimental class were higher in the Post-Test compared to the results of the problem-solving abilities of students in the control class.

The use of the Research-Based Learning (RBL) model has proven effective in enhancing students' problem-solving abilities by actively involving them in the process of inquiry and knowledge construction. In the context of PGMI, RBL contributes uniquely to the development of science learning by fostering scientific literacy, critical thinking, and the ability to conduct simple research-essential competencies for prospective elementary school teachers. This aligns with the objectives of the *Merdeka Belajar-Kampus Merdeka* (MBKM) program, which emphasizes student autonomy, interdisciplinary learning, and real-world engagement.

The research findings indicate that curricula overly focused on cognitive concept mastery through linear, rote, or procedural learning approaches tend to overlook the development of students' creativity, because such approaches prioritize the reproduction of knowledge over the exploration of diverse solutions and original thinking, which are essential for solving complex and ill-structured problems(Van Hooijdonk et al. 2024).

By integrating RBL into science education, PGMI not only prepares students to be active learners but also equips them to implement inquiry-based approaches in their future classrooms (Uzezi and Jonah 2017) emphasizes that RBL cultivates essential skills such as critical thinking and problem-solving through authentic research activities. Similarly, international studies (Ahdika 2021) highlight RBL as a high-impact educational practice that bridges the gap between teaching and research, while (Rahman et al. 2022) confirms its role in improving knowledge application, research skills, and scientific communication. Thus, RBL is not only effective but also highly relevant for supporting the MBKM vision of producing independent, innovative, and research-oriented graduates.

Although the success of Research-Based Learning (RBL) demonstrates its ability to foster students' critical understanding and accelerate content mastery, this study still reveals limitations in cultivating genuine learner autonomy. This shortcoming may be attributed to the lack of explicit strategies in guiding students to manage their time, set learning goals, and evaluate their own learning processes and outcomes (Andersen and Rustad 2022).

In this Research-Based Learning model, students have an initial understanding of the existence of research and observation experiments in groups (teams) to provide students with experience in critical, analytical, and evaluation thinking. Healey & Jenkins, stated that "Research-based learning experiences play a crucial role in developing students' critical and analytical thinking skills, enabling them to identify problems, analyze data, and develop innovative solutions". Research-based learning plays an important role in developing students' critical and analytical thinking skills because, through research experiences, students are trained to identify problems, analyze data, solve complex problems, evaluate information, and develop logical thinking and creative solutions.

The Research-Based Learning model provides students with experience in raising questions during the learning process. This is in line with the opinion of Mahmood, who explains the importance of question-and-answer sessions in the learning process: "The questioning session is the most important time in the learning process. Questions of students from teachers and also questions of teachers from students are necessary for better learning". (Mahmood et al. 2013) Question and answer sessions are an important aspect of the learning process. The availability of time given by lecturers to ask questions to students can improve the learning process. This activity will quickly affect students' thinking skills in reasoning critically, analytically, and generating new innovations in the learning process.

Effective questions are important to apply to create a critical and challenging learning environment for students. In line with Chin, who stated that, "Effective questioning fosters critical thinking, deep learning, and intellectual growth. It enhances academic success, promotes curiosity, and improves learning outcomes. Cultivating questioning skills is vital for academic achievement and lifelong learning". Effective questions facilitate critical thinking, deep learning, and intellectual growth. This increases academic success, arouses curiosity, and improves learning outcomes. Developing questioning skills is essential for achieving academic success and lifelong learning.

Besides that, the research findings also reveal that the Research-Based Learning (RBL) model offers significant advantages because teachers actively involve students in the research process, which demands critical and creative thinking. Through RBL, students not only sharpen their reasoning skills but are also trained to generate original ideas and innovative solutions when facing complex and unstructured problems. (Moh salimi, Tri saptuti susiani 2017). Thus, RBL effectively develops comprehensive problem-solving abilities by combining both logical and creative aspects, which are essential for addressing real-world challenges in education and everyday life.

Through research experiences, students learn to accurately identify problems, formulate hypotheses, and explore various solutions using logical and creative approaches (Ichsan et al. 2023). This method combines sharp questioning skills with in-depth analysis in the context of solving real-world problems.

b. Effectiveness of Research-Based Learning Model on Students' Problem-Solving Ability

Based on the results of the hypothesis testing, it can be seen that the use of the Research-Based Learning learning model is effective in improving students' problem-solving abilities, meaning that there is a difference in students' problem-solving abilities in the experimental class and the control class. In the experimental class, the Research-Based Learning learning model was applied and obtained higher problem-solving results than students who were taught using conventional learning models.

In the control class, students during the learning process only received centralized information from lecturers without any creativity, which required them to be active in processing the material during the learning process. Sumbawati in her statement emphasized, "The benefits of RBL for undergraduate students include (1) student interest in knowledge, (2) confidence, (3) learning spirit, (4) learning achievement, (5) motivation and enthusiasm, (6) interest in continuing studies to a higher level, (7) and problem-solving skills. Students who actively participate in the learning process encourage research ideas which, if acted upon, will result in publication". It can be interpreted that students who are given research experience have a big impact on increasing interest and enthusiasm for learning, self-confidence, achievement, motivation, and problem-solving skills, as well as encouraging research publications and student self-development.

It is proven that the experimental class that was given problem-solving ability treatment using the Research-Based Learning model obtained a higher Post-Test score of 85.79 than the control class, 65.52. These data indicate that the use of the Research-Based Learning model is more effective than the conventional learning model. The difference is also shown from the results of the One-Way Anova test, which shows a significant difference where the results obtained ($F = 55.238$, $p = 0.00$), indicating that the use of the Research-Based Learning model is effective in improving students' problem-solving abilities.

In line with the findings of (Brew and Saunders 2020), the implementation of Research-Based Learning (RBL) has been shown to be effective in developing students' critical thinking skills, as evidenced by their abilities in interpretation, analysis, evaluation, inference, and explanation. However, research findings indicate that the implementation of the RBL model among lecturers is often based on personal experience, resulting in inconsistencies in achieving learning objectives, particularly in the development of student learning autonomy (Wan et al. 2024). Therefore, to ensure the effectiveness of the RBL model, a standardized and uniform application is necessary.

The effectiveness of using the Research-Based Learning model during learning can also be seen from the change in students' mindsets, which are increasingly critical and analytical in identifying and solving problems when conducting mini-research, observations, and experiments in class. Through this ability, students can find optimal solutions in solving complex problems, making the right, effective, and evidence-based decisions, and making new discoveries in the learning process. In line with the statement by Srikoon, "Research-based learning can improve students' skills in solving problems, thinking critically, and finding new knowledge. Research-based learning can improve students' skills in solving problems, thinking critically, and finding new knowledge. Likewise, Usmeldi explained, “The research-based learning is effective in improving the mastery of physics concepts and students' generic abilities”. The Research approach is very effective in improving students’ mastery of physics material concepts and generic abilities (Usmeldi, Amini, and Trisna 2017). Strengthened by Walkington's opinion (2011 that "Research-based learning can increase students' curiosity about the subject matter". This means that research-based learning can increase students' curiosity about the material being studied.

However, several studies indicate that certain aspects of learning, such as self-regulation abilities, have not yet developed optimally through the implementation of RBL (Saptuti Susiani, Salimi, and Hidayah 2018). Although students demonstrate progress in critical thinking and problem-solving, their ability to manage independent learning processes still requires strengthening through more specific and sustained interventions.

Through critical thinking, creativity, and problem-solving skills, students can realize deeper, meaningful learning. Biggs & Tang “The meaningful learning outcomes of RBL include authentic learning experiences, real life connections, and academic identity development, recognize the connection between knowledge and practical applications, and develop their researcher and learner identities” through Research Based Learning, meaningful learning can be obtained by students with authentic learning experiences, direct connections with real life, connecting knowledge with real applications, and developing identities as researchers and learners.

Moreover, the implementation of the Research-Based Learning (RBL) model can enhance lecturers' competencies in cultivating students’ teamwork and collaborative problem-solving skills. This, in turn, positively impacts the development of students’ social and cognitive competencies by fostering an inclusive and challenging learning environment (Anchunda and Kaewurai 2025).

The successful implementation of RBL also requires innovative supporting media, as well as contextual and interactive activities throughout the learning process to maximize the development of students' thinking skills and problem-solving abilities (Brew and Saunders 2020). Nevertheless, the RBL model demands an integrated assessment approach that comprehensively evaluates creative thinking and problem-solving skills (Ichsan et al. 2023).

As a research lecturer, I also feel the benefits of implementing the Research-Based Learning model. The learning process becomes more active, effective, and challenging for students because research activities provide experience to experiment in the field. The time needed by students in the experimental class to understand the material is faster compared to students who are taught with conventional learning models. This reality occurs because students who are taught with the Research-Based Learning model have previously had an initial understanding of the opportunity to ask questions, given, and the activity of tracing information from various research results that provide a lot of information for students.

Overall, although the RBL model and related instructional approaches hold significant potential to enhance the quality of learning and student skills, their successful implementation largely depends on teachers' readiness to holistically manage pedagogical aspects and the learning context. Research by (Van Hooijdonk et al. 2024) states that teachers must be able to integrate instructional strategies that support the development of students' cognitive, affective, and metacognitive domains in order to optimally achieve the goals of 21st-century education.

4. CONCLUSION

The problem-solving ability of students before using the Research-Based Learning model in the experimental class showed an average of 44.14, and the control class 44.83. This shows that the problem-solving ability of students before using the Research-Based Learning model in both the experimental and control classes is the same. Based on the results of the One Way Anova test, it shows that there is a significant difference between students' problem-solving abilities before and after being given treatment using the Research-Based Learning learning model, which was implemented, where the results were obtained ($F = 55.238$, $p = 0.00$). This shows that the treatment of using the Research-Based Learning learning model based on MBKM for Science (IPA) MI material in the PGMI Study Program is effective in improving students' problem-solving abilities.

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