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Students' Problem-Solving Ability through Problem-Based Learning and Ricosre Learning Model in Modern Biotechnology

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ABSTRACT
Problem-solving abilities is important to master so that students can analyze problems, evaluate scientific information, and make decisions based on data. Problem-solving ability can be empowered through interactive learning models. This study aims to determine students' problem-solving ability differences with the Problem-Based Learning model and the Ricosre model on modern biotechnology material. This study used a quasi-experimental research method with a pretest-posttest control group design conducted at SMAN 3 Sukoharjo. The instruments used in this study were problem-solving ability test questions, observation sheets, and student interviews. The results showed a difference in problem-solving ability in classes with PBL and Ricosre models based on the Ancova test results of 0.00. Furthermore, the N-Gain test found that the Ricosre model resulted in an increase in students' problem-solving ability of 0.556 which is classified as moderate is higher when compared to the Problem-Based Learning model, which resulted in an N-Gain test value of 0.361 which is classified as moderate. These findings confirm that the Ricosre learning model is effective in improving students' problem-solving abilities and can be applied to other science subjects in secondary schools and universities because this model involves discovering alternative strategies based on prior experiences gained through intensive discussion and repeated problem-solving, there by familiarising students with problem-solving that promotes the mastery of 21st-century skills.

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1. INTRODUCTION

Changes in 21st-century education that occur require students to have 21st-century life skills to face global competition. In 21st-century learning, learning activities not only focus on knowledge but also skills. Based on the ATCS (Assessment and Teaching for 21st-Century Skills), the three main topics of 21st-century skills are life skills, ways of thinking, and work tools (Griffin & Care, 2015). Learners must have one of the three 21st century skills, namely problem-solving ability. Problem-solving ability are included in the way of thinking 21st-century skills that are very important to use in work, learning, and daily life in the amid of advancing times (Lu & Xie, 2024).

The importance of problem-solving ability is inversely proportional to the condition of the mastery level of students in Indonesia (Sutrisno & Kharisudin, 2020). A research survey conducted by the Organization for Economic Co-operation and Development (OECD) shows that the problem-solving ability of students in Indonesia on the Programme for International Student Assessment (PISA) is ranked 70 out of 80 countries in the world which is in a very low category (OECD, 2022). In this study, researchers conducted problem-solving ability tests at a senior high school in Sukoharjo, which showed that students' problem-solving abilities were still in the low category. In line with research by Magfhira et al.(2025), Elvianasti et al. (2022), and Simatupang & Ionita (2020) which states that students have low problem-solving ability, so they cannot find the right solution.

The development of problem-solving ability requires a learning model that supports learners to identify problems correctly to produce creative solutions and implement strategies effectively (Adeoye & Jimoh, 2023).

One of the applications of problem-solving-based learning models is Problem-Based Learning. Learners are required to conduct collaborative learning in identifying, applying, and reflecting on their new knowledge of problems with effective strategies to improve problem-solving ability (Yew & Goh, 2016). However, students still find it difficult to adapt to Problem-Based Learning due to limited initial experience in exploring the material independently and requiring high-level critical thinking ability, so that students have not been able to develop the problem-solving ability they should have (Wijnia et al., 2024).

The development of science creates various solutions to the problems faced in the world of education, one of which is related to the limitations of early experience through exploration of knowledge to develop problem-solving ability by improving critical thinking ability. Improving problem-solving ability in students can be done in various ways, one of which is through the application of the Ricosre learning model (Mahanal & Zubaidah, 2017). The Ricosre learning model is a problem-based model to improve students' critical thinking skills through detailed problem-solving activities (Mahanal et al., 2019). The Ricosre syntax is the result of a combination and development of several learning syntaxes from Polya (1973), Dewey (1993), and Krulik & Rudnick (1988). The Ricosre learning model is an acronym for the syntax of the learning model, which includes Reading (Providing initial experiences), Identifying the problem (Providing problems), Constructing the solution (Creating various solutions to problems), Solving the problem (Implementing the selected strategy), Reviewing the solution (Intensive discussion through debate), and Extending the solution (Solving similar problems) (Mahanal & Zubaidah, 2017). The Ricosre learning model, which requires students to think systematically, provide initial experience, solve problems slowly, and in detail, can be used as an alternative to improve problem-solving ability (Mahanal et al., 2022).

Biotechnology is a science that requires an understanding of the concept of sufficient material, most of which is the application of science, is multidisciplinary, and always undergoes development to improve the quality of human life (Larasati & Syamsurizal, 2022). Learners experience difficulties in biotechnology material. After all, it is a relatively difficult science always experiences complex developments, raises many debates related to morals and ethics, complex understanding, and difficulty in reasoning and remembering the concepts of modern biotechnology material (Todd & Murphy, 2003 and Jumain et al., 2022). Learners are required to have problem-solving ability, be critical, and be able to determine the right solution for the benefit of the wider community in modern biotechnology material, so that this material is relevant to be used for content in improving problem-solving ability.

However, previous studies related to the Ricosre learning model have placed more emphasis on critical thinking skills, thus not focusing solely on problem-solving abilities. In addition, modern biotechnology material is still rarely studied in depth for use in improving problem-solving abilities. Based on this description, research is needed to examine the differences in the application of the Problem-Based Learning and Ricosre learning models in improving students' problem-solving abilities with modern biotechnology material. Therefore, the research with the title "Students' Problem-Solving Ability through Problem-Based Learning and Ricosre Learning Model in Modern Biotechnology" is expected to provide an overview of the differences in students' problem-solving abilities in both problem-based learning models to develop 21st-century skills in the form of students' problem-solving abilities.

2. RESEARCH METHOD

This research design is a quasi-experiment. The research was conducted over three sessions for each class, with each session estimated to last 90 minutes. The biotechnology topics covered in the research included DNA fingerprinting, bioremediation, aquaculture, biopesticides, modern artificial insemination, and insulin. The population in this study was grade XII students at SMAN 3 Sukoharjo, with sampling techniques using cluster random sampling, namely random selection of samples from three classes whose biology scores from the odd semester final exams had undergone normality and homogeneity tests and were declared normal and homogeneous. Thus, the research samples were grade XII F1A as the control class and XII F1B as the experimental class. The data collection technique was done by problem-solving ability test and observation. The problem-solving ability test is in the form of pretest and posttest questions in the form of essays. All instruments used in this study have been validated by several experts as well as validity tests, reliability tests, question differentiator tests, and item difficulty tests. The problem-solving ability test instrument is adjusted to the problem-solving indicators presented in Table 1.

Table 1. Indicators of Problem-Solving Ability

Aspects of Problem-Solving Ability	Indicator
Understanding the Problem	a. Identify the main cause from the many causes presented in the problem b. Checking for causality in the problem c. Examine the difficulty and severity of the problem at hand d. Checking problem solutions that have been implemented
Devising the Plan	a. Determine the problem to be solved by making a list of problems b. Developing problem-solving strategies c. Mapping problems and solutions d. Determine the theory used in problem-solving e. Sequencing the steps or flow of problem-solving f. Conjecture the outcome of the problem-solving process
Carrying Out	a. Implement the strategy that has been made to solve the problem
Looking Back	a. Rechecking the solution to the problem that has been made before b. Make predictions about other solutions to solve the problem

Source : (Polya, 1973)

The results of the research instrument validity test are presented in Table 2.

Tabel 2. Instrument Validity Test Results

Assessment	Aspect	r_{hitung}	r_{tabel}	Description
Pretest	*Understanding 1*	0,595	0,361	Valid
	Understanding 2	0,608	0,361	Valid
	Devising 1	0,673	0,361	Valid
	Devising 2	0,457	0,361	Valid
	Carrying out 1	0,611	0,361	Valid
	Carrying out 2	0,641	0,361	Valid
	Looking back 1	0,732	0,361	Valid
	Looking back 2	0,666	0,361	Valid
Posttest	*Understanding 1*	0,640	0,361	Valid
	Understanding 2	0,740	0,361	Valid
	Devising 1	0,673	0,361	Valid
	Devising 2	0,855	0,361	Valid
	Carrying out 1	0,722	0,361	Valid
	Carrying out 2	0,724	0,361	Valid
	Looking back 1	0,717	0,361	Valid
	Looking back 2	0,460	0,361	Valid

The results of the item validity test presented in Table 3.6 show that the problem-solving ability test instrument can be declared valid and can be used in this study because all items have a calculated r value > r table.

The results of the reliability test of the research instrument are presented in Table 3.

Table 3. Instrument Reliability Test Results

Assessment	N of items	Cronbach's Alpha	Description
Pretest	8	0,767	*Reliable*
Posttest	8	0,840	*Very Reliable*

The reliability test results presented in Table 3 show that the problem-solving ability test instrument produced Cronbach's Alpha values of 0.767 and 0.840, indicating that it is reliable and highly reliable and can be used for research.

Quantitative data in this study were obtained from the pretest and posttest scores of students' problem-solving ability. The test results of students' problem-solving ability will be assessed using a rubric for problem-solving ability. The percentage of students' problem-solving ability scores is categorized into several levels presented in Table 4.

Table 4. Interval Categories of Problem-Solving Ability

Percentage (%)	Category
81 ≤ P ≤ 100	Very High
61 ≤ P ≤ 80	High
41 ≤ P ≤ 60	Middle
21 ≤ P ≤ 40	Low
0 ≤ P ≤ 20	Very Low

Source : (Prapti et al., 2023)

The criteria for improving problem-solving ability with the N-Gain test are presented in Table 53.

Table 5. Interval Category of N-Gain Score

Percentage (%)	Category
g < 0,30	Low
0,30 ≤ P ≤ 0,70	Moderate
g < 0,70	High

Source : (Hake, 1998)

The data in this study are in the form of test scores, which then the data will then be processed by hypothesis testing using the Ancova test and the N-Gain test, provided that it has been normally distributed and homogeneous, by going through the normality test and homogeneity test. The Ancova test was used to determine differences between groups related to research data after being declared normally distributed and homogeneous by controlling for confounding variables (covariates) (Montgomery, 2022). The data criteria for the Ancova test are that if the statistical test results obtained show a significance value (Sig.) of less than 0.05, it can be stated that there is a significant difference between the two research groups. The N-Gain test was conducted by calculating the value before and after treatment by looking at the results of the increase that occurred due to the application of the learning model. Then, the test results were analyzed and reviewed in the literature study.

3. RESULT AND DISCUSSION

The results showed that students with the application of the Ricosre learning model had a higher average value of problem-solving ability compared to the application of the Problem-Based Learning model. The increase in students' problem-solving ability can be seen from the results of the average value of the students' problem-solving ability test in the Problem-Based Learning model of 18,44 and in the Ricosre model of 26,89.

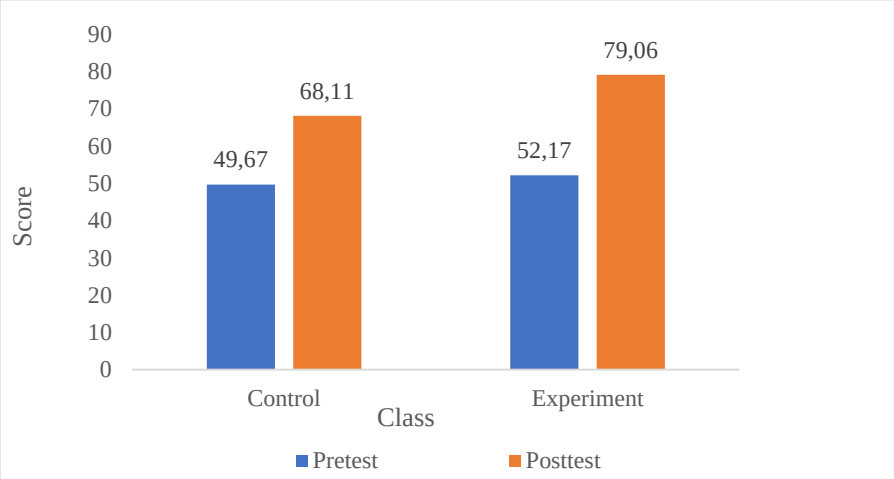

Figure 1. Average Value of Students' Problem-Solving Ability

Based on Figure 1, the problem-solving ability test scores show that the improvement of students' problem-solving ability with the application of the Ricosre model is higher than with the application of the Problem-Based Learning model. The description of pretest and posttest data of students' problem-solving ability is presented in Table 4.

Table 6. Data Description of Students' Problem-Solving Ability

Statistik Results	*Pretest*		*Posttest*	
	Control	**Experiment**	**Control**	**Experiment**
N	36	36	36	36
Mean	49,67	52,17	68,11	79,06
Std. Deviation	7,309	6,597	6,786	6,607
Variance	53,429	43,514	46,044	43,654
Minimum	34	38	56	63
Maximum	66	66	81	91

Based on Table 6, the pretest and posttest scores in the experimental class show a variance of 53.429 and 46.044 and a standard deviation of 7.309 and 6.786. In the experimental class, the pretest and posttest scores have a variance of 43.514 and 43.654 and a standard deviation of 6.597 and 6.607. Based on these data, the control class has a standard deviation and variance value that is greater than the experimental class which proves that the control class has a value of problem-solving ability with a wide and even distribution based on the average value of the pretest and posttest in the control class when compared to the experimental class. To find out the differences in students' problem-solving ability with the application of the Problem-Based Learning model, hypothesis testing was carried out, which began with normality and homogeneity tests.

The results of the prerequisite test, with the normality test and homogeneity test of pretest and posttest data on students' problem-solving ability have been declared normally distributed and homogeneous, so that the Ancova test can be carried out because the conditions have been met.

Table 7. Ancova Test Result of Students' Problem-Solving Ability

Data	Sig.	Criteria
Pretest & Posttest	0,00	Sig. < 0,05

Based on Table 7, the significance value of the ancova test results on student problem-solving ability test data is 0.00. This proves that the significance is smaller than 0.05, so that the results of the posttest value of students' problem-solving ability between the two sample classes are declared to have a significant difference. Test scores that are significantly different indicate that the experimental and control classes have different problem-solving abilities after being treated. Based on this description, it can be stated that the increase in students' problem-solving ability is influenced by the application of the Ricosre learning model.

The N-Gain test used to determine the effectiveness of the Ricosre and Problem-Based Learning learning models on improving students' problem-solving ability is presented in Table 6.

Table 8. N-Gain Test Results of Students' Problem-Solving Ability

Class	N-Gain		
	Mean	***Minimum***	***Maximum***
Problem-Based Learning	0,361	0,125	0,620
Ricosre	0,556	0,200	0,842

Based on Table 8, the control class produces an N-Gain value of 0.361 which is included in the moderate group with the lowest improvement value of 0.125 and the highest value of 0.620. The experimental class produces an N-Gain value of 0.556 which is included in the medium group with the lowest improvement value of 0.200 and the highest value of 0.842. The average value, the lowest value, and the highest value of the N-Gain test results in the experimental class are higher than the control class, which indicates that the application of the Ricosre model is effective in improving students' problem-solving ability with a moderate category.

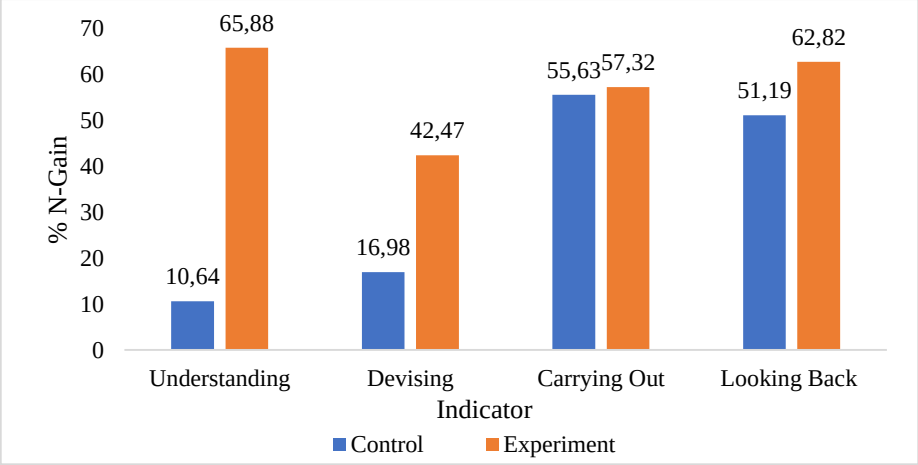

Figure 2. Percentage of Improvement in Students' Problem-Solving Ability

Problem-solving ability as an indicator of understanding the problem, requires students to identify the problem and recognize important information in the problem. The results of the value of students' problem-solving ability on the indicator of understanding the problem show that the percentage of improvement in students' problem-solving ability in the experimental class is 65.88% which is classified as moderate while the percentage of improvement in students' problem-solving ability in the control class is 10.64% which is classified as low. The percentage value of improving the problem-solving ability of the experimental class is higher because the syntax of reading and identifying the problem in the Ricosre model is connected to the indicator of understanding the problem. Reading materials provided related to scientific articles on stem cells, vaccines, biofuels, bacterial bioremediation, DNA fingerprinting, recombinant DNA, golden rice, tissue culture, aquaculture, transgenic animals, cloning, and artificial insemination. In line with research, Vilenius-Tuohimaa et al. (2008) states that there is a correlation between students' understanding and reading ability because students can understand a problem, convert knowledge into an alternative answer, select the necessary information, and find a problem solution. Based on research from Ghafar (2024), which states that students experience significantly improved reading comprehension through engagement in debate, so that they are more adept at understanding unfamiliar terminology and new ideas. In addition, learners are also involved in the critical thinking process in problem identification activities through data processing and data evaluation so as to produce the right understanding of the problem (Webb et al., 2021).

Problem-solving ability in devising the plan indicator requires students to connect the problem with previous experience or knowledge to predict the right strategy to solve the problem. The results of the value of students' problem-solving ability on the devising the plan indicator show that the percentage of improvement in students' problem-solving ability in the experimental class is 42.47% which is classified as moderate while the percentage of improvement in students' problem-solving ability in the control class is 16.98% which is classified as low. The percentage value of improving the problem-solving ability of the experimental class is higher because students carry out strategic planning activities that will be used to solve problems coherently and systematically. In line with research Mahanal et al. (2022), which states that the Ricosre model requires students to build solutions through planning that associates the knowledge they have with details, details, and systematically. Targeted solution planning that provides many strategic options helps students connect their prior knowledge with new knowledge, thereby encouraging flexible and creative thinking in determining alternative solutions (Mahanal et al., 2019). Thus, Ricosre contributes to improving problem-solving skills.

Problem-solving ability in carrying out the plan indicator requires students to apply the chosen strategy in detail and systematically as a solution to the problem by exchanging arguments. In this research, learners conduct investigations related to solutions that have been chosen based on conjectures and assumptions in the previous stage to determine problem solving strategies related to murder cases in Subang, river pollution in Sragen due to batik waste, seeds and pests that threaten potato production in Wonosobo, and the tuna reproduction crisis that can threaten ecosystems and the national fishing industry. The results of the value of students' problem-solving ability on the carrying out the plan indicator show that the percentage of improvement in students' problem-solving ability in the experimental class is 55.63% which is classified as moderate while that the percentage of improvement in students' problem-solving ability in the control class is 57.32% which is classified as moderate. The percentage value of improving the problem-solving ability of the experimental class is higher because students are actively involved in the cognitive process of problem solving through arguments and reviewing the solutions used to determine the best solution. In line with research Badriah et al. (2023) which states that students in the Ricosre model are required to develop problem-solving ability through information gathering, analysis, classification, accuracy of solution making, and scientific reasoning that focuses on

processing information efficiently and in detail, making accurate decisions, and forming complete ideas through group discussions.

Problem-solving ability on the looking back indicator requires students to review, evaluate, and reflect on the chosen solution and alternative solutions to be applied again to other problems. The results of the value of students' problem-solving ability on the looking back indicator show that the percentage of improvement in students' problem-solving ability in the experimental class is 62.82% which is classified as moderate while the percentage of improvement in students' problem-solving ability in the control class is 51.19% which is classified as moderate. The percentage value of improving the problem-solving ability of the experimental class is higher because the syntax of reviewing the problem solution and extending the problem solution in the Ricosre model is connected to the looking back indicator. At the debate stage, each of the two groups will debate the motion that has been determined. Each group will be divided into pro and con groups on the debate motions about the accuracy of identifying criminals using DNA fingerprinting, handling river waste without using bioremediation, the use of pesticides in dealing with pests in potato plants, and the effectiveness of aquaculture. In line with the research of Badriah et al. (2023) which states that students in the Ricosre learning model are required to develop problem solving skills through information gathering, analysis, classification, accuracy of solution making, and scientific reasoning that focuses on processing information efficiently and in detail, making accurate decisions, and forming complete ideas. Students not only defend the solutions they have found, but also assess the strengths and weaknesses of their arguments and compare them with the opinions of others . Students also actively involved in debates tend to acquire broader knowledge and improve strategic abilities (Rahmawati et al., 2021). In addition, expanding solutions by familiarizing learners with Problem-Based Learning will anable them to anticipate and overcome similar problems with appropriate and more efficient solutions (Mahanal et al., 2022). Learners who are accustomed to the problem-solving process will potentially improve their problem-solving ability Students who are accustomed to problem-solving through similar problem-solving tasks will potentially improve their problem-solving skills (Aisa et al., 2023).

The Ricosre model stimulates learners with detailed and systematic problem-solving activities. Learners are given real-world problems to find solutions through the discussion process. The discussion is carried out to discuss some conjectures and assumptions from each group member that will be used as a draft problem-solving solution. After each group determines the problem solution, a debate will continue which makes each learner exchange information and evaluate the selected problem-solving solution. Furthermore, learners again solve similar problems so that they can get used to the problem-solving process. The Ricosre learning model is in line with Piaget and Vygotsky's constructivist theory, which emphasises that knowledge is actively constructed through experience, social interaction, and reflection. Core Ricosre activities such as discussions, debates, and reflection support the formation of meaning both independently and collaboratively. This is research by Mahanal & Zubaidah (2017) and Mahanal et al. (2019) that the Ricosre learning model directs students' problem-solving process to be more systematic and detailed, to make it easier for students to find the right solution and familiarize students with problem-solving activities. The results of this study are in line with the research by Mahanal et al. (2022), which states that the Ricosre learning model can consistently improve students' problem-solving abilities. Additionally, research by Azrai et al. (2022) and Badriah et al. (2023) also shows that the Ricosre learning model plays a role in simplifying students' complex thinking processes regarding problems through a series of systematic activities, thereby producing effective and efficient solutions.

4. CONCLUSION

The results of the study can be concluded that the application of the Ricosre model has great potential in improving students' problem-solving ability compared to the Problem-Based Learning model. This is evidenced by the average test score of students' problem-solving ability with the application of the Ricosre model is higher than that of students with the application of the Problem-Based Learning model. In addition, the hypothesis test states that there is a difference in students' problem-solving ability with Problem-Based Learning and Ricosre learning models because it produces an Ancova test value of 0.00, with the most effective model in improving students' problem-solving ability being the Ricosre model, because it produces an N-Gain test value of 0.556 which is classified as moderate which is higher when compared to the Problem-Based Learning model, which produces an N-Gain test value of 0.361, which is classified as moderate. Research related to the application of the Ricosre learning model needs to be expanded to several schools and applied at the university level. It can also be studied in greater depth among 10th grade secondary school students to introduce them early on to the rapid development of modern biotechnology so that they can keep up with the times.

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