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# Enhancing problem-solving and collaborative skills through RICOSRE learning model: A socioscientific approach in physics education

**Rahma Diani**
UIN Raden Intan Lampung, INDONESIA

**Bambang Sri Anggoro**
UIN Raden Intan Lampung, INDONESIA

**Eny Retno Suryani**
UIN Raden Intan Lampung, INDONESIA

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**Abstract**

**Background:** Problem-based learning fosters critical thinking by requiring students to analyze information, evaluate solutions, and make well-judged decisions, thereby enhancing their problem-solving skills.
**Aim:** The study aims to assess the impact of the RICOSRE learning model, which is based on socioscientific issues, on students' problem-solving and collaboration skills.
**Method:** Quasi-experimental research was used in this research involving students in classes XI MIPA 2 and XI MIPA 3. Purposive random sampling was used to select participants. Data were collected using test and non-test instruments: essay questions assessed problem solving skills, while questionnaires measured collaboration skills. Hypothesis testing was carried out using Multivariate of Variance (MANOVA).
**Results:** The RICOSRE learning model based on socioscientific issues can influence the problem-solving ability and collaboration skills of students, as evidenced by the MANOVA test's significant value (0.000). It was also observed that students with higher levels of collaboration tend to have stronger problem-solving capabilities, suggesting a proportional relationship between these two skills. Notably, students in the experimental class who exhibited outstanding collaborative abilities also showed a high problem-solving rate of 80.67%.
**Conclusion:** The study concludes that the RICOSRE learning model, when combined with the Discovery Learning model and a scientific approach, positively influences students' problem-solving and collaboration skills. This model provides an effective learning strategy, enhancing students' ability to apply theoretical concepts to real-world scenarios, thereby making learning more engaging and relevant. Additionally, it prepares students for teamwork, improving their communication and interpersonal skills.

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## INTRODUCTION

The ability to solve problems and collaborate closely relates in the learning process. Both are critical skills needed not only in the academic environment but also in the workplace and everyday life. The problem-solving process often involves collaboration among individuals or groups. By working together, learners can combine ideas, perspectives, and knowledge to find more creative and effective solutions. Collaboration allows for idea sharing, joint analysis, and the creation of more holistic solutions (Partnership for 21st Century learning, 2015; Johnson et al., 2014). These skills not only assist students in school learning but also in facing real-life challenges in the future. Future challenges in collaboration and problem-solving skills include various factors reflecting the dynamics of change in the educational and work environment. Some of these challenges include rapid technological changes, such as artificial intelligence and automation, which can affect work methods and require high adaptability. Students need to be able to collaborate with increasingly sophisticated technology and solve problems related to the use of technology. Global issues, such as climate change, economic inequality, and health crises, are becoming more complex and require

* **Corresponding author:**
Rahma Diani, UIN Raden Intan Lampung, INDONESIA. ✉ rahmadiani@radenintan.ac.id

effective problem-solving and collaboration. Learners need to develop a deep understanding of these issues and work together to find sustainable solutions (Silver-Hmelo, 2004).

The capability to solve problems is crucial in physics learning, as it encompasses skills that require analytical thought. This mode of thinking involves mapping the problem and identifying its various components. Problem-solving is essentially the discovery or creation of novel solutions to a problem, or the implementation of newly learned rules. Such skills entail the proficiency to seek, choose, assess, organize, contemplate multiple alternatives, and decipher information. Enhancing problem-solving abilities is key to advancing human resource quality (Kurniawati et al., 2019). These abilities significantly contribute to students' comprehension of the subject matter, its application to real-world scenarios, and the enhancement of their analytical and synthetic skills (Dogru, 2008; Hadiprayitno et al., 2022). Possessing problem-solving skills also fuels students' motivation to deepen their conceptual understanding, thereby achieving a more comprehensive grasp of physics education.

Beyond the skill of problem-solving, the proficiency in collaboration is also essential for students. Collaborative efforts, whether in individual or group settings, enhance the efficiency of problem identification and formulation. This ties into the collaborative principle, where diverse ideas and perspectives contribute to a richer collective grasp of a problem (Yang, 2023). Often, problem-solving involves making decisions. Through collaboration, the decision-making process benefits from the diverse inputs of team members, culminating in a collectively agreed-upon solution. The skill of collaboration plays a vital role in physics education, elevating students' academic performance, improving their interaction capabilities, and deepening their problem comprehension (Firman et al., 2023). In physics, the mastery and understanding of concepts are crucial, necessitating educators to focus more intensively on physics concepts during teaching (Anwar et al., 2019). Consequently, it is anticipated that students, post-learning, will not only grasp physics concepts but also apply their skills in tackling physics-related challenges.

Based on observations at SMA Negeri 01 Tanjung Raya, the learning process involves students primarily listening to and observing the teacher explain. They primarily transcribe what is written on the chalkboard. Activities in the classroom rarely include practical laboratory work, with students focusing on attentive observation, note-taking, and responding to example questions posed by the teacher. Presently, assessments are confined to content management rather than evaluating problem-solving skills, and tests primarily assess the application of physics formulas. A significant reliance on rote memorization of formulas and examples is evident. There is a notable scarcity of teacher-initiated questions aimed at enhancing students' problem-solving capabilities, resulting in minimal student collaboration during the learning process. Such deficiencies in problem-solving and collaborative abilities are likely to adversely affect achievements in physics learning (Anggelita et al., 2020).

In addition to presenting educational content, educators have a range of strategies at their disposal to enrich both the educational process and the students' experience of learning. During educational activities, teachers can employ dynamic teaching methodologies like project-based learning, inquiry-based approaches, or group discussions. These techniques can foster a more active engagement in physics education among students, leading to enhanced conceptual grasp and heightened motivation (Meltzer & Thornton, 2012). Adopting problem-based learning strategies enables students to tackle real-world challenges and apply physical concepts, which is instrumental in honing their problem-solving abilities (J.R Savery, 2006). Moreover, encouraging collaborative activities both in and outside the classroom aids in the development of students' social, teamwork, and collaborative competencies. Participating in group discussions or undertaking group projects has been shown to significantly bolster student comprehension (W. Johnson & T. Johnson, 2019).

As a solution, the educational approach known as Reading, Identifying the problem, Constructing the solution, Solving the problem, Reviewing the problem solving, Extending the problem solving (RICOSRE) has been innovated and implemented across a range of educational settings (Azrai et al., 2022). This RICOSRE method is a form of problem-based learning, noted for its ability to boost the effectiveness of students' educational experiences. Such a model actively engages students by immersing them in the process of addressing real, pertinent, and captivating problems (Wardani, 2023). It enables students to systematically engage in the identification, formulation, and resolution of problems (Purbaningrum, 2017). This educational approach allows students to collaboratively devise solutions, exchange ideas, and tackle problems, thereby enhancing their social and teamwork skills (Redhana, 2019; Sarifah & Nurita, 2023). The RICOSRE model, particularly when focused on socioscientific issues, stands out as an effective strategy to foster students' problem-solving and collaborative capabilities.

In practical application, the study employed the RICOSRE problem-based learning framework, utilizing a socioscientific method to tackle social or scientific matters. This method combines both social and scientific aspects into the educational process, thus making the learning more relevant and deepening students' grasp of scientific principles (Sandoval, 2014). The socioscientific-oriented educational models enable students to explore scientific concepts within the scope of contemporary and pertinent social issues, which they encounter in daily life. Such an approach significantly boosts their comprehension and interaction with the educational content. Addressing social issues prompts students to engage in critical thinking, consider diverse viewpoints, and form decisions grounded in scientific rationale (Zeidler, 2014). By examining real-world social challenges, students gain insights into the practical application of scientific ideas for understanding and solving local problems, thereby enhancing their ability to apply knowledge in real-world scenarios (Chowdhury et al., 2020). Incorporating SSI in educational settings has demonstrated effectiveness in fostering students' scientific insights and critical thinking abilities (Zulyusri et al., 2022). This research explores the degree to which the RICOSRE model, informed by SSI, can enhance students' problem-solving skills and collaborative competencies.

Several relevant studies reveal that there is a positive relationship between the RICOSRE learning model, which has been proven to develop students' higher-level thinking abilities, and their involvement in identifying problems, solving problems, and finding solutions (Noviyanti et al., 2021; Yuliskurniawati et al., 2021). The RICOSRE model is noted for offering scaffolding, motivation, and support in learning and problem-solving activities (Zubaidah & Mahanal, 2017), promoting scientific literacy (Mawaddah et al., 2021), and facilitating the development of scientific process abilities (Costa et al., 2022; Setiawan et al., 2020). Meanwhile, the SSI approach aids students in engaging in genuine scientific practices and promotes comprehensive learning, including skills in problem-solving and teamwork (Sadler, 2009; Kolst, 2007). Collaborative exercises such as debates, idea-sharing, and tackling intricate problems are known to foster advanced thinking skills (Johnson et al., 2007). Investigations into the RICOSRE and SSI educational models have confirmed their efficacy in cultivating scientific comprehension. However, integrative studies of these models are relatively scarce, particularly regarding their effectiveness and application in varied and multifaceted educational settings. This study seeks to explore the impact of the RICOSRE model, grounded in socioscientific issues, on the problem-solving and collaborative skills of learners.

## METHOD

This test instrument trial was conducted to determine and measure the feasibility of the research instrument that will be used as a data collection tool in the study. This testing phase encompassed assessments of the instrument's validity, reliability, the discriminative power of the questions, and their difficulty levels. The researcher employed MANOVA (Multivariate Analysis of Variance) in hypothesis testing to assess the impact of the SSI-based RICOSRE learning model on students' problem-solving and collaborative abilities. The prerequisite for the MANOVA test is data that fulfill certain conditions, showing a normal distribution and homogeneity.

The study was executed at SMA Negeri 01 Tanjung Raya, targeting all students in the 11th grade as the research sample. Using purposive random sampling, one class was selected as the experimental group, class XI MIPA 2, which implemented the SSI-based RICOSRE model, and another, class XI MIPA 3, as the control group, employing the discovery learning model with a scientific approach for the 2022/2023 academic year. The methodology adopted for this research was a quasi-experimental design with a quantitative framework (Arikunto, 1998). The study's instruments included both test and non-test elements, with the test comprising essay questions to evaluate problem-solving skills, and the non-test involving a survey to assess collaborative skills. The hypothesis was tested using Multivariate Analysis of Variance (MANOVA) in the SPSS version 25 software.

The research methodology is further elucidated through a flowchart presented in Figure 1 for easier comprehension

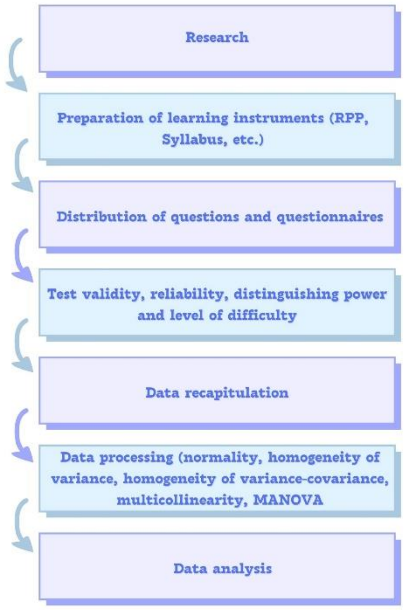


**Figure 1**. Research flow design

The research instruments used were tests and non-tests. The test component included questions on problem-solving capabilities, featuring 7 items designed to evaluate the students' proficiency in this area. The non-test portion was a questionnaire with 12 statements aimed at assessing students' collaborative abilities. The problem-solving test covered five key indicators: effective description, approach to physics, precise physics application, mathematical methodologies, and rational progression (Docktor et al., 2016). The collaborative skills questionnaire was built around six indicators: contribution levels, management of time, problem-solving efficiency, teamwork dynamics, research methodologies, and integrative capabilities (ReadWriteThink, 2005). The selected test and non-test questions had undergone rigorous evaluation and were chosen based on their adherence to standards of validity, reliability, discrimination capacity, and appropriate difficulty levels. The problem-solving ability question instrument is presented in Table 1.

**Table 1**. Instrument about problem solving abilities

| Indicator | Question | Answer | Analysis |
|---|---|---|---|
| • *Useful description*<br>• *Physics approach*<br>• *Specific application of physics*<br>• *Mathematical procedures*<br>• *Logical progression* | A Carnot engine produces 490 kW of power while absorbing 700 kJ of heat per second from a hot reservoir. If the temperature of the hot reservoir is 1000 K, then the temperature of the cold reservoir is... | ***(Useful description)***<br>Is known:<br>$P = 490\ kW = 490.000\ W$<br>$Q_1 = 700\ kJ = 700.000\ J$<br>$T_1 = 1000\ K$<br>Asked:<br>$T_2 \ldots ?$<br>Answer:<br><br>***(Physics approach)***<br>This problem can be solved by determining the heat and temperature released into the low reservoir<br><br>***(Specific application of physics)***<br>$P = \frac{W}{t} = \frac{Q_1 - Q_2}{t}$ | This question shows how students' physics concepts are able to solve problems which include five indicators of problem-solving ability. This question is considered valid with a moderate level of difficulty and sufficient distinguishing power. |

| | | | |
|---|---|---|---|
| | | Determines the temperature at low reservoir<br>$\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$<br>$P = \frac{Q_1 - Q_2}{t}$<br><br>***(Mathematical procedure)***<br>$490.000 = \frac{700.000 - Q_2}{1}$<br>$Q_2 = 700.000 - 490.000$<br>$Q_2 = 210.000\ Joule$<br>$Q \sim T$<br>$\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$<br>$T_2 = \frac{210.000 \times 1000}{700.000} = 300\ K$<br><br>***(Logical progression)***<br>So, the temperature of the cold reservoir is 300 K. | |
| • *Useful description*<br>• *Physics approach*<br>• *Specific application of physics*<br>• *Mathematical procedures*<br>• *Logical progression* | Aydan was asked to make hot coffee by his father. Aydan uses water in a thermos. Analyze why hot water is placed in a thermos? What will happen if you put it in a normal bottle? | ***(Useful description)***<br>Is known:<br>Aydan makes coffee using water in a thermos<br>Asked:<br>Analyze why hot water is placed in a thermos? What will happen if you put it in a normal bottle?<br>Answer:<br><br>***(Physics approach)***<br>This question is answered using thermodynamic systems theory.<br><br>***(Specific application of physics)***<br>Systems in thermodynamics are divided into 3 types, namely:<br>1. An open system is a system that allows the exchange of matter and energy.<br>2. Closed system, is a system that allows the exchange of energy but not matter.<br>3. An isolated system is a system that allows no exchange of energy and matter to occur<br><br>***(Mathematical procedure)***<br>The thermos is an insulated system because it has a silver coating which can minimize heat absorption. Apart from that, it also has a vacuum which cannot transfer heat out of the thermos. Meanwhile, if hot water is placed in an ordinary bottle, whether plastic or glass, heat exchange will occur. So, the water will have a low temperature or will no longer be hot.<br>***(Logical progression)***<br>So, based on this, hot water is placed in a thermos to prevent the exchange of energy in the form of heat from the water to the | This question shows how students' physics concepts are able to solve problems which include five indicators of problem-solving ability. This question is considered valid with a moderate level of difficulty and sufficient distinguishing power. |

environment (bottle and air).

Furthermore, to measure students' collaboration abilities, researchers used a questionnaire which can be seen in the following Table 2.

**Table 2.** Non-test instrument to measure students' collaboration abilities

| *Indicator* | *Statement* | *N* | *S* | *O* | *VO* |
|---|---|---|---|---|---|
| *Contributions* | Each team/group member contributes by participating or providing ideas in large or small group discussions. | | | | |
| *Time Management* | Each member of the team/group is responsible for completing the task according to the agreed time. | | | | |
| ***Problem Solving*** | Each team/group member tries to find and provide answers to the problems being worked on. | | | | |
| ***Working with Others*** | Each team/group member asks a friend when they encounter problems in completing the task. | | | | |
| ***Research Techniques*** | Each team/group member uses more than one learning source (not focusing on one source) and records the necessary information. | | | | |
| ***Synthesis*** | Each member of the team/group is able to work together to complete the tasks given correctly and in a structured manner | | | | |

Information:
N = Never
S = Seldom
O = Often
VO = Very Often

In table 2, indicators of collaboration ability consist of contributions, time management, problem solving, working with others, research techniques, synthesis. There are 12 statements with four answer choices N, S, O, and VO.

## RESULTS AND DISCUSSION

The researcher used the RICOSRE learning model based on Socioscientific Issues to treat the experimental class and the Discovery Learning model with a scientific approach for the control class, then observed their effects on problem-solving abilities by administering 7 questions and collaborative skills with 12 questionnaire statements. The researcher then gathered quantitative data, implementing a series of statistical tests including normality, variance homogeneity, variance-covariance matrix homogeneity, multicollinearity, and MANOVA to analyze the influence of these educational models. The findings from this analysis are detailed in Table 3.

**Table 3.** Data analysis results

| | **Normality** | | | | **Homogeneity of variance** | | **Homogeneity of the variance-covariance matrix** | **Multicollinearity** | | **Manova** | **Conclusion** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | KPM Exs | KPM Cont | KK Exs | KK Cont | KPM | KK | | *Tolerance* | VIF | | |
| Sig | 0.141 | 0.200 | 0.200 | 0.062 | 0.365 | 0.777 | 0.768 | 0.989 | 1.011 | 0.030<br>0.001<br>0.000 | $H_1$ accepted |

According to Table 3, the data exhibit normal distribution and homogeneity. The outcomes of the MANOVA test, revealing a significance level below 0.05, imply that the socioscientific issues-based RICOSRE educational model significantly impacts both problem-solving and collaborative capabilities. The study's findings are elucidated through an analysis of responses from students who achieved varying scores - high, moderate, and low - in physics problem-solving tasks, alongside a comparison of these scores with the results from the collaboration skills survey related to their grasp of physics concepts.

**Table 4**. Pretest and posttest results per indicator of students' problem-solving abilities

| No. | Problem Solving Ability Indicator | Persentase Percentage of Pretest Posttest Results for Problem Solving Ability | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pre Exs | Criteria | Post Exs | Criteria | Pre Cont | Criteria | Post Cont | Criteria |
| 1 | *Useful Description* | 5,32% | Very low | 62,04% | High | 19,48% | Very low | 80,95% | Very high |
| 2 | *Physics Approach* | 47,20% | Currently | 74,79% | High | 6,06% | Very low | 29,73% | Low |
| 3 | *Specific Application of Physics* | 69,05% | High | 98,46% | Very high | 63,06% | High | 95,38% | Very high |
| 4 | *Mathematical Procedure* | 55,46% | Currently | 97,48% | Very high | 58,44% | High | 87,88% | Very high |
| 5 | *Logical Progression* | 28,15% | Low | 70,59% | High | 28,14% | Low | 66,23% | High |
| | Average | 41,04 | | 80,67 | | 35,04 | | 72,03 | |

Table 4 presents the pretest and posttest outcomes across different problem-solving skill indicators for students. These results reveal a notable difference in problem-solving abilities between the experimental and control groups both before and after implementing specific learning models. Particularly noteworthy is the 'Specific Application of Physics' indicator within the problem-solving category. This indicator registered high percentages post-intervention, both with the SSI-based RICOSRE approach in the experimental class and the discovery learning model utilizing a scientific method in the control class. The essence of this indicator lies in assessing the extent to which individuals comprehend and effectively apply physics concepts to specific problem scenarios. It encompasses an understanding of physical laws, mathematical concepts, and the practical application of physics theories (Redish & Burciaga, 2004; McDermott & Shaffer, 2018).

The Socioscientific Issues-focused RICOSRE educational approach significantly impacts students' problem-solving and collaboration abilities. Research by Mahanal and Zubaidah highlights that the RICOSRE model's educational stages are structured to encourage active student participation in problem identification, resolution, and solution discovery (Mahanal & Zubaidah, 2017). Additionally, studies by Ariani and Fauzia suggest that problem-based educational models foster student collaboration in tackling challenges (Ariani, 2020; Fauzia & Kelana, 2021). In this research, the RICOSRE model, a problem-based learning approach, utilizes socioscientific issues from students' surroundings as a starting point for the learning journey. Students analyze these issues collaboratively, enhancing their critical thinking and problem-solving competencies (Hendriana et al., 2018; Irwanti & Zetriuslita, 2021). This comprehensive learning process in the Socioscientific Issues-based RICOSRE model not only bolsters students' critical thinking but also builds confidence in their intellectual skills. Furthermore, this model engenders more impactful learning experiences and fosters a proactive educational atmosphere, enabling students to adeptly address and resolve various problems.

### 3.1 Analysis of Students' Problem-Solving Abilities

In this section, the researcher presents two problems with medium and high difficulty categories to see the level of students' problem-solving abilities. This can be seen from the questions given which can train students' creative thinking in solving problems and improve their understanding of physics concepts for the better.

**Table 5**. Questions with medium difficulty categories to see the level of students' problem-solving abilities.

| Question | Indicator | Question Category | Analysis |
| --- | --- | --- | --- |
| 0.24 mole of ideal gas is in a system connected to a thermal reservoir, so that the system is at a constant temperature of 40°C. If it is known that the initial volume of the system is 4 liters and the work done is 20 joules, then the final increase in volume and pressure of the gas is... | • *Useful Description*<br>• *Physics Approach*<br>• *Specific application of physics*<br>• *Mathematical procedure*<br>• *Logical progression* | Currently | This problem can measure students' abilities by applying appropriate physics concepts in solving the given problem. Students can analyze problems based on what is known and design solutions with appropriate algorithms (Rusilowati et al., 2015; Harefa, 2020; Yanda et al., 2019). |

Table 5 shows examples of questions with a medium level of difficulty. Then from these questions, three student answers with different scores were selected to determine students' problem-solving abilities with the problems given.

**Table 6.** Questions with high difficulty categories to see the level of students' problem-solving abilities.

| Question | Question Category | Student Answers | Analysis |
| --- | --- | --- | --- |
| 0.24 mole of ideal gas is in a system connected to a thermal reservoir, so that the system is at a constant temperature of 40°C. If it is known that the initial volume of the system is 4 liters and the work done is 20 joules, then the final increase in volume and pressure of the gas is... | High | Is known:<br>n = 0,24 mol<br>T = 40°C = 313K<br>$V = 4$ liter $= 4 \times 10^{-3}$<br>$W = 20\, Joule$<br>$R = 8{,}31\, J/mol - K$<br><br>$\Delta V$ *and* $p \ldots ?$<br>Answer:<br>This problem can be solved using the equation to find pressure and volume.<br>Determine the amount of pressure<br>$pV = nRT$<br>$p = \frac{nRT}{V}$<br>Determine the temperature rise<br>$W = p\Delta V$<br>$\Delta V = \frac{W}{p}$<br>$p = \frac{nRT}{V}$<br>$p = \frac{0{,}24\, mol \times 8{,}31 \frac{J}{mol} - K \times 313K}{4 \times 10^{-3}}$<br>$p = 1{,}56 \times 10^5\, pa$ | As can be seen, students write down the information they know from the question. Then students determine the problem-solving concept and design the conceptual approach used by creating a formula to find pressure and volume. The pressure value calculated by the student is $1{,}56 \times 10^5\, pa$ and volume $12{,}8 \times 10^{-5}\, m^3$. It can be concluded that students obtain the correct conclusions through a good answering process with algorithms and complete answers. And this proves that students' problem-solving abilities are good (Mariam et al., 2019) |

| | | | |
|---|---|---|---|
| | | Determine the temperature rise<br>$\Delta V = \frac{W}{p} = \frac{20\ Joule}{1{,}56 \times 10^5 pa} = 12{,}8\ \times 10^{-5}\ m^3$<br>So, the final increase in volume and pressure of the gas is $12{,}8\ \times 10^{-5}\ m^3$ and $1{,}56 \times 10^5 pa$ | |
| | Currently | Is known:<br>n = 0,24 mol<br>t = 40°C<br>V = 4 liter<br>N = 20 $Joule$<br>$\Delta V\ and\ p$ …?<br>Answer:<br>Use the pressure equation<br>great pressure<br>$pV = nRT$<br>$p = \frac{nRT}{V}$<br>Determine the temperature rise<br>$W = p\Delta V$<br>$\Delta V = \frac{W}{p}$<br>$p = \frac{nRT}{V}$<br>$p = \frac{0{,}24\ mol \times 8{,}31 \frac{J}{mol} - K \times 313K}{4 \times 10^{-3}}$<br>$p = 1{,}56 \times 10^5\ pa$<br>Determine the temperature rise<br>$\Delta V = \frac{W}{p} = \frac{20\ Joule}{1{,}56 \times 10^5 pa} = 12{,}8\ \times 10^{-5}\ m^3$<br>So, the final increase in volume and pressure of the gas is $12{,}8\ \times 10^{-5}\ m^3$ and $1{,}56 \times 10^5 pa$ | As can be seen, students write the information they know from the question. Then students determine the concept of problem solving and design the conceptual approach used by creating a formula for finding pressure. The pressure value calculated by the student is $1{,}56 \times 10^5\ pa$ and volume $12{,}8\ \times 10^{-5}\ m^3$. This can be concluded that at the useful description and physics approach stages students used an incomplete approach but obtained correct conclusions. Therefore, this proves that students' problem-solving abilities are in the medium category (Hadi & Radiyatul, 2014; Siregar et al., 2021). |
| | Low | n = 0,24 mol<br>T = 40°C<br>V = 4 l<br>W = 20 $Joule$<br>$R = 8{,}31\ J/mol\ - K$<br>$\Delta W\ and\ p$ …?<br>Answer:<br>Using the pressure and work equations.<br>Determine the amount of pressure<br>$pV = nRT$<br>$p = \frac{nRT}{V}$<br>Determine the temperature rise<br>$W = p\Delta V$<br>$\Delta V = \frac{W}{p}$<br>$p = \frac{nRT}{V}$<br>$p = \frac{0{,}24\ mol \times 8{,}31 \frac{J}{mol} - K \times 313K}{4 \times 10^{-3}}$<br>$p = 1{,}56 \times 10^5\ pa$<br>Determine the temperature rise<br>$\Delta V = \frac{W}{p} = \frac{20\ Joule}{1{,}56 \times 10^5 pa} = 12{,}8\ \times 10^{-5}\ m^3$ | As can be seen, students write down the information they know from the question. Then students determine the problem-solving concept and design the conceptual approach used by creating a formula to find pressure and effort. The pressure value calculated by the student is $1{,}56\ \times 10^5\ pa$ and volume $12{,}8\ \times 10^{-5}\ m^3$. It can be concluded that at the useful description and physics approach stages students used inappropriate approaches and did not include correct conclusions. Therefore, this proves that students' problem-solving abilities are in the low category (Rachmawati & Adirakasiwi, 2021; Zamnah, 2017). |

The analysis of data presented in Table 6 underlines the significance of an effective learning environment in physics teaching. This conducive setting is pivotal for fostering students' proficiency in solving physics-related problems and improving their collaborative abilities. Mastery in problem-solving is crucial for students to grasp and interlink various concepts. Effective problem-solving typically involves creating representations of problems to enhance comprehension (Novriani & Sury, 2017). Students with a robust understanding of physics concepts are likely to excel compared to their peers with lesser understanding (Mauke et al., 2013; Trianggono, 2017; Budiyono et al., 2020). The process of problem-solving encompasses analytical and critical thinking, alongside creativity, reasoning, and experiential learning (Reeve, 2013). Key steps in a strategic problem-solving process include defining the problem, conducting assessments, collating pertinent data, formulating various solutions, evaluating different alternatives, selecting the optimal solution, and applying the findings broadly (Al-Hassawi et al., 2020)

Consistent with these findings, the RICOSRE educational model, incorporating Socioscientific Issues, has been effective in enhancing students' problem-solving skills. This aligns with Yuliskurniawati's study, which found a positive correlation between the RICOSRE model and the advancement of students' higher-order thinking skills, particularly in problem identification, resolution, and solution exploration (Yuliskurniawati et al., 2021). The pretest and posttest outcomes, detailed in Table 4, demonstrate that initially, both the experimental and control groups had low problem-solving capabilities, with average scores of 41.04 and 35.04, respectively. However, post-treatment, the students' problem-solving abilities significantly improved. In the experimental group, where the RICOSRE model based on Socioscientific Issues was applied, the average score rose dramatically to 80.67, indicating a very high level of skill. In the control group, the average score improved to 72.03, a high level of problem-solving ability. These results suggest that the implementation of the RICOSRE model based on Socioscientific Issues markedly enhanced the students' problem-solving skills during the study period (Mahanal et al., 2019; Zeidler & Nichols, 2009).

### 3.2 Analysis of Student Collaboration Ability

The ability to collaborate is a crucial skill essential for effective and harmonious teamwork, as well as for streamlining the decision-making process to achieve mutual agreements (Redhana, 2019). The effectiveness of collaborative skills is significantly enhanced when multiple learners actively engage in group activities

The research conducted at SMA Negeri 1 Tanjung Raya revealed that teaching practices were predominantly led by teachers, leading to a primarily unidirectional flow of communication from the teachers to the students. This teacher-centric approach, often through lectures, resulted in students being mostly silent and attentive to the instructions. The observation also noted that only a few students engaged in questioning or responding to the teacher. Many students showed reluctance in voicing their opinions, possibly due to embarrassment or fear of making mistakes. In group learning scenarios, it was evident that collaboration among students was insufficient. Typically, only a single student would take charge of explaining while others remained passive. This lack of cooperative engagement was also evident in situations where students were reluctant to share responsibilities with peers. Additionally, during class discussions and presentations, only a few students actively contributed, and teachers often had to encourage student participation. These observations point to a deficit in collaborative skills among the students of SMA Negeri 1 Tanjung Raya

During the learning activities, students were provided with a questionnaire to assess their collaborative skills, particularly in the context of solving physics problems. In responding to this questionnaire, students were instructed to choose options that most accurately reflected their self-perception. The outcomes of this assessment, detailing the students' collaborative proficiency across various indicators in both the experimental and control groups, are presented in Table 7.

**Table 7**. Pretest Posttest Results Collaboration Ability

| No | Collaboration Capability Indicators | Pretest Posttest Results Collaboration Ability | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pre Exs | Criteria | Post Exs | Criteria | Pre Cont | Criteria | Post Cont | Criteria |
| 1 | *Contributions* | 57,8 | Quite Collaborative | 78,7 | Collaborative | 38,5 | Less Collaborative | 69,6 | Collaborative |
| 2 | *Time Management* | 33,8 | Less Collaborative | 82,4 | Very Collaborative | 49,3 | Quite Collaborative | 74,3 | Collaborative |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | *Problem Solving* | 38,6 | Less Collaborative | 73,9 | Collaborative | 62,1 | Collaborative | 69,1 | Collaborative |
| 4 | *Working with Others* | 57,8 | Quite Collaborative | 78,7 | Collaborative | 53,4 | Quite Collaborative | 69,4 | Collaborative |
| 5 | *Research Techniques* | 61,8 | Collaborative | 86,0 | Very Collaborative | 54,4 | Quite Collaborative | 74,3 | Collaborative |
| 6 | *Synthesis* | 57,0 | Quite Collaborative | 81,6 | Very Collaborative | 50,4 | Quite Collaborative | 77,6 | Collaborative |
| | Average | 51,14 | | 80,21 | | 51,35 | | 72,37 | |

Table 7 illustrates the collaborative skill indicators before and after implementing the RICOSRE educational model based on socioscientific issues. Post-intervention, the collaborative ability for each indicator was rated as highly collaborative, suggesting students exhibit strong collaborative skills across all indicators. The ability to collaborate effectively has a significant impact on problem-solving skills. Collaborative efforts enable students to address problems more efficiently by undertaking a thorough analysis of the issues (Lane, 2013). Sudrajat's research indicates that challenges in scientific education can be addressed through collaborative instructional planning (Sudrajat, 2017). Additionally, in the control class employing the discovery learning model with a scientific approach, there was a notable improvement in collaborative abilities following the intervention, compared to the pre-intervention phase.

Collaborative exercises, including debates, idea sharing, and tackling complex issues, are known to cultivate advanced cognitive abilities (Laal & Laal, 2012). Table 7, outlining the pretest and posttest results for collaborative skill indicators, reveals that before the intervention (pretest), students in both the experimental and control groups displayed adequate collaborative skills, with average scores being 51.14 and 51.35, respectively. Post-intervention (posttest), applying the Socioscientific Issues-based RICOSRE model, the experimental group achieved a 'highly collaborative' rating with an average score of 80.21, while the control group was categorized as 'collaborative' with a score of 72.37. These results demonstrate the effectiveness of the Socioscientific Issues-informed RICOSRE model in significantly enhancing students' collaborative abilities during the research period (Hartina et al., 2022). Table 8 describes the process carried out by researchers during the research process.

**Table 8**. Process during research on each indicator of problem-solving ability and collaboration ability

| RICOSRE Model Syntax | Problem Solving Ability Indicator | Collaboration Ability Indicator |
|---|---|---|
| ***Reading***   | ***Useful description*** For effectively employing significant descriptions in tackling physics problems, students should begin with the reading phase (Cahyani & Setyawati, 2016). Furthermore, Hussain and Munshi have highlighted that reading activities serve as a means to broaden students' knowledge base and information (Hussain & Munshi, 2011). To demonstrate this indicator, it's useful to identify and articulate the known elements and the queries raised in the given problem. | ***Contributions*** The contribution component within collaborative abilities reflects how students offer their ideas or insights, particularly in their reading skills, to comprehend the specific physics phenomena under discussion (Greenstein, 2012; Junita et al., 2021). |

| | | |
|---|---|---|
| ***Identifying the Problem***<br> | ***Physics approach***<br>Identifying the suitable physics concept or approach relevant to the issue at hand is essential. This means choosing the physics concept that best matches the physics phenomenon being examined. Within this aspect of problem-solving skills, students are coached to ascertain the problem grounded in the phenomenon they have explored. The ability to discover the relevant physics conceptual approach is enhanced when students concentrate on a thorough analysis of the problem (King et al., 2012). | ***Time management***<br>Among different groups, students are able to identify the relevant physics concept that aligns with the predefined time management, by fulfilling their respective roles and responsibilities within the group (Szewkis, 2011). |
| ***Constructing the Solution***<br> | ***Specific application of physics***<br>In the application of concepts to address pertinent physics phenomena, students' problem-solving abilities are crucial. This involves formulating hypotheses regarding the root causes of the issues encountered and devising efficient strategies for their resolution (Mahanal & Zubaidah, 2017). | ***Problem solving* dan *Working with others***<br>Within the collaborative group dynamics, there's a focus on teamwork, embracing suggestions, and reaching collective decisions (Sorensen, 2014). This collaborative effort is key in formulating solutions and addressing problems identified earlier (Muhali, 2019). |
| ***Solving the Problem***<br> | ***Mathematical procedures***<br>Applying a physics methodology consistent with mathematical techniques. Here, students are encouraged to expand their conceptual knowledge by expressing and implementing the selected physics approach or concept (Yerushalmi & Eylon, 2021). | |
| ***Reviewing the Problem Solving***<br><br>***Extending the Problem Solving***<br> | ***Logical progression***<br>Developing logical conclusions. In this phase, students are tasked with finalizing the problem-solving process by reviewing and evaluating the solutions they have developed (Mahanal & Zubaidah, 2017). This includes synthesizing conclusions from their problem-solving efforts. Additionally, students are encouraged to extend this process by linking the insights gained from problem-solving with other related areas of knowledge (Lee, 2016). | ***Research techniques* dan *Synthesis***<br>In this context, the approach to research and synthesis focuses on assessing the long-term viability of the selected solution, taking into account the information gathered from the resolved problem (ReadWriteThink, 2005). |

This study's analysis is in harmony with various research findings that highlight the effectiveness of the RICOSRE learning model in consistently enhancing the problem-solving skills of students from different academic backgrounds (Mahanal et al., 2022; Mahanal et al., 2019; Mahanal & Zubaidah, 2015; Yuliskurniawati et al., 2021). The systematic approach inherent in RICOSRE can maximize the potential of each phase. In the reading phase, students bolster their reading comprehension, aiding them in grasping complex topics and identifying pertinent information (Akın et al., 2015). The problem identification stage allows students to outline steps towards their goals (von Hippel & von Krogh, 2016). The solution construction phase is key in inspiring students to create work of superior quality (Cheng et al., 2018). Problem resolution involves devising suitable solutions. The solution review phase is crucial for students to assess the effectiveness of their problem-solving efforts (Mahanal et al., 2017), while extending the solution phase prepares students for continuous problem resolution by evaluating the applicability of solutions to broader contexts (Mahanal et al., 2017).

Implementing the socioscientific issues-based RICOSRE model cultivates consistent problem-solving practices among students. The educational experiences from this study illustrate how the RICOSRE model with Socioscientific Issues equips students to become adept at resolving problems. The RICOSRE model is also established as a tool for nurturing higher-order thinking and engaging students in problem identification, resolution, and solution-finding (Yuliskurniawati et al., 2021). Collaborative exercises such as debates and idea-sharing sessions, especially in complex problem-solving scenarios, are instrumental in fostering advanced cognitive skills. In this study, involving 67 students in both experimental and control groups, an extended duration was required for the learning activities, particularly in addressing and solving intricate problems. It is recommended for teachers to maintain an engaging and productive classroom environment, ensuring student comprehension and engagement to achieve the learning goals fully. According to Hmelo-Silver, problem-based learning models are effective in enhancing students' problem-solving skills by presenting them with real-world challenges, thereby facilitating the development of their analytical, synthetic, and problem-solving abilities in a contextual learning setting (Hmelo-Silver et al., 2007). Savery and Duffy's research underscores the value of problem-based learning in fostering robust collaborative experiences, where students collaboratively tackle problems, exchange ideas, and sharpen their communication skills for effective teamwork (Savery & Duffy, 2009). The problem-based learning approach offers students opportunities to apply their problem-solving and teamwork skills in practical settings, with students involved in such projects more likely to apply their knowledge in real-life situations (Juwah et al., 2004).

## CONCLUSION

The RICOSRE learning model based on socioscientific issues can influence the problem-solving ability and collaboration skills of students, as evidenced by the MANOVA test's significant value (0.000). It was also observed that students with higher levels of collaboration tend to have stronger problem-solving capabilities, suggesting a proportional relationship between these two skills. Notably, students in the experimental class who exhibited outstanding collaborative abilities also showed a high problem-solving rate of 80.67%. This underscores the influence of the socioscientific issues-based RICOSRE model on enhancing students' problem-solving and collaborative skills. In light of these findings, the researcher suggests future enhancements, particularly in time management for learning activities, as the RICOSRE model with a socioscientific focus demands more time for identifying and addressing complex issues. Educators are advised to foster a supportive classroom atmosphere throughout the educational process to ensure students are engaged and comprehensively understand the material, thereby achieving optimal learning outcomes.

## AUTHOR CONTRIBUTION STATEMENT

RD : Conceptualizing the main ideas
BSA : Analyzing data obtained from surveys and interviews with students
ERS : Editing, Reviewing, and Supervision

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