Problem-Based Learning Integrated Reading and Writing in Work and Energy Phenomena: Its Effectiveness on Problem-Solving Skills and Reading-Writing Literacy

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Article Info

ABSTRACT

Problem-solving Skills and Reading-Writing Literacy are two necessary things students must have to compete in the 21st century. This study aims at determining the effectiveness of Problem-based Learning with Integrated Reading and Writing tasks to improve students' problem-solving and reading-writing literacy skills. A quantitative method using a quasi-experimental design with a non-equivalent control group was employed in this study. The sampling technique used in this study was the purposive sampling technique. The sample used in this study was 36 students divided into two groups: the control group and the experimental group. The instrument used in this study was a physics problem-solving skill test instrument and a reading-writing literacy instrument. The data analysis technique in this study was a quantitative analysis technique. The results showed that the N-gain value of the physics problem-solving skill test for the experimental group was 0.67 in the medium category, and the control group was 0.65 in the medium category. In the reading-writing literacy test, the N-gain value for the experimental group was 0.55 in the medium category and 0.29 in the low category for the control group. The Problem-based Learning model with Integrated Reading and Writing Tasks has little impact on improving students' problem-solving skills. However, it has a significant effect on increasing students' reading-writing literacy.

INTRODUCTION

Physics plays a very important role in the development of the world, which is closely related to everyday life, especially in the field of technology and innovation in various aspects of life (Bao & Koenig, 2019). Physics has many concepts, theories, and equations. Moreover, in physics, there are also many calculations. This issue makes it difficult for students to solve physics problems (Jannah et al., 2022; Priadi et al., 2021; Rivaldo et al., 2020; Simbolon et al., 2019). This is supported by several research results that students' physics problem-solving skills are still in the low category. A study by (Alami et al., 2018) showed that

students' problem-solving skills in solving physics problems using the Rosengrant stage are still in the low category or need improvements. Research from (Waremra et al., 2021) also showed that students' physics problem-solving skills are still in the low category. Besides, students were lack to use various representation formats in solving physics problems (Hung & Wu, 2018).

In solving physics problems, students must be able to determine the principles, laws of physics, and equations involved in a problem and then make a picture of the problem (Reddy & Panacharoensawad, 2017). Gagne states that to solve a problem, students must know and understand the

concepts or principles related to the problem (Alami et al., 2018). In addition, students' success in solving physics problems is also influenced by the use of various representation formats in solving a problem (Rosengrant et al., 2007).

The stages of problem-solving in learning physics, according to Rosengrant, are divided into five stages, namely describing the problem, visualizing the problems (image representation), determining the mathematical representation and problem-solving plan, implementing problem-solving solutions, and conducting evaluations. From the stages of solving physics problems, according to Rosengrant, it can be seen that there are stages of using multimodal representations in solving physics problems. Representations that can be used in solving physics problems in the Rosengrant stage are free-body diagrams, image representations, mathematical representations, and verbal representations.

Students who can make various forms of representation (multimodal representation) of a concept tend to understand physics problems easily and clearly (Simbolon et al., 2019). Multimodal representations can help students learn, understand problems, provide instructions on problems, and assist in solving problems (Alami et al., 2018). Using various representations in solving physics problems can help students understand problems and apply concepts in everyday life (Simbolon et al., 2019; Tms & Sirait, 2016; Yolenta et al., 2020). This will support the students to be ready to face more complex challenges in the 21st century. Using various representations of a physics concept can help students not only remember but also help them understand the concept well (Widyawati et al., 2015).

Several studies have shown that students' physics problem-solving skills with multimodal or various representations can be improved and trained using the Problem-based Learning model. A study by (Jonny et al., 2020; Simanjuntak et al., 2021) shows that the Problem-based Learning model can train and improve physics problem-solving skills. In addition, learning using the Problem-based Learning model requires students to think critically in dealing with the given physics problems. Thus the students not only understand concepts that are appropriate to the problem but also have higher thinking patterns in solving problems (Ngalimun, 2013).

In addition to having physics problem-solving skills, students should have physics literacy to help them understand physics well. Literacy means literate or eradicating illiteracy (Pratiwi et al., 2019). According to the Director of Primary and Secondary Education (Sufa et al., 2021), literacy is the ability to access, understand and apply methods through reading, viewing, listening, writing, and speaking activities. Literacy includes various skills such as reading, writing, information processing, decision-making, ideas and opinions, and problem-solving (Tavdgiridze, 2016). So, one of the literacy skills that students need to have is reading and writing. Reading and writing literacy is the knowledge and skill to read, write, search, browse, process, and understand information to analyze, respond to, and use written texts to achieve goals, increase understanding and potential, and participate in the social environment (Agustin & Sugiyono, 2019).

The literacy of students in Indonesia is relatively low. This is supported by UNESCO statistical data in 2012, which shows that Indonesia's reading interest index has only reached 0.001, meaning that only 1 out of 1,000 people is interested in reading. The literacy of students in Indonesia is still in the low category, and literacy needs to be more integration in school learning (Mufit, 2018). Reading and writing are the keys to learning science that can increase concentration power (Widiyarto et al., 2021). Students with excellent literacy will have good foundations to achieve and live a quality life now and in the future.

Through the 2013 curriculum, the Indonesian government has announced the

School Literacy Movement known as *the Gerakan Literasi Sekolah* (GLS) program to improve the literacy of students in the low category. Furthermore, the government launched the National Literacy Movement (GLN) in 2018, aiming to increase student literacy and improve community literacy. The GLN program only focuses on increasing student literacy in general in all subjects. However, in this study, the main focus of increasing student literacy was aimed at physics subjects. Therefore giving treatment to increase physics literacy is no longer using the GLN program.

In addition, several researchers have also conducted research to improve the literacy skills of students. (Fisher et al., 2002) suggest seven strategies to improve student literacy: read-aloud or share readings, K-W-L charts, graphic organizers, vocabulary instructions, writing to learn, structured note-taking, and reciprocal teaching. Integrated Reading and Writing Task (IRWT) is a strategy for improving student literacy by providing reading and written assignments to students (Feranie et al., 2016). From several studies conducted by (Istiqlal, 2013; Rahmadewi, 2019; Sundari 2016; Wangsa, 2013), it has been shown that the implementation of IRWT can improve understanding of concepts, physical literacy, scientific literacy, ability to translate between multimodal representation and consistency of representation, as well as several other skills. However, most of these studies only focus on the implementation of IRWT. In this study, researchers Integrated Reading and Writing Tasks (IRWT) into PBL to improve physics problem-solving skills and literacy. The use of IRWT, integrated with PBL in class, is carried out using student activity sheets in each learning stage. So that each stage of PBL and IRWT can be measured properly.

Based on several solutions that other researchers have carried out to improve problem-solving skills and students' reading and writing literacy, the authors used a Problem-based Learning (PBL) model integrated with a literacy strategy, namely IRWT (Integrated Reading and Writing Task). The use of Problem-based Learning (PBL) in the classroom can improve physics problem-solving skills and when PBL is integrated with IRWT will help students to increase physics literacy from the results of the learning process in class. From this study, the authors want to know, "How to improve problem-solving skills of high school students after implementing Problem-based Learning with Integrated Reading and Writing Tasks?", "How to increase reading-writing literacy of high school students after implementing Problem-based Learning with Integrated Reading and Writing Task?" and "How is the effectiveness of Problem-based Learning with Integrated Reading and Writing Task to practice problem-solving skills, reading, and writing literacy for high school students?". This study aimed to determine the effectiveness of Problem-based Learning with Integrated Reading and writing to improve problem-solving skills and reading-writing literacy in work and energy concepts.

METHODS

The method used in this study was a quantitative method using a quasi-experimental design with a non-equivalent control group (Creswell, 2015). In this design, there were two research groups: the experimental and the control groups. Both groups were given a pre-test to determine the initial skills of solving physics problems and early literacy skills in reading and writing. After being given a pre-test, the experimental group was given a treatment in the form of learning using the Problem-based Learning model with the Integrated Reading and Writing Task. The control group was given learning using the Problem-based Learning model without the assistance of the Integrated Reading and Writing Task. Then the experimental and control groups were given a final test (post-test) to measure the effectiveness of the

Problem-based Learning model on physics problem-solving skills and physics literacy skills of high school students.

The population in this study were students of grade 10 majoring in Science in all High Schools in Bandung for the academic year 2021/2022. The sampling technique used in this study used a purposive sampling technique, namely the sample selection technique based on consideration of certain conditions (Sugiyono, 2013). The samples of this study were 36 students aged between 15 to 17 years with almost the same family background.

This research flow starts with studying the literature and formulating a research problem. Furthermore, to be able to answer the formulation of the problem that has been made, research instruments are made. Research instruments that have been validated are used to obtain data that can answer the problem formulation. The data that has been collected and processed is used to be analyzed in answering questions and making conclusions.
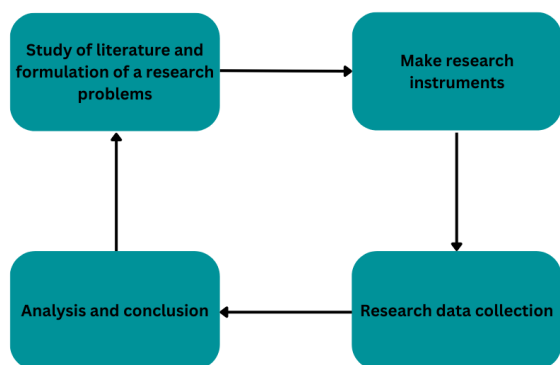

Figure 1. Research Flow

To obtain data supporting the research, the authors used several instruments prepared to answer the research. The instruments used were the physics problem-solving skills test, reading-writing literacy test, worksheets with IRWT, student response questionnaires, and learning implementation observation sheets. The research procedure carried out was formulating problems and also conducting

preliminary studies related to research, compiling various learning tools (lesson plans and worksheets) and research instruments, conducting trials and testing the validity of instruments, conducting pre-tests, and administering treatment to the control group and the experimental control, conducting post-tests, and processing and analyzing research data.

The research data were analyzed using the N-gain test to see the improvement of students' problem-solving skills and literacy through Problem-based Learning with Integrated Reading and Writing Tasks based on the normalized Gain scores obtained from pre-test scores and post-test scores.

$$< g > = \frac{\% < G >}{\% < G >_{max}}$$

$$< g > = \frac{\% < S_f > - \% < S_i >}{100 - \% < S_i >}$$

Table 1. Gain Interpretation

$<g>$	Interpretation
$<g> \geq 0.7$	High
$0.3 \geq <g> < 0.7$	Medium
$0.0 \geq <g> < 0.3$	Low

(Hake, 1998)

After knowing whether or not there is an increase in problem-solving skills and reading and writing literacy of students through Problem-based Learning with Integrated Reading and Writing Tasks, the hypothesis test was carried out on the N-gain score to determine whether or not there was a significant difference between the scores obtained by the experimental group and the control group. Hypothesis testing can be done in two ways, namely, parametric statistical tests and non-parametric statistical tests. The normality test and homogeneity test were carried out first to determine the correct statistical test, then continued with hypothesis testing or difference test of two means. Non-parametric statistical tests were carried out

using the Mann-Whitney U test with the help of the IBM SPSS Statistics program.

Suppose the difference test of the two averages shows no difference in problem-solving skills and a difference in students' reading-writing literacy through Problem-based Learning with Integrated Reading and Writing Tasks. In that case, the next step is to find the effect size. The value of the treatment effect in learning can be used by Cohen's d formula as follows:

$$d = \frac{\bar{x}_t - \bar{x}_c}{S_{pooled}}$$

The combined standard deviation (S_{pooled}) is calculated using the following formula:

$$S_{pooled} = \sqrt{\frac{(n_t - 1)s_t^2 + (n_c - 1)s_c^2}{n_t + n_c}}$$

Table 2. Cohen's d Interpretation

Cohen's d	Interpretation
$1.00 \leq d$	Very High
$0.8 \leq d \leq 1.00$	High
$0.5 \leq d \leq 0.8$	Medium
$0.2 \leq d \leq 0.5$	Low
$d < 0.20$	Very Low

In this study, the Problem-based Learning model with the Integrated Reading and Writing Task was implemented in the experimental group, and the Problem-based Learning model was implemented in the control group. Hence, the research hypothesis can be formulated in this way: "There is no significant difference in the average N-gain of the problem-solving skills test results, and there is a significant difference in the average N-gain of the students' physics reading-writing literacy test results between the experimental group and the control group. "

RESULTS AND DISCUSSION
The Improvement of Students' Problem-Solving Skills in Physics

The first research problem in this study is "How to improve problem-solving skills of high school students after implementing Problem-based Learning with Integrated Reading and Writing Task?". In Table 3, the results of the N-gain test of the pre-test and the post-test are presented for the test of physics problem-solving skills in the experimental group and the control group.

Table 3. N-gain for Physics Problem-solving Skills

Class	$\langle S_{pre} \rangle$	$\langle S_{post} \rangle$	$\langle g \rangle$	Interpretation
Experiment	32.59	76.44	0.67	Medium
Control	29.19	74.22	0.65	Medium

Based on the results of the N-gain test in Table 3, it can be inferred that the N-gain score of the physics problem-solving skill test for the experimental group was 0.67 in the medium category, and for the control group was 0.65 in the medium category. The N-gain score for the experimental group was higher than that of the control group (0.67 > 0.65). In addition, if it referred to indicators of physics problem-solving by Rosengrant, it can be seen which problem-solving indicators experienced an improvement after treatment was given to the control and experimental groups. The results showing the increase of each indicator of physics problem-solving for the experimental group are presented in Figure 2, and for the control group are presented in Figure 3.
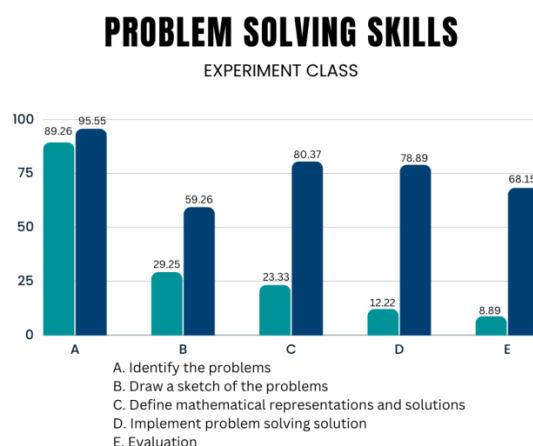

Figure 2. The Improvement Results of Physics Problem-solving Skills for Each Experiment Group Indicator
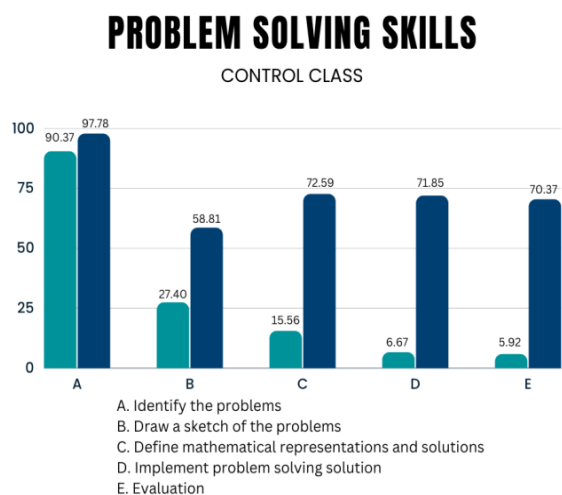
Figure 3. The Improvement Results of Physics Problem-solving Skills for Each Control Group Indicator

Figures 2 and 3 show that the average indicator for evaluating the experimental group before learning Problem-based Learning with Integrated Reading and Writing Tasks is 23.33. These results indicate that students' evaluating skills are in a low category. However, after being given learning, the average score of students became 80.37. This means there is an increase in students' skills in conducting evaluations.

Figures 2 and 3 show that the average score of the indicator evaluating the control group before learning Problem-based Learning is 15.56. These results indicate that students' evaluating skills are still in the low category. However, after being given PBL learning, the average score of students became 72.59. This means there is an increase in students' skills in conducting evaluations.

Thus, problem-solving indicators that have remained relatively high are indicators of identifying problems. Students can identify problems quite well before and after the treatment is given. There has been a considerable increase in the other four indicators of solving physics problems, such as visualizing the problem (image representation), determining the formulation (mathematical representation) and planning

solutions, executing the plan, and scrutinizing the results. This is because students at first need to become more accustomed to solving physics problems coherently and correctly.

From the results of the N-gain score for the experimental and control group, the physics problem-solving skills of students have increased in the medium category. This indicates that Problem-based Learning with Integrated Reading and Writing Tasks in the experimental group and Problem-based Learning without the assistance of Integrated Reading and Writing Tasks in the control group can improve physics problem-solving skills.

Similar research results also show that Problem-based Learning can improve physics problem-solving skills. Research by (Putri et al., 2020) shows that using Problem-based Learning models can improve physics problem-solving skills. In addition, research was conducted by (Mardatila et al., 2019). shows that students' physics problem-solving skills improve after implementing Problem-based Learning. This is because the Problem-based Learning model applied is a learning model that can provide opportunities for students to represent their understanding of the concepts being studied (Silitonga & Sirait, 2018). Therefore, the Problem-based Learning model with the Integrated Reading and Writing Task can improve the physics problem-solving skills of students in solving physics problems.

The Improvement of Reading and Writing Literacy

The second research problem in this study is "How to enhance reading-writing literacy of high school students after implementing Problem-based Learning with Integrated Reading and Writing Task?". Table 4 presents the results of the N-gain test of the pre-test and the post-test for the reading-writing literacy test in the experimental group and the control group.

Table 4. N-gain for Reading-Writing Literacy

Class	$<S_{pre}>$	$<S_{post}>$	$<g>$	Interpretation
Experiment	64.13	81.88	0.55	Medium
Control	68.72	77.66	0.29	Low

Based on the results of the N-gain test in Table 4, it can be seen that the N-gain score of the reading-writing literacy test for the experimental group was 0.55 in the medium category and 0.29 for the control group in the low category. The N-gain score for the experimental group was greater than that of the control group (0.55 > 0.29). In addition, when viewed based on the aspect of reading and writing literacy, it can be seen which aspects of reading-writing literacy experienced an increase after the treatment was given to the control and experimental groups. The improvement of each aspect of reading and writing literacy for the experiment group is presented in Figure 4 and Figure 5 for the control group.
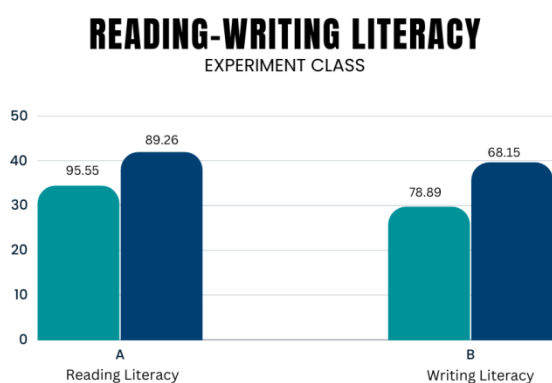

Figure 4. The Improvement Results of Reading and Writing Literacy of the Experiment Group
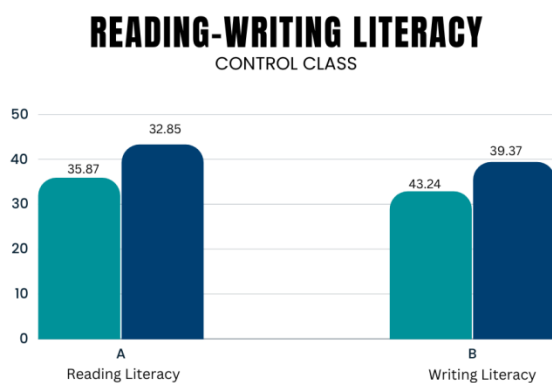

Figure 5. The Improvement Results of Reading and Writing Literacy of the Control Group

The literacy aspect of reading and writing students has increased significantly. However, a higher increase occurred in the writing aspect compared to the reading aspect. This is because students must become more accustomed to reading and writing properly. Based on the results of observations during learning, students tend to need more motivation to read long passages or discourses in the learning process.

From the results of the N-gain calculation for the experimental group, it can be concluded that the student's reading and writing literacy has increased in the medium category. The reading and writing literacy of students in the control group has increased in the low category. This shows that Problem-based Learning with Integrated Reading and Writing Tasks in the experimental group can improve students' reading and writing literacy. Therefore, it can be concluded that Problem-based Learning with Integrated Reading and Writing tasks influences increasing students' reading and writing literacy (0.55 > 0.29).

Similar research results also show that integrating literacy strategies in learning can improve student literacy. Research conducted by (Istiqlal, 2013; Wangsa, 2013) shows that integrating literacy strategies in learning activities called Integrated Reading and Writing Tasks can improve students' physical literacy. In addition, research conducted by (Pratiwi et al., 2019; Sundari, 2016) shows that students' scientific literacy can increase after implementing the Integrated Reading and Writing Task in the Problem-based Learning learning model. Thus, the Problem-based Learning model with Integrated Reading and Writing Tasks can improve students' literacy skills.

According to (Abidin et al., 2018), learning to improve student literacy at the secondary school level has the goal of making students ready to face the 21st century, such as helping students to be able to communicate actively, responsibly, and creatively by involving various texts and

technology, which can help the learning process. Learning focusing on literacy also aims to poster students master high reading comprehension skills, good writing skills to construct and express meaning, speaking skills, and digital media mastery skills.

The Effectiveness of Problem-based Learning with Integrated Reading and Writing Task

The third research problem in this study is "How effective is Problem-based Learning with Integrated Reading and Writing Tasks to enhance problem-solving skills, reading and writing literacy for high school students?". The results of the N-gain test of problem-solving skills and reading and writing literacy showed an increase after implementing the Problem-based Learning model with the Integrated Reading and Writing Task. Further, a hypothesis test was conducted on the N-gain score to determine whether there was a significant difference between the scores obtained by the experimental and control groups.

From the results of the normality test and homogeneity test, it was found that the data were not normally distributed, but it was homogeneous. If one of the two conditions is not fulfilled, a two-average difference test will be carried out using a non-parametric method. Therefore, a non-parametric statistical test was used, namely the Mann-Whitney U test.

Table 5. Results of Hypothesis Test for Problem-solving Skills

	N-Gain Test Result
Mann-Whitney U	155.000
Wilcoxon W	326.000
Z	-0.221
Asymp.Sig (2-tailed)	0.825

Based on the results of hypothesis testing using the Mann-Whitney U Test presented in Table 5, it can be seen that H_0 is accepted, where the Asymp.Sig (2-Tailed) is more than 0.05, which is 0.825. There is no significant difference between the improvement of physics problem-solving

skills in the experimental and control groups. This follows the results of the N-gain physics problem-solving skills of the experimental group and the control group, which have the same results.

The results of the N-gain score on the physics problem-solving skill test in the experimental and control groups have the same results. This is because both groups apply Problem-based Learning, known to train students' physics problem-solving skills.

This result is also reinforced by the student worksheets in the problem-solving section, which have a similar average score, as many as 88.89 for the experimental group and 88.59 for the control group. In the physics problem-solving section, students were given five questions using Rosengrant's five-step problem-solving process. Furthermore, hypothesis testing was carried out on the reading and writing literacy variables.

Table 6. Results of Hypothesis Test for Reading and Writing Literacy

	N-Gain Test Result
Mann-Whitney U	53.500
Wilcoxon W	224.500
Z	-3.433
Asymp.Sig (2-tailed)	0.001

Based on the results of hypothesis testing using the Mann-Whitney U Test presented in Table 6, it can be seen that H_0 is rejected, where the Asymp.Sig (2-Tailed) is less than 0.05, which is 0.001. So there is a significant difference between the increase in literacy in the experimental and control groups. This is also in line with the N-gain reading and writing literacy test results of students in the experimental group who obtained a higher score than the average N-gain reading and writing literacy test results of students in the control group.

The factor that can cause the N-gain reading and writing literacy test results in the experimental group to be higher than the control group is that the experimental group

gets learning using the Integrated Reading and Writing Task (IRWT) literacy strategy, which can enhance students' reading and writing literacy. The control group did not provide learning to enhance students' reading and writing literacy. In addition, in the learning process, the experimental group was given worksheets with the help of IRWT, which is part of the learning process to improve student's reading and writing literacy. Several parts of the worksheets are included in the IRWT, namely the reading section, conceptual construction, mind mapping, and conclusion.

This is also reinforced by the results of the student worksheets in the reading and writing literacy section, which has different average scores, namely 87.50 for the experimental group and 75.83 for the control group. It is shown that the results of the worksheets in the reading and writing literacy section for the experimental group have higher results than the results of the worksheet in the reading and writing literacy section for the control group.

In this study, it was found that students' reading and writing literacy had increased using the PBL model with the help of IRWT for the experimental group. This shows that the IRWT can improve students' reading-writing literacy.

Furthermore, the results obtained from the two-average difference test using the Mann-Whitney U test showed that there were no differences in problem-solving skills, and there were differences in students' reading and writing literacy through Problem-based Learning with Integrated Reading and Writing Tasks. The next step is to find the effect size of Problem-based Learning with the Integrated Reading and Writing Task on physics problem-solving skills and students' reading and writing literacy using Cohen's d effect size. The following are the results of the Effect Size calculation for the physics problem-solving skill test, which are shown in Table 7.

Table 7. Results of Effect Size on the Physics Problem-solving Skills

Class	Experiment	Control
$\langle g \rangle$	0.67	0.65
STDev	0.19	0.18
S_{pooled}	0.18	
d	0.11	
Interpretation	Very Low	

The data in Table 7 shows the effect size value for the physics problem-solving skill test of 0.11, which is included in the very low category. This means that the Problem-based Learning learning model with the Integrated Reading and Writing Task has a very low effect on students' physics problem-solving skills. This is because the experimental and control classes get the same model learning (Problem-based Learning), which focuses on improving problem-solving skills. And the Integrated Reading and Writing Task doesn't impact problem-solving skills. Then the results of the effect size calculation for the reading-writing literacy test are shown in Table 8.

Table 8. Results of the Effect Size on the Reading and Writing Literacy

Class	Experiment	Control
$\langle g \rangle$	0.55	0.24
STDev	0.29	0.18
S_{pooled}	0.20	
d	1.26	
Interpretation	Very High	

The data in Table 8 shows the effect size value for the reading-writing literacy test of 1.26, which is included in the very high category. This means that the Problem-based Learning learning model with the Integrated Reading and Writing Task greatly affects students' reading and writing literacy. This is because the experimental and control classes get the same model learning (Problem-based Learning) but different literacy strategies (Integrated Reading and Writing Tasks) that focus on improving literacy skills. The implication of this research is the application of Problem-based Learning with an Integrated Reading and Writing Tasks model can be an option

for teachers in implementing physics learning which aims to improve students' physics problem-solving skills and reading-writing literacy.

CONCLUSION AND SUGGESTION

Based on the results of research and analysis of data obtained during the research activity entitled "The Effectiveness of Problem-based Learning with Integrated Reading and Writing Tasks to Improve Problem-solving Skills and Reading-Writing Literacy of High School Students," it was concluded that there was no significant difference in the N-gain average of the problem-solving skills test results. There is a significant difference in the N-gain average of the student's reading and writing physics literacy test results between the experimental and control groups. Furthermore, the Problem-based Learning model with the Integrated Reading and Writing Task effectively improves students' problem-solving skills and reading-writing literacy.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this work. IS, PS, and ES conceptualize ideas, prepare the design, present research data and figures, and compile abstracts and conclusions.

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