The Effect of Problem-Based Learning Assisted by Video on Student's Scientific Literacy and Problem-Solving Ability in Eight-Grade of Junior High School

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***Abstract*—This study addresses the persistent issue of low Scientific Literacy (SL) and Problem-Solving (PS) abilities among secondary school students. The research aims to examine the effect of Problem-Based Learning (PBL) assisted by video on students' SL and PS abilities, assess the improvement in these competencies, and explore their correlation in the context of science learning. A quasi-experimental design with a pretest-posttest nonequivalent control group was applied in two junior high schools in Medan, involving 13–14-year-old students. Two classes from each school were randomly selected, with one class in each school assigned as the experimental group and the other as the control group. Students' SL and PS were measured using a 20-item multiple-choice test and a five-item essay test, respectively. Multivariate Analysis of Covariance (MANCOVA) results showed a significant effect of video-assisted PBL on both SL and PS. The approach enhanced students' comprehension by visualizing abstract concepts and engaging them in real-life scientific problems. Cohen's d effect sizes ranged from 2.18 to 3.81, indicating a strong impact. A positive correlation was observed between SL and PS in both schools, with correlation coefficients of 0.595 in School X and 0.892 in School Y. N-gain analysis also confirmed greater improvements in the experimental group, categorized as high, compared to the low improvement seen in the control group. These findings support the effectiveness of video-assisted PBL in fostering higher-order thinking skills and scientific understanding in junior high school science education.**

***Keywords*—Problem-Based Learning (PBL), video, conventional, scientific literacy, Problem Solving (PS)**

I. Introduction

In the 21st century, the world is inundated with easily accessible information, making it essential for individuals to develop the ability to access, manage, and apply this information effectively to remain competitive. One way to develop these skills is through learning Natural Sciences in school, which play a crucial role in enhancing students' scientific literacy and problem-solving abilities. Thus, science education should be prioritized by educators and policymakers, as it plays a vital role in improving these aspects [1].

The Program for International Student Assessment (PISA) in 2018 defines scientific literacy as the ability of individuals to engage with science-related issues and ideas as reflective citizens [2]. Scientific literacy is needed by students to face global issues in the 21st century, and the role of students needs to be formed through scientific literacy through science learning. According to PISA (2022), scientific literacy includes the competency to (a) explain scientific phenomena, (b) evaluate and design scientific investigations, and (c) interpret scientific data and evidence. These competencies are categorized into aspects of context, knowledge, and competence [3].

Indonesia's PISA score in 2022 was 383, significantly below The Organization for Economic Cooperation and Development (OECD) average of 485, indicating that many Indonesian students face difficulties in understanding scientific concepts and procedure, as well as applying them in daily life [3]. Additionally, research also highlights widespread misconceptions among Indonesian students regarding science topics, which further impede their understanding and application of scientific knowledge [4].

Improving students' scientific literacy is crucial for enabling them to apply acquired knowledge and address global challenges through effective problem-solving. Recent studies have underscored the importance of integrating Socio Scientific Issues (SSI) into science education to promote functional scientific literacy [5]. Scientific literacy enhances informed decision-making and foster problem-solving abilities critical for addressing complex real-world issues [6].

Exploring scientific literacy abilities is an integral aspect of science learning. However, science education also recognizes the importance of thoughtful and critical problem-solving abilities. This skillset is essential for students, as they continually encounter diverse problems [7]. In addition to scientific literacy, problem-solving is another crucial competency in science education. It involves the ability to formulate and apply mental representations of problems to derive solutions across various contexts [8]. However, the 2015 Third International Mathematics and Science Study (TIMSS) results showed that Indonesian students' problem solving abilities were relatively low, with Indonesia ranking 45th out of 50 participating countries [9], underscoring the urgent need to develop this skills in students. Problem-solving engages critical thinking and creativity, enabling students to identify issues and devise innovative solutions [10].

Field observations conducted on March 24, 2023, at two public junior high schools in Medan, North Sumatra, revealed that science often lacks emphasis on developing students' scientific literacy and problem-solving skills. The study was conducted at two schools (School X and Y), where Junior High School X (School X) represents public junior high schools in Medan city, while Junior High School X School Y represents public junior high schools located in the suburbs of Medan. The observations from both schools indicate that several contributing factors were identified: (1) teacher-centered instruction focused on memorization of concepts, which makes students less active; (2) limited use of learning videos; (3) absence of contextual phenomena; (4) inadequate laboratory-oriented scientific activities; (5) lack of training for students in expressing scientific opinions on and solving real-life problems; (6) insufficient training with scientific and problem-solving-based assessment. These issues reflect previous findings which highlight that traditional, teacher-centered approaches may hinder students' problem-solving and decision-making abilities [11, 12]. Additionally, factors such as the learning environment and school administrative support play a crucial role in influencing students' scientific literacy skills [13]. This assertion was supported by Shohib *et al*. [14], who contend that the low of students' Problem-Solving (PS) ability in conventional learning environments is due to a lack of exposure to concrete problems.

The traditional teaching approach commonly used by teachers does not actively engage students in learning and is unsuitable for today's learning environment. One contributing factor to the lack of student engagement is the use of ineffective learning materials. Instruction is often limited to the blackboard and occasional PowerPoint presentations, with minimal use of learning videos. For instance, teachers rarely incorporate videos to explain complex biological processes, such as urine formation, which could be more effectively understood through visual representation. Videos can present objects and events in real time, capturing students' attention and enhancing comprehension during instruction. Moreover, videos allow learners greater control over their learning experiences and offer a variety of cognitive benefits [15]. Another major shortcoming of the current instructional approach is the absence of contextual learning that connects scientific concepts to everyday life. Scientific literacy, defined as the ability to apply scientific knowledge in real-world contexts, is closely tied to contextual learning [16, 17]. Without this connection, students' scientific literacy skills remain underdeveloped, and opportunities to practice problem-solving are limited. Research shows that traditional methods, such as lectures and rote memorization, continue to dominate science education. These approaches restrict students' engagement with real-life issues and hinder the development of critical thinking and problem-solving skills [18]. The learning process is not designed to address or solve problems, even though science education is inherently rich with everyday problem contexts [11, 19].

To provide students with meaningful and in-depth learning experiences, instructors must employ innovative strategies in selecting and implementing appropriate instructional models. Such approaches stimulate student engagement and enhance the learning process, thereby fostering the development of scientific literacy and problem-solving abilities. One effective instructional model for promoting these skills is Problem-Based Learning (PBL) [20, 21]. PBL has been widely recognized as a student-centered approach that encourages inquiry, collaboration, and real-world problem solving. However, the successful implementation of PBL in science education depends on the availability of appropriate resources. A major challenge is the limited use of engaging instructional media, which can hinder students' understanding of complex scientific concepts.

To address this challenge, PBL assisted by video has emerged as a promising instructional approach. Research suggests that integrating videos into PBL can enhance students' conceptual understanding, provide real-life contextualization, and increase engagement [22]. Videos help students visualize abstract scientific concepts, making learning more accessible, interactive, and meaningful. Several studies have demonstrated the effectiveness of video-assisted learning in improving students' comprehension and problem-solving skills [23, 24]. However, despite these potential benefits, there is still limited research that systematically investigates the impact of PBL assisted by video on scientific literacy and problem-solving ability, particularly among junior high school students.

Traditional science instruction often fails to develop students' scientific literacy and problem-solving skills, as it typically emphasizes textbook-based learning with limited opportunities for active engagement and contextual understanding [25, 26]. Although PBL has been extensively studied and recognized for its ability to promote higher-order thinking and student engagement, its integration with video-assisted media remains underexplored, particularly in junior high school science education. Research has shown that video-assisted PBL can enhance students' scientific literacy, critical thinking, and perseverance by creating interactive and engaging learning environments [24]. This study aims to address this gap by examining the impact of PBL assisted by video on students' scientific literacy and problem-solving abilities in the context of the Human Excretory System.

This research contributes to the broader field of science education by providing empirical evidence on the effectiveness of video-assisted PBL. The findings offer valuable insights for educators and policymakers seeking innovative teaching strategies that foster student engagement, deepen conceptual understanding, and improve problem-solving skills. Moreover, the study supports the integration of multimedia tools in science instruction, aligning with global trends toward technology-enhanced learning.

The study aims to: 1) analyze the effect of PBL assisted by video on students' Scientific Literacy (SL) and PS abilities through Multivariate Analysis of Covariance (MANCOVA) analysis, 2) measure the improvement in students' SL and PS abilities resulting from the application of PBL assisted by video, 3) explore the correlation between students' SL and PS abilities in science learning with PBL assisted by video.

II. Literature Review

A. *Problem-Based Learning (PBL)*

Problem-Based Learning (PBL) is a learning model that involves tackling real and engaging problems to enable students to consolidate their knowledge, enhance their problem-solving skills, and develop solutions [18]. PBL is a student-centered approach that encourages learners to use scientific methods, with the teacher acting as a facilitator [27]. Unlike traditional teacher-centered instructions, PBL fosters active learning by encouraging students to identify problems, generate hypotheses, and collaboratively develop solutions while teachers guide the process [28]. In the PBL setting, students worked in groups to resolve presented problems by drawing on their prior knowledge and acquiring new, relevant information [15, 19]. The PBL cycle can be adapted to suit specific school environments and context [20]. By focusing on real-world problems and questions, PBL encourages students to apply scientific concepts and principles to solve problems, promoting scientific literacy and problem-solving abilities.

B. The Effectiveness of PBL in Enhancing Scientific Literacy and Problem-Solving Ability

Numerous studies support the effectiveness of PBL in enhancing students' scientific literacy. Research indicated that PBL improves students' ability to evaluate and interpret scientific information, skills that are integral to scientific literacy [21, 22, 29].

Furthermore, the PBL model has been widely recognized for its effectiveness in developing students' problem-solving abilities. The PBL model guides students through the structured problem-solving experiences [24]. According to Kim *et al*. [25], the investigation stage of the PBL syntax involves data collection, hypothesis formulation, and solution generation, all of which strengthen students' problem-solving competencies. Multiple studies affirm that PBL is a powerful approach for fostering students' problem-solving abilities [17, 26–33].

C. The Role of Video-Assisted Learning in PBL

To maximize the benefits of PBL, educators have increasingly integrated video-assisted learning, which provides students with both visual and auditory stimuli to support their understanding of complex topics [30]. Videos offer dynamic and engaging learning experiences that allow learners to visualize abstract ideas and enhance comprehension [31]. By incorporating videos into their lessons, instructors can provide students with greater control over their learning; they can pause, rewind, or fast-forward as needed [32]. Research consistently shows that incorporating video clips positively impact students' comprehension of scientific content [33]. Therefore, educators are encouraged to utilize collaborative, video-based instructional materials to support inquiry-based learning environments. In this study, video-assisted PBL was employed to enhance students' scientific literacy and problem-solving abilities. Additionally, video-assisted learning allows students to review content at their own pace, thereby reinforcing conceptual understanding and promoting deeper learning [34].

Although previous studies have explored the benefits of PBL and video-assisted learning independently, limited research has investigated their combined impact on scientific literacy and problem-solving ability at junior high school level. For instance, Putri *et al*. [35] examined the effectiveness of interactive videos with PBL in elementary school settings and found improved student engagement and conceptual understanding. However, their study did not assess the direct correlation between scientific literacy and problem-solving abilities in secondary education. Similarly, Nicholus *et al*. [30] explored video-based PBL approach and its impact on academic performance and critical thinking among Ugandan secondary school students. While the study emphasized video's contribution to foster critical thinking skills, it did not specifically evaluate scientific literacy or problem-solving ability as specific learning outcomes.

In contrast, the present study uniquely integrates PBL with video to directly investigate its effects on both scientific literacy and problem-solving ability among junior high school students. Focusing on the Human Excretory System topic, this research evaluates not only students' conceptual understanding but also the correlation between their scientific literacy and problem-solving skills within the PBL framework. While previous studies have highlighted the effectiveness of interactive media in learning, this study provides empirical evidence on how video-assisted PBL enhances student performance across multiple cognitive domains. It addresses a significant gap in the literature by systematically investigating the dual impact of this integrated approach on scientific literacy and problem-solving.

III. Materials and Methods

This study employed a quasi-experimental method using a pretest-posttest nonequivalent control group design, involving 2 classes per school: Grade Eight-1 in school X and Grade Eight-2 in school Y as the experimental group (using PBL assisted by video (x_1)), and Grade Eight-4 in school X and Grade Eight-5 in school Y as the control groups (using conventional learning (x_2)). Each class in school X consisted of 30 students, while each class in school Y consisted of 29 students. The research design is presented in Table 1.

Table 1. Research design pretest-posttest nonequivalent control group

Class	Pretest	Treatment	Posttest
Experimental	O_1	X_1	O_3
Control	O_2	X_2	O_4

X_1: Implementation of Problem-Based Learning (PBL) assisted by video; X_2: Conventional learning; O_1: Pre-test of students' Scientific Literacy (SL) and Problem-Solving (PS) before the application of PBL assisted by video; O_2: Pre-test of students' SL and PS before the application of conventional learning; O_3: Post-test of students' SL and PS solving after the application of PBL assisted by video; O_4: Post-test of students' SL and PS solving after the application of conventional learning.

The population included two junior high schools in Medan, School X (located in the city of Medan) and School Y (located in the outskirts of Medan). Purposive sampling was used to select classes with comparable academic levels and learning environments. Each class in School X comprised 30 students, while each class in School Y had 29 students, resulting in a total sample of 118 students aged 13–14 years.

The research instruments used in this study consisted of a SL and a problem-solving test. A SL test consists of 20 multiple-choice questions (four options each), assessing students' ability to explain scientific phenomena, evaluate and design scientific inquiries, examine and interpret data, and utilize scientific knowledge in practical situations. Each correct answer was worth 5 points, with a total score of 100. A PS test is 5 open-ended essay questions based on real-life problems related to the Human Excretory system. Each question was assessed across five phases: identifying the problem, describing the problem, planning a solution, implementing the solution, and evaluating the solution. Each phase was rated on a 1-to-4-point scale, resulting in a maximum of 20 points per question and an overall potential score of 100.

To ensure validity and reliability, three independent evaluators, including two science education experts and one practicing science instructor, reviewed the instruments. Content validity was established through expert judgment, where three validators (two lecturers and one teacher) reviewed the accuracy of test items in relation to their indicators, item construction, and language clarity. Predictive validity was tested using a sample of 29 students from school X (Class Grade Eight-10) who had previously studied the material. The Kuder-Richardson formula (KR-20) was used to calculate the reliability of the test instrument, ensuring internal consistency and accuracy in assessing students' scientific literacy and problem-solving skills. The scientific literacy test obtained a reliability score of 0.70 (acceptable), while the problem-solving ability test had a reliability score of 0.81 (high). From 21 SL questions tested, 20 were deemed valid based on difficulty level (easy, moderate, very difficult) and discrimination index (good, deficient, enough). For problem-solving ability, out of seven tested questions, three met the validity, reliability, difficulty, and discrimination index criteria and were included in the study.

The study involved four learning sessions (excluding pre-tests and post-tests). Before carrying out the treatment, both the experimental group (who received video-enhanced Problem-Based Learning) and the control group (who received traditional teaching) completed a pretest questionnaire to evaluate their initial SL and PS skills related to the topic of Human Excretory System. The control group received conventional teaching through teacher-led instruction, PowerPoint presentations, textbook explanations, and class discussion. In contrast, the experimental group received a PBL method supported by video, involving problem-solving scenarios and visual representations of biological processes. The lessons included problem-solving activities or real-world applications. Each group included video-based problems scenarios and guided students' investigations through worksheets. After treatment, both groups took a post-test questionnaire to assess their final SL and PS abilities and to evaluate the impact of each teaching method on students' learning outcomes.

In this study, the independent variable was science instruction using PBL assisted by video, while the dependent variables were scientific literacy and problem-solving ability. The study was conducted in three stages. The first stage involved research preparation, the second stage involved implementation, and the third stage constituted the final stage. The flowchart of the research stages is shown in Fig. 1, and the detailed stages are presented in Table 2.

The stages of learning with the application of PBL assisted by video are presented in Table 3.

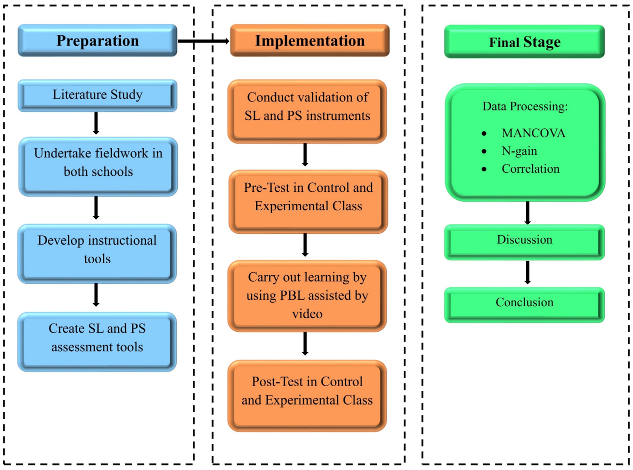


Fig. 1. Research flowchart.

Table 2. Research stages

Num.	Phase	Activity
1.	Research Preparations	Conducted a literature study related to the research. Field studies were conducted at both schools through observations, interviews, document reviews, and initial testing. Observations focused on science teaching practices, while interviews with teachers and selected students explored their experiences with scientific literacy and problem-solving. Document analysis was also carried out to review existing teaching materials. Prepared learning tools such as problem-based lesson plans and student worksheets, learning videos that presented problems related to Human Excretory System material, science literacy-based teaching materials, and scientific literacy and problem-solving test instruments. Developed scientific literacy and problem-solving test instruments based on real problems in students' lives.
2.	Research Implementation	Scientific literacy and problem-solving instruments were validated through two stages: content and construct validation. - Content validation was conducted by experts in science and education, who evaluated each item based on content accuracy, structure, and language clarity. - Construct validation involved testing the instruments on students from a different school who had previously studied the Human Excretory System. This process assessed the validity, reliability, difficulty level, and item discrimination. Carried out pretests of scientific literacy and problem-solving in control and experimental classes. Implemented learning using problem-based learning assisted by video. Conducted posttests of scientific literacy and problem-solving in control and experimental classes.
3.	Final Research	Data from the sample classes were analyzed using the MANCOVA test to examine the effect of video-assisted PBL on students' scientific literacy and problem-solving abilities. N-gain analysis was used to determine the percentage of improvement, while a correlation test was applied to explore the relationship between the two abilities. All analyses were conducted under the assumption that the data were normally distributed and homogeneous. Drew research conclusions.

Table 3. Stages of application of PBL assisted by video on scientific literacy and problem-solving ability

PBL Phases	Activity
Phase 1: orient students to the problem	The researcher explained the learning goals and helped students build science skills. These skills included understanding and explaining scientific events and interpreting data to solve problems. The students watched learning videos that showed different problems: (1) "Acute Renal Failure in Children in Indonesia" in the first meeting, (2) "Excessive Sweating of the Skin" in the second meeting, (3) "Pneumonia in Children" in the third meeting, and (4) "Hepatitis Disease in Children" in the fourth meeting. Students were asked to identify and ask questions about these problems. However, only a few students were

PBL Phases	Activity
	able to fully explore and describe the issues, including their causes. The initial findings showed many cases of acute kidney failure in children in Indonesia due to kidney function failure. Although this issue was common, many students did not know its causes, solutions, or how to prevent it.
Phase 2: organize students for study	The researcher assisted students use reading and writing skills to define and organize learning tasks about the problem. In the second stage of PBL, students explored scientific literacy. They started by gathering information related to the problems shown in learning videos. In this phase, students worked in groups and learned to collaborate. The researcher divided the students into six groups, each with 4–5 members. During this phase, students' scientific literacy was assessed by their ability to explain acute kidney failure using information from the videos and teaching materials. These materials provided more details about the video content and real-life situations.
Phase 3: assist independent and group investigation	The researcher guided students in locating relevant information using the teaching materials and student books. Students conducted experiments to address previously introduced problems. This helped them enhance their understanding of scientific concepts and the problem-solving process. At this stage, students were able to (a) explain scientific ideas, (b) evaluate and plan investigations, and (c) interpret data and evidence. In the third phase, students strengthened their problem-solving skills by identifying problems, planning solutions, implementing them, and evaluating their outcomes. The researcher facilitated students working independently or in groups using worksheets that required research, data analysis, and critical thinking.
Phase 4: develop and present artifacts and exhibits	The researcher supported students in presenting their problem-solving results. Each group presented their findings to the class, while their peers listened and provided feedback. This activity enhanced both scientific comprehension and collaborative skills. In the fourth phase, students showcased their projects as part of the problem-solving task. They explained their findings and responded to workbook questions that reinforced key concepts and deepened their understanding.
Phase 5: analyze and evaluate the problem-solving process	The researcher encouraged students to reflect on and evaluate their problem-solving process. Students compared their work with that of other groups and consulted additional resources. This reflection reinforced their scientific understanding and critical thinking. In the final phase, the researcher guided students through reviewing and revising their work to ensure clarity and accuracy. For example, after examining kidney failure cases, students verified the correctness of their solutions and conclusions.

The sub-materials studied for each meeting are presented in Table 4.

Table 4. Learning meetings and problem-based scenarios in the human excretory system

Meeting	Topic	Learning Focus	Problem-Based Case Study
I	Kidney Structure and Function	Understanding kidney anatomy, functions, common disorders, and preventive measures	Acute Renal Failure in Children in Indonesia
II	Lung Structure and Function	Exploring lung anatomy, respiratory disorders, and strategies to maintain lung health	Pneumonia in Children
III	Skin Structure and Function	Examining skin physiology, dermatological disorders, and skin care practices	Excessive Sweating of the Skin
IV	Liver Structure and Function	Studying liver functions, liver-related diseases, and preventive healthcare	Hepatitis Disease in Children

The data were analyzed using the MANCOVA test, normalized gain (N-Gain), and correlation of students' scientific literacy and problem-solving ability. The percentage improvement in scientific literacy and problem-solving ability was analyzed by conducting an average N-Gain score.

$$N\text{-gain}\ (\%) = \frac{\text{posttest average-pretest average}}{\text{maximum score-pretest average}} \times 100$$

The N-gain values obtained can be categorized into several categories. The value categories of N-gain are listed in Table 5.

Table 5. N-gain categories [36]

N-gain Score (%)	Category
$g > 70$	high
$30 < g \leq 70$	moderate
$g \leq 30$	low

Additionally, effect size was calculated to determine the magnitude of the effectiveness of the applied learning method. The effect size (d) was measured using the formula:

$$d = \frac{\overline{X_T} - \overline{X_C}}{S_{pooled}} \quad or \quad d = \frac{Ngain_T - Ngain_C}{SD_{Pooled}}$$

with

$$S_{pooled} = \sqrt{\frac{(n_T - 1)S_T^2 + (n_C - 1)S_C^2}{n_T + n_C - 2}}$$

Explanation:
$\overline{X_T}$: Average score of treatment class;
$\overline{X_C}$: Mean score of control class;
S_{pooled}: Standard deviation;
$Ngain_T$: N-gain of treatment class;
$Ngain_C$: N-gain of control class;
S_T: Standard deviation of experimental class;
S_C: Standard deviation of control class;
n: Number of subjects;
d: Effect size [37].
The effect size test categories are presented in Table 6.

Table 6. Effect size test interpretation categories [38]

< d > (%)	Category
$d \geq 0.80$	high
$50 \leq d < 80$	medium
$d < 50$	low

IV. Result

A. *The Effect of PBL Assisted by Video on Students SL and PS Ability*

The data recapitulation of students' SL and PS abilities in the control and experimental classes at School X and Y is presented in Table 7.

Based on Table 7, differences in students' scores between the control and experimental classes can be observed through the minimum and maximum values, followed by the average score and standard deviation.

To determine whether the data met the assumption for further analysis, normality tests were conducted on the pretest and post-test scores of scientific literacy and problem-solving ability in the control and experimental classes. The Shaphiro-Wilk test results, as presented in Table 8, indicate that all data in both control and experimental classes followed a normal distribution, with significance values greater than 0.05.

Table 7. Recapitulation data of students' SL and PS ability

Schools	Category	Data	Class	Number of Students	Minimum Score	Maximum Score	Mean	Standard Deviation
X	Scientific Literacy	Pretest	Control	29	10	35	22.67	8.38
			Experiment		15	45	27.33	8.17
		Posttest	Control		40	75	52.83	9.70
			Experiment		65	90	80.67	5.83
	Problem Solving Ability	Pretest	Control		17	63	41.57	12.05
			Experiment		27	61	36.16	11.26
		Posttest	Control		40	75	60.30	10.92
			Experiment		71	97	83.76	8.88
Y	Scientific Literacy	Pretest	Control	30	5	25	20.00	5.72
			Experiment		10	35	25.83	7.55
		Posttest	Control		30	70	49.67	11.93
			Experiment		65	85	80.17	4.44
	Problem Solving Ability	Pretest	Control		15	49	37.27	10.24
			Experiment		16	52	35.8	10.77
		Posttest	Control		33	72	56.33	11.41
			Experiment		71	91	82.37	6.75

Table 8. Normality test of scientific literacy and problem-solving ability data for control and experiment classes

School	Variable	Group		Shapiro-Wilk			Normality Assumption
				Statistic	df	Sig. (*p*-value)	
X	Scientific Literacy	Control	Pretest	0.942	29	0.112	normal
			Posttest	0.938	29	0.087	normal
		Experiment	Pretest	0.936	29	0.077	normal
			Posttest	0.931	29	0.059	normal
	Problem-Solving Ability	Control	Pretest	0.958	29	0.298	normal
			Posttest	0.929	29	0.052	normal
		Experiment	Pretest	0.963	29	0.398	normal
			Posttest	0.950	29	0.188	normal
Y	Scientific Literacy	Control	Pretest	0.942	30	0.101	normal
			Posttest	0.952	30	0.194	normal
		Experiment	Pretest	0.942	30	0.104	normal
			Posttest	0.931	30	0.052	normal
	Problem-Solving Ability	Control	Pretest	0.979	30	0.795	normal
			Posttest	0.948	30	0.193	normal
		Experiment	Pretest	0.965	30	0.408	normal
			Posttest	0.939	30	0.086	normal

Furthermore, a homogeneity test was performed using Levene's Test with the assistance of SPSS software to assess the equality of variances between the control and experimental groups. The results, as shown in Table 9, reveal that the data were homogeneous for both SL and PS, as significance values exceeded 0.05.

Table 9. Homogeneity test of scientific literacy and problem-solving ability data for control and experiment classes

School	Variable	Levene's Statistic	Sig. (*p*-value)	Homogeneity Assumption
X	Scientific Literacy	2.597	0.113	Homogeneous
	Problem-Solving Ability	0.976	0.328	Homogeneous
Y	Scientific Literacy	1.782	0.154	Homogeneous
	Problem-Solving Ability	2.443	0.068	Homogeneous

Additionally, a linearity test was conducted to examine the linear relationship between SL and PS, which is a fundamental assumption for conducting further analyses, including regression and MANCOVA. The results in Table 10 indicate that the relationship between SL and PS in all groups and schools is linear, with *p*-values greater than 0.05.

To examine the impact of the PBL intervention assisted by video, a MANCOVA was conducted. This analysis assessed whether the implementation of PBL significantly affected students' SL and PS abilities while controlling for relevant covariates. As shown in Table 11, the result indicated a significant effect of PBL assisted by video on both variables in school X (Wilks' Lambda = 0.149, F = 150.771, $p < 0.001$, $\eta^2 = 0.851$) and school Y (Wilks' Lambda = 0.201, F = 109.543, $p < 0.001$, $\eta^2 = 0.799$). Specifically, the study focused on evaluating the effectiveness of PBL assisted by video in enhancing students' understanding of the Human Excretory System, including the Kidney, Liver, Skin, and Lungs, after four instructional lessons.

Table 10. Linearity test of scientific literacy and problem-solving ability data for control and experiment classes

School	Variable	Group	F-value (Deviation from Linearity)	Sig. (*p*-value)	Conclusion
X	Scientific Literacy	Control	4.038	0.057	linear
		Experiment	3.039	0.094	linear
	Problem-Solving Ability	Control	4.554	0.077	linear
		Experiment	1.477	0.252	linear
Y	Scientific Literacy	Control	0.084	0.775	linear
		Experiment	3.494	0.074	linear
	Problem-Solving Ability	Control	0.014	0.907	linear
		Experiment	1.931	0.188	linear

Table 11. Results of MANCOVA test for scientific literacy and problem-solving ability of both school

Schools	Class	Effect	value	F	Hypothesis df	Eror df	p	Partial η^2
X	Class	Wilks' Lambda	0.149	150.771[b]	2.000	53.000	0.000	0.851
Y			0.201	109.543[b]	2.000	55.000	0.000	0.799

[b] The F statistic is based on Wilks' Lambda.

Based on the post-test outcomes from the MANCOVA test, it can be concluded that there is a statistically significant effect of the application of PBL assisted by video on students' scientific literacy and problem-solving ability related to the material of the Human Excretory System in both school X and school Y in Medan city, with a significance level of α = 0.05. A small Wilks' Lambda value coupled with a significant p-value ($p < 0.05$) suggests that the experimental treatment significantly influenced the dependent variables. Furthermore, the high Partial Eta Squared values indicate a strong effect of the intervention on students' SL and PS abilities.

B. The Improvement of Students Scientific Literacy Ability through PBL Assisted by Video

The improvement in scientific literacy was measured using normalized gain (N-gain), as shown in Table 12.

Table 12. Improvement of scientific literacy

Schools	Class	N-gain (%)	Category
X	Control	39	medium
	Experiment	73	high
Y	Control	28	low
	Experiment	51	medium

According to the results presented in Table 12, the experimental class at School X showed a 73% increase (high category), while the control class demonstrated a 39% increase (medium category) In contrast, at School Y, the experimental class achieved a 51% improvement (medium category), and the control class demonstrated a 28% increase (low category).

Further analysis of N-gain per indicator for scientific literacy ability is shown in Table 13.

Table 13. Percentage improvement of N-gain of scientific literacy ability per indicator

School	Scientific Literacy Competency Indicators	Experiment Class		N-gain (%)	Category	Control Class		N-gain (%)	Category
		Pretest	Posttest			Pretest	Posttest		
X	Explaining scientific phenomena	32	84	76	high	25	60	38	medium
	Evaluate and design scientific investigations	24	84	69	medium	22	50	28	low
	Interpret data and evidence scientifically	23	79	72	high	15	55	41	medium
Y	Explaining scientific phenomena	31	81	73	high	32	58	33	medium
	Evaluate and design scientific investigations	22	79	60	medium	24	38	12	low
	Interpret data and evidence scientifically	24	78	69	medium	22	53	35	medium

In both schools, the highest improvement was found in the indicator "Explaining Scientific Phenomena" by 76% in school X and by 73% in school Y, both in the high category.

Table 14. Percentage improvement of N-gain of problem-solving ability

Schools	Class	N-gain (%)	Category
X	Control	24	low
	Experiment	74	high
Y	Control	22	low
	Experiment	69	medium

The percentage improvement of N-gain in problem solving ability is shown in Table 14.

The N-gain of problem-solving ability in School X, where PBL assisted by video was applied, was 72% (high) in the experimental class and 24% (low) in the control class. Similarly, in School Y, the N-gain of problem-solving ability in the experimental class was 69% (medium) and in the control class was 22% (low). Problem-Solving ability (PS) was measured using five indicators: recognizing problems, describing problems, planning solutions, implementing solution plans, and evaluating solutions. The percentage increase in N-gain for PS ability per indicator in both experimental and control classes is presented in Table 15. As shown in Table 16, the experimental class demonstrated significantly better performance in PS ability than the control class.

Table 15. Percentage of N-gain improvement of problem-solving ability per indicator

Schools	Problem Solving Indicator	Experiment Class		N-gain (%)	Category	Control Class		N-gain (%)	Category
		Pretest	Posttest			Pretest	Posttest		
X	Examining the problem	59	88	71	high	20	30	28	low
	Defining the problem	46	87	76	high	18	27	15	low
	Planning the solution	31	81	72	high	24	26	22	low
	Implement the plan that has been made	21	66	54	medium	26	29	19	low
	Evaluate the solution result	17	74	67	medium	28	50	26	low
Y	Examining the problem	46	85	70	medium	16	26	24	low
	Defining the problem	30	84	73	high	18	27	15	low
	Planning the solution	24	77	66	high	19	25	22	low
	Implement the plan that has been made	12	59	52	medium	16	35	19	low
	Evaluate the solution result	25	74	61	medium	15	41	24	low

The experimental classes in both schools showed the highest improvement in N-gain the "Defining the Problem" indicator, with an N-gain score of 76% in school X and 73% in school Y, both in the high category, a good understanding of a concept was achieved by students. The lowest improvement was observed in the "Implementing the Plan" indicator, with 54% (moderate) in school X and 52% (moderate) in school Y. This is indicating that there were several students who lacked the ability to select and explain fully the most appropriate solution for problem solving.

C. Effect Size of PBL Assisted with Video on Scientific Literacy and Problem-Solving Ability

To determine the magnitude of the impact of PBL assisted with video on students' SL and PS ability, the effect size was calculated using Cohen's d. This measure helps to evaluate the strength of the intervention in influencing students' learning outcomes. Based on the standard of Cohen's [38] guidelines categories, the calculated effect sizes for both schools are presented in Table 16.

Table 16. Effect size of PBL assisted with video on scientific literacy and problem-solving ability

School	Variable	Cohen's d	Effect Size Interpretation
X	Scientific Literacy	3.81	Large
	Problem-Solving Ability	2.18	Large
Y	Scientific Literacy	3.14	Large
	Problem-Solving Ability	2.45	Large

As shown in Table 16, all values exceed 2.0, which is significantly higher than the conventional threshold of 0.8, indicating large effect sizes for students' scientific literacy and problem-solving ability in both schools.

In both schools, the effect size for scientific literacy is extremely large (3.81 in School X and 3.14 in School Y). These results suggest that students in the experimental class demonstrated significantly higher scientific literacy skills compared to the control group. The higher effect size in School X indicates that the intervention was slightly more impactful in this setting, which could be attributed to differences in instructional implementation, student demographics, or prior knowledge levels.

However, the effect size for problem-solving ability also falls in the large range (2.18 in School X and 2.45 in School Y), demonstrating the intervention's effectiveness in fostering students' analytical and critical thinking skills. Interestingly, the effect size in School Y is slightly higher for problem-solving ability compared to scientific literacy, suggesting that students in this school may have benefited more from the intervention in this specific domain.

D. Effect Size of PBL Assisted with Video on Scientific Literacy and Problem-Solving Ability per Indicator

Effect sizes were also calculated for each indicator within the scientific literacy and problem-solving domains are summarized in Table 17 and Table 18.

As shown in Table 17, the highest effect size for SL was observed in the "Explaining Scientific Phenomena" indicator ($d = 1.54$ in School X) and ($d = 1.46$ in School Y), indicating that video-assisted PBL significantly enhanced students' ability to describe and comprehend scientific concepts. Following this, the effect sizes for "Evaluating & Designing Scientific Investigations" and "Interpreting Data Scientifically" were also large ($d > 1.4$), demonstrating that the intervention effectively improved students' abilities to critically analyze experiments and draw evidence-based conclusions.

Table 17. Effect size of PBL assisted with video on scientific literacy per indicator

School	Variable	Cohen's d	Effect Size Interpretation
X	Explaining Scientific Phenomena	1.54	Large
	Evaluate & Design Scientific Investigations	1.47	Large
	Interpret Data & Evidence Scientifically	1.42	Large
Y	Explaining Scientific Phenomena	1.46	Large
	Evaluate & Design Scientific Investigations	1.44	Large
	Interpret Data & Evidence Scientifically	1.41	Large

Table 18. Effect size of PBL assisted with video on problem-solving ability per indicator

School	Problem-Solving Indicator	Cohen's d	Effect Size Interpretation
X	Examining the Problem	2.04	Large
	Defining the Problem	2.00	Large
	Planning the Solution	1.90	Large
	Implementing the Plan	1.59	Large
	Evaluating the Solution	1.78	Large
Y	Examining the Problem	2.04	Large
	Defining the Problem	1.95	Large
	Planning the Solution	1.83	Large
	Implementing the Plan	1.56	Large
	Evaluating the Solution	1.72	Large

Similarly, Table 18 shows the highest effect size in problem-solving ability was found in "Examining the Problem" ($d = 2.04$ in both schools), suggesting that PBL with video significantly enhanced students' ability to identify key issues within scientific problems. Other indicators such as "Defining the Problem," "Planning Solutions," "Implementing the Plan," and "Evaluating Solutions") also recorded large effect sizes, ranging from 1.56 to 2.00.

These results confirm video-assisted PBL substantially enhanced students' performance across all key indicators of scientific literacy and problem-solving ability.

E. The Relationship between SL and PS Ability after the Implementation of PBL Assisted with Video

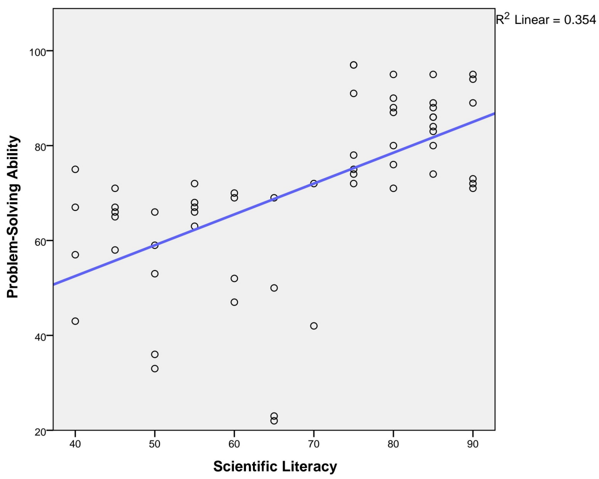


Fig. 2. Graph the relationship between SL and PS ability in school X.

Pearson correlation analysis by using SPSS was used to examine the relationship between students' scientific literacy and problem-solving ability after the intervention. The correlation between students' SL and PS ability illustrated in the correlation graphs for school X (Fig. 2) and school Y (Fig. 3).

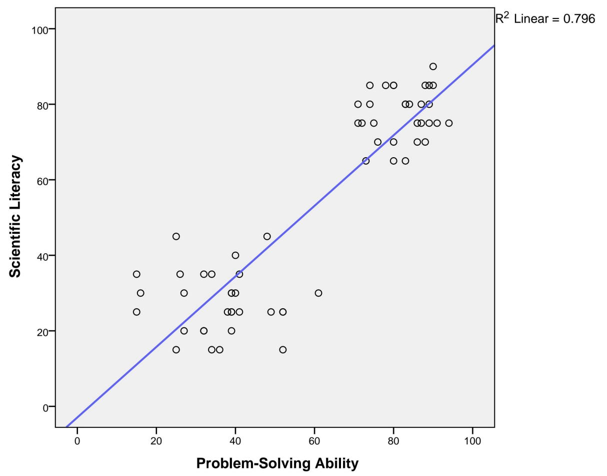


Fig. 3. Graph the relationship between SL and PS ability in school Y.

The Figures reveal a positive correlation between students' SL and PS ability in both Linear R-square (R^2) values of 0.354 (school X) and 0.796 (school Y), respectively.

V. Discussion

A. The Effect of PBL Assisted by Video on Students SL and PS Ability

The results of the post-test, analyzed using the MANCOVA test with $\alpha = 0.05$, indicate a significant impact of PBL assisted by video on students' SL and PS abilities in Human Excretory System in School X and School Y in Medan City. This finding aligns with Khoirulloh *et al.* [32], who stated that the PBL assisted by video effectively develops student's scientific literacy, which in turn enhances their ability to solve problems related to natural phenomena and their environment. The success of PBL assisted by video can be attributed to the contribution of each component in the PBL syntax.

Furthermore, the effect size analysis using Cohen's d supports the large impact of intervention on both SL and PS abilities. The effect sizes were consistently large, particularly in the indicator related to examining and defining problems. In both School X and School Y, students in experimental class showed significantly greater improvement than those in the control class. The large effect size in scientific literacy reflects that students became more proficient in understanding, interpreting, and applying scientific concepts, particularly in human biology. These results support previous studies emphasizing that PBL fosters inquiry-based learning and knowledge construction through exploration and problem-solving [1]. Moreover, the strong effect size in Problem-Solving abilities indicates that PBL strengthens students' ability to analyze complex issues, formulate strategic solutions, and evaluate outcomes effectively [33].

This finding is consistent with research by Putri *et al.* [35], who found that PBL assisted by interactive video improved scientific literacy among elementary students. Unlike their study, which did not incorporate scientific inquiry worksheets, this study provided junior high school students with structured worksheets to support their investigation. The findings are also in line with those of Salim *et al.* [39], who reported that PBL supported by animation media enhanced elementary students' problem-solving ability. However, this study integrated media and inquiry components using real-life videos and guided worksheets. Similarly, Simanjuntak *et al.* [11] found that PBL combined with computer simulation improved high school students' problem-solving and creative thinking skills. While they used simulation, this study applied authentic video problems contextualized in junior high curriculum topics. In addition, Distrik *et al.* [40] also demonstrated the value of integrating PBL with media, 3D-PageFlip worksheets with PBL in a blended setting. However, their study focused more on concept understanding and digital literacy, while the current study simultaneously improved SL and PS in a face-to-face classroom setting.

1st Meeting: Video display of the case "Acute Renal Failure in Children in Indonesia"

2nd Meeting: Video display of the case "Excessive Sweating of the Skin"

3rd Meeting: Video display of the case "Pneumonia in Children"

4th Meeting: Video display of the case "Hepatitis Disease in Children"

Fig. 4. Learning video display at each meeting.

In the first meeting, students explored the sub-topic "Kidney Structure and Function, Disorders, and Efforts to Maintain Kidney Health in the Human Excretory System.". Students were introduced to the problem by watching a video presenting several cases of acute kidney failure in Indonesian children, as depicted in Fig. 4.

Implementing PBL helped understand and apply concepts from the outset by presenting the with relevant, authentic problems. Khoirulloh *et al.* [32] highlighted that PBL assisted by video can significantly improve students' critical thinking abilities through structured inquiry-based learning. Similarly, Hasanah *et al.* [41] noted that video-assisted PBL boosts students' self-efficacy and creative thinking skills in science education.

During the initial phase of learning, students were trained to understand and explain scientific phenomena and interpret relevant scientific data. These scientific literacy skills were developed from the first phase of PBL, where students engaged with real-world problems [42]. Additionally, several studies have shown that integrating video assistance into PBL can significantly enhance students' scientific literacy [35, 43]. In this study, scientific literacy was fostered in students during the first phase by exposing them to real-life issues related to kidney failure, as illustrated in the accompanying video.

In the second phase of PBL assisted by video, students demonstrated knowledge acquisition by collecting relevant information about the problems they encounter in the environment and interpreting them with the basic knowledge they have [44]. In this phase, aspects of scientific literacy were explored.

In the third phase of PBL assisted by video, students further developed their scientific literacy abilities, including their ability to explain scientific phenomena and design solutions, such as identifying the connection between kidney failure and the urine formation process. The application of PBL assisted by video fosters the development of three scientific competencies, including identifying scientific issues, explaining phenomena scientifically, and utilizing scientific evidence [45]. Through this third phase, students also honed their problem-solving skills by planning, implementing, and evaluating the solutions. These outcomes align with several studies highlighting that PBL enables students to develop problem-solving abilities through group discussions and guided investigation [46, 47].

In the fourth phase, students presented their findings, further reinforcing their SL and PS skills. Yang and Oh [24] found that video-assisted PBL effectively enhances students' investigative skills, scientific literacy, and problem-solving competencies. By engaging in investigative activities, students enhanced their scientific literacy by gathering information from various sources and participating in Q&A sessions and evaluated alternative approaches to problems like kidney failure. By doing so, they gained a greater appreciation for the importance of maintaining kidney health as part of the human excretory system.

In the last PBL phase, students analyzed and evaluated the problem-solving process. PBL assisted by video facilitated students to assess both the outcomes and methods of their scientific literacy development [35] and problem-solving [48, 49]. For instance, one group had not clarified the link between kidney failure and kidney function due to inadequate attention to the instructional video or insufficient relevant literature, including the student textbook, teaching materials, and worksheets. To address these issues, the researchers provided guidance and feedback to help students improve their understanding and clarify misconceptions.

During the initial meeting, only a few students demonstrated scientific literacy and problem-solving abilities. Most students were hesitant to participate and struggled with finding relevant information to solve problems. These challenges were likely due to students' unfamiliarity with scientific inquiry and problem-solving learning. Additionally, some students were less cooperative and disruptive during group discussions, which hindered their ability to collaborate effectively.

By the second meeting on the sub-topic "Structure and Function of Lungs, Disorders, and Efforts to Maintain Lung Health in the Human Excretory System", students' engagement and understanding began to improve. Presented with the case of pneumonia in children in Indonesia, students could explain scientific phenomena, formulate scientific questions, and interpret data with evidence-based reasoning. This finding aligns with previous studies showing that PBL assisted by video encourages active engagement with scientific content and inquiry [35].

The third meeting focused on "Structure and Function of the Skin, Disorders, and Efforts to Maintain Skin Health in the Human Excretory System". There was a marked improvement in students' scientific literacy and problem-solving ability. When presented with a problem related to excessive sweating, they could describe scientific phenomena, develop scientific questions, interpret data, and present scientific evidence. For example, one student demonstrated their understanding of scientific concepts by explaining, "*Our body uses sweating as a natural temperature regulation mechanism. The process of evaporation helps cool the body when we sweat*.". This showcases the student's proficiency in accurately describing scientific processes. Another student exhibited their scientific inquiry skills by asking, "*Is there a connection between certain medical conditions and excessive sweating?*". This question highlights the student's ability to formulate pertinent scientific inquiries. Additionally, students analyzed a hyperhidrosis case and proposed potential treatments such as using antiperspirants or seeking medical advice. Regarding problem-solving skills, students worked together to develop strategies for managing excessive sweating. One team proposed, "*To address excessive sweating, one can wear breathable clothing and maintain good hygiene practices*", demonstrating their capability to apply science to everyday live. These improvements are consistent with Anantasuk [21] who suggested that the implementation of PBL can foster discussions and active participation, enhancing learning outcomes. Moreover, integrating PBL assisted by video has been shown to improve students' scientific literacy by engaging them in active learning and real-world problem-solving scenarios. This approach encourages students to take an active role in their learning, promoting deeper understanding and retention of information [50].

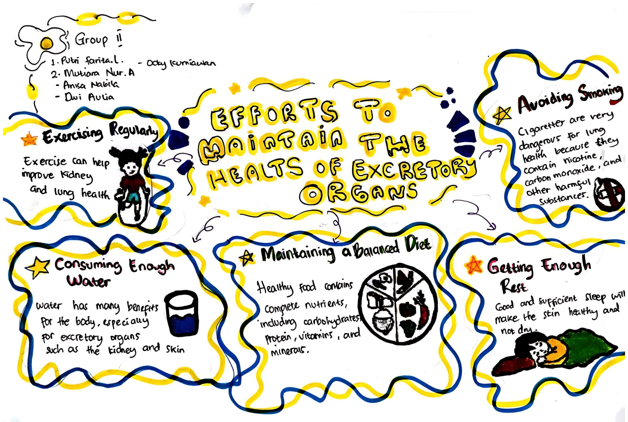


Fig. 5. A poster designed by students about the maintenance of the health of the human excretory system.

In the fourth meeting on "Structure and Function of the Liver, Disorders, and Efforts to Maintain Liver Health in the Human Excretory System", students exhibited significant improvement in SL and PS abilities. They analyzed a case about hepatitis in children, interpreted graphs, and created problem-solving posters as shown in Fig. 5. Poster presentations allowed students to summarize and communicate their understanding, fostering both deeper understanding and scientific communication. According to Rauschenbach *et al*. [51], engaging students in inquiry-based learning activities culminating in poster presentations enhanced their ability to conduct scientific investigations and communicate their findings effectively. This, in turn, has led to improved problem-solving abilities.

By the end of the fourth meeting, students displayed improved participation, conceptual understanding, and ability to complete problem-solving tasks. This is consistent with, Prastika *et al*. [52], who reported a noticeable improvement in students' scientific literacy after four PBL sessions.

PBL assisted by video during the first to fourth meetings proved to be an effective instructional strategy, consistently strengthening students' SL and PS abilities. These findings are aligned with broader research showing that this approach can foster scientific literacy and scientific understanding [45, 53]. As students become more familiar with scientific concepts through video-supported inquiry, their capacity to identify, analyze, and solve problems improves significantly. This aligns with research indicating that the problem-solving process involves understanding scientific phenomena, which then generates ideas [25].

B. The Improvement of Students Scientific Literacy Ability through PBL Assisted by Video

The findings show that the implementation of PBL assisted by video in schools in Medan resulted in higher gains in students' scientific literacy abilities compared to conventional learning. This is consistent with the findings of Refs. [54–56] , which suggest that PBL is more effective in enhancing scientific literacy than traditional methods. These results also align with recent studies indicating that PBL, especially when integrated with video assistance, effectively improves students' scientific understanding and problem-solving skills [57].

Based on the N-gain analysis, the experimental class showed an improvement of 51% (medium category), while the control class showed a 22% increase (low category). This indicates that students who received PBL with video experienced more substantial improvement in scientific literacy than those who received conventional instruction. The use of video-assisted PBL allowed for the integration of various multimedia components, such as visuals, narration, sound, and dynamic graphics, which made the learning environment more immersive and realistic. Incorporating multiple information modalities kept students engaged and supported a more holistic understanding of scientific concepts, enabling them to communicate ideas more effectively [28, 58, 59].

In particular, the highest N-gain was found in the indicator "Interpreting Data and Evidence", with improvements of 72% in School X (high category) and 69% in School Y (medium category). This improvement can be attributed to the visual reading materials that supplemented verbal explanation with tables, graphs, and images [60]. students were trained to interpret scientific data and evidence more effectively. They were directed to search for relevant information from various sources, including videos, books, teaching materials, and other sources. In line with Wang [61], who explained that in the third stage of PBL, students refine their interpretation skills by engaging in scientific inquiry and research activities. This approach fosters deeper understanding by encouraging students to actively engage with scientific content, analyze complex data, and apply their knowledge to solve real-world problems.

Furthermore, students improved in the indicator "evaluating and designing scientific investigations," with N-gain scores of 69% and 60% in Schools X and Y, respectively, both falling under the moderate category. This improvement is supported by the structured PBL activities that required students to engage in simple scientific investigations. For instance, in the lesson of pneumonia, which is related to the breathing process that takes place in the lungs, students conduct simple experiments to understand the mechanism of lung function during breathing by investigating "Metabolic Waste Excreted through the Lungs.". Throughout the process of problem-solving, students practiced evaluating their investigation results and proposing explanations. Research by Wang [61] and Dermentzi *et al*. [62] supports this result, highlighting that PBL can enhance students' problem-solving and critical thinking skills through structured inquiry and hands-on experience with the real-world.

PBL assisted by video also facilitates students the opportunity to share ideas and discuss real-life issues. This aligns with research by Suardika *et al*. [63], who emphasized that the integration of interactive videos with PBL enhances conceptual understanding and critical thinking. This approach has also been found effective in improving students' scientific literacy [64]. PBL assisted by video provides opportunities to think critically and solve real-world problems, encouraging the development of analytical thinking skills and overall scientific comprehension [65]. Through the application of PBL assisted by video, students become more capable of identifying and understanding scientific issues and phenomena that exist around them.

The control classes showed limited improvement. The N-gain in scientific literacy for the control class at School X was 38%, while at School Y it was 33%, both falling under the medium category. For the "Evaluating and Designing Scientific Investigations" indicator, the control groups scored 28% and 12% in Schools X and Y, respectively, both in the low category. The "Interpreting Data and Evidence Scientifically" indicator saw moderate gains of 41% at School X and 35% at School Y. These results suggest that the lack of training and limited exposure to inquiry activities in conventional classrooms hindered students' development of scientific literacy. This finding is consistent with previous study indicating that students' scientific literacy remains relatively low when they are not given opportunities to understand everyday phenomena during the learning process [35].

Additionally, students in school X showed a greater improvement than those in School Y, possibly due to better learning conditions and access to learning media. School X students were more familiar with video-supported learning and hands-on science activities, as such resources were occasionally used in prior classes. The integration of interactive video in PBL has been previously shown to effectively improve scientific literacy among elementary school students [35], and these results suggest the same benefit at the junior high school level.

C. Improvement of Students' Problem-Solving Ability through PBL Assisted by Video

The highest improvement in problem-solving ability was observed in "Defining the Problem' indicator, which showed N-gain scores of 76% in school X and 73% in Y, both categorized as high. This improvement indicates that students developed a better understanding of scientific concepts, which enabled them to clearly define the issues presented. On the other hand, the lowest improvement was in the "Implementing the Plan" indicator, with scores 54% in school X and 52% in school Y, both in the moderate category. This could be attributed to students' difficulty in selecting and articulating appropriate solutions for specific problems.

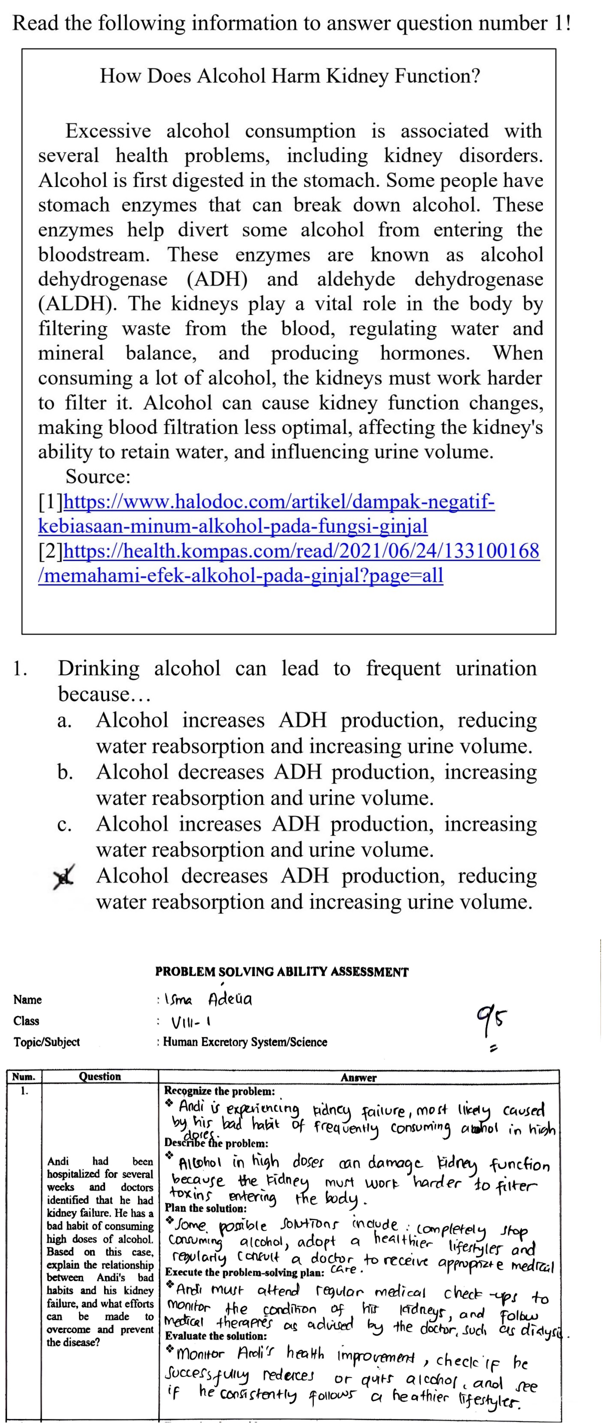
Overall, the experimental class demonstrated significantly better performance in PS abilities than the control class. Students who were taught using PBL assisted by video showed a more significant improvement compared to those taught through conventional methods. These findings align with previous studies demonstrating that PBL fosters problem-solving skills by immersing students in real-life scenarios that require critical thinking and collaboration. The results indicated that students actively engaged in problem-solving processes, leading to a deeper understanding of scientific concepts [66]. Additionally, several studies have highlighted the positive effects of PBL on developing students' problem-solving abilities [67, 68] and improving student learning engagement [69] Moreover, other research has demonstrated that PBL is an effective model for enhancing students' problem-solving abilities [70] and refining their PS ability [48, 49, 56, 71, 72]. Therefore, adopting student-centered approaches like PBL, particularly when integrated with video assistance, provide more effective learning experiences and promote the development of essential skills [73].

In contrast, problem-solving abilities in conventional classrooms tend to remain low due to limited exposure to concrete, contextualized problems. Traditional instruction often emphasizes teacher dominance, reducing opportunities for ide exchange among students. This assertion was supported by Shohib *et al*. [14], who stated that the low PS ability of students in conventional learning environments stems from a lack of exposure to concrete problems. In addition, Sulastri and Pertiwi [55] noted that students in control classes have fewer opportunities to actively engage, which negatively impacts their social interaction and interpersonal skills.

D. *The Relationship between SL and PS Ability after the Implementation of PBL Assisted by Video*

The findings of this study revealed a positive correlation between students' scientific literacy and their problem-solving abilities. This suggests that students with higher literacy levels are more capable of solving problems effectively. This correlation indicates that the development of scientific literacy contributes to enhancing students' ability to identify, analyze, and solve problems in various context.

Figs. 6 and 7 depict the problem-solving process of students from Schools X and Y as they addressed the topics of kidney failure and lung disorders. The students' responses indicate that they successfully employed their scientific literacy skills to analyze and solve the problems presented. They were able to identify the issues and evaluate the solutions effectively, indicating a positive linear relationship between scientific literacy and problem-solving abilities. This finding supports the conclusion of Tezel and Tezgören [7], who reported a positive correlation between students' scientific literacy levels and their problem-solving skills.


Read the following information to answer question number 1!

How Does Alcohol Harm Kidney Function?

Excessive alcohol consumption is associated with several health problems, including kidney disorders. Alcohol is first digested in the stomach. Some people have stomach enzymes that can break down alcohol. These enzymes help divert some alcohol from entering the bloodstream. These enzymes are known as alcohol dehydrogenase (ADH) and aldehyde dehydrogenase (ALDH). The kidneys play a vital role in the body by filtering waste from the blood, regulating water and mineral balance, and producing hormones. When consuming a lot of alcohol, the kidneys must work harder to filter it. Alcohol can cause kidney function changes, making blood filtration less optimal, affecting the kidney's ability to retain water, and influencing urine volume.

Source:
[1]https://www.halodoc.com/artikel/dampak-negatif-kebiasaan-minum-alkohol-pada-fungsi-ginjal
[2]https://health.kompas.com/read/2021/06/24/133100168/memahami-efek-alkohol-pada-ginjal?page=all

1. Drinking alcohol can lead to frequent urination because…
   a. Alcohol increases ADH production, reducing water reabsorption and increasing urine volume.
   b. Alcohol decreases ADH production, increasing water reabsorption and urine volume.
   c. Alcohol increases ADH production, increasing water reabsorption and urine volume.
   d. Alcohol decreases ADH production, reducing water reabsorption and increasing urine volume.

PROBLEM SOLVING ABILITY ASSESSMENT

Name : Isma Adelia
Class : VIII-1
Topic/Subject : Human Excretory System/Science

95

Num.	Question	Answer
1.	Andi had been hospitalized for several weeks and doctors identified that he had kidney failure. He has a bad habit of consuming high doses of alcohol. Based on this case, explain the relationship between Andi's bad habits and his kidney failure, and what efforts can be made to overcome and prevent the disease?	**Recognize the problem:** ❖ Andi is experiencing kidney failure, most likely caused by his bad habit of frequently consuming alcohol in high doses. **Describe the problem:** ❖ Alcohol in high doses can damage kidney function because the kidney must work harder to filter toxins entering the body. **Plan the solution:** ❖ Some possible solutions include: completely stop consuming alcohol, adopt a healthier lifestyles and regularly consult a doctor to receive appropriate medical care. **Execute the problem-solving plan:** ❖ Andi must attend regular medical check-ups to monitor the condition of his kidneys, and follow medical therapies as advised by the doctor, such as dialysis. **Evaluate the solution:** ❖ Monitor Andi's health improvement, check if he successfully reduces or quits alcohol, and see if he consistently follows a heathier lifestyles.

Fig. 6. Sample results of students' PS process in school X.

Students who are accustomed to facing problems and have strong scientific literacy tend to solve problems easier. Through their participation in PBL assisted by video, students learned to understand problems, formulate solution plans, implement strategies based on those plans, and evaluate the outcomes—all grounded in the scientific concepts they have developed throughout the learning process. These findings align with prior research demonstrating that integrating video-assisted learning into PBL enhances both scientific understanding and problem-solving skills [74]. This conclusion is further supported by Lestari *et al*. [20], who state that scientific literacy competencies contribute to effective problem-solving. Similarly, Diquito *et al*. [75] emphasize that PBL immerses learners in real-life issues, fostering the creation of practical and applicable solutions.

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Source:
[1]https://www.halodoc.com/artikel/dampak-negatif-kebiasaan-minum-alkohol-pada-fungsi-ginjal
[2]https://health.kompas.com/read/2021/06/24/133100168/memahami-efek-alkohol-pada-ginjal?page=all

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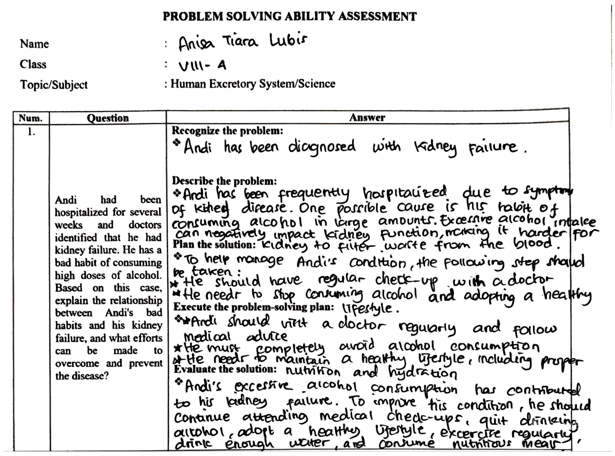
   c. Alcohol increases ADH production, increasing water reabsorption and urine volume.
   d. Alcohol decreases ADH production, reducing water reabsorption and increasing urine volume.


PROBLEM SOLVING ABILITY ASSESSMENT

Name : Anisa Tiara Lubis
Class : VIII- A
Topic/Subject : Human Excretory System/Science

Num.	Question	Answer
1.	Andi had been hospitalized for several weeks and doctors identified that he had kidney failure. He has a bad habit of consuming high doses of alcohol. Based on this case, explain the relationship between Andi's bad habits and his kidney failure, and what efforts can be made to overcome and prevent the disease?	**Recognize the problem:** ❖Andi has been diagnosed with kidney failure. **Describe the problem:** ❖Andi has been frequently hospitalized due to symptoms of kidney disease. One possible cause is his habit of consuming alcohol in large amounts. Excessive alcohol intake can negatively impact kidney function, making it harder for kidney to filter waste from the blood. **Plan the solution:** ❖To help manage Andi's condition, the following step should be taken: ★He should have regular check-up with a doctor ★He needs to stop consuming alcohol and adopting a healthy lifestyle. **Execute the problem-solving plan:** ❖★Andi should visit a doctor regularly and follow medical advice ★He must completely avoid alcohol consumption ★He needs to maintain a healthy lifestyle, including proper nutrition and hydration **Evaluate the solution:** ❖Andi's excessive alcohol consumption has contributed to his kidney failure. To improve this condition, he should continue attending medical check-ups, quit drinking alcohol, adopt a healthy lifestyle, excercise regularly, drink enough water, and consume nutritious meals.

Fig. 7. Sample results of students' PS process in school Y.

VI. Conclusion

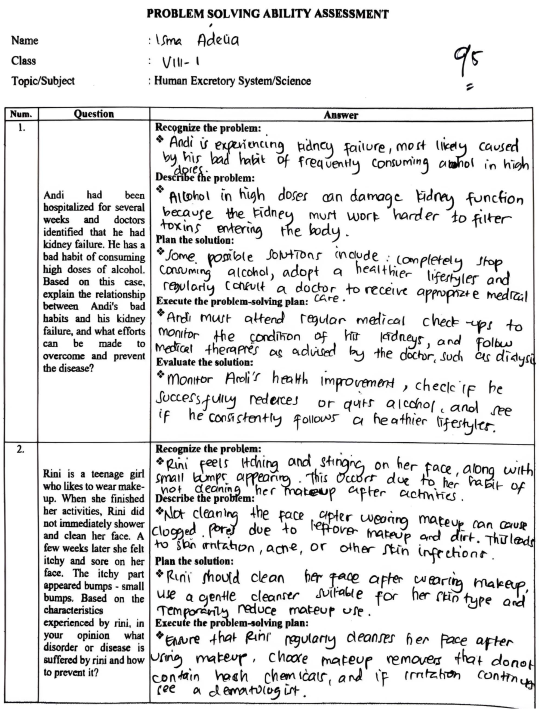
Based on the research findings and discussion, the following conclusions can be drawn:

1) Effectiveness of PBL Assisted by Video: The implementation of PBL assisted by video significantly improves students' SL and PS abilities in learning the Human Excretory System in eighth-grade junior high school.
2) Improvement in SL and PS: The N-gain analysis indicates that students in the experimental group (taught using PBL assisted by video) showed greater improvement than those in the control group (taught using conventional methods). At School X, the experimental group achieved a high improvement category, with 73% improvement in SL and 72% in PS. In contrast, the control group demonstrated medium (39%) and low (24%) improvements, respectively. At School Y, the experimental group attained medium improvements in SL (51%) and PS (69%), while the control group remained in the low category for both SL (28%) and PS (22%).
3) A strong positive correlation was found between SL and PS abilities, with $r = 0.595$ (high) in School X and $r = 0.892$ (very high) in School Y. This suggests that students with stronger scientific literacy tend to perform better in problem-solving when learning through PBL assisted by video.

Despite these promising outcomes, the study encountered several limitations. Challenges included the lack of validated assessment tools for junior high students, difficulties in identifying real-life science problems and designing matching instruments, time constraints, and student unfamiliarity with the PBL model. Some students also struggled with maintaining focus and engaging with the material, while limited school resources restricted experimental options.

Further studies should explore the long-term impact of PBL assisted by video across various science topics and educational levels. In particular, research should investigate how combining interactive video-based learning with hands-on activities can further enhance student engagement, conceptual understanding, and overall learning outcomes. Addressing these aspects will help refine the implementation of PBL and reinforce its role in advancing modern science education.

Research has shown that PBL ultimately, this study highlights the importance of innovative, student-centered learning approaches that promote active engagement and essential 21st-century skills. PBL assisted by video offers valuable insights for educators in selecting and implementing effective instructional models and media, especially in science education. Education stakeholders are encouraged to adopt video-assisted PBL as an effective strategy for improving students' scientific literacy and problem-solving abilities.


PROBLEM SOLVING ABILITY ASSESSMENT

Name : Isma Adelia
Class : VIII- 1
Topic/Subject : Human Excretory System/Science

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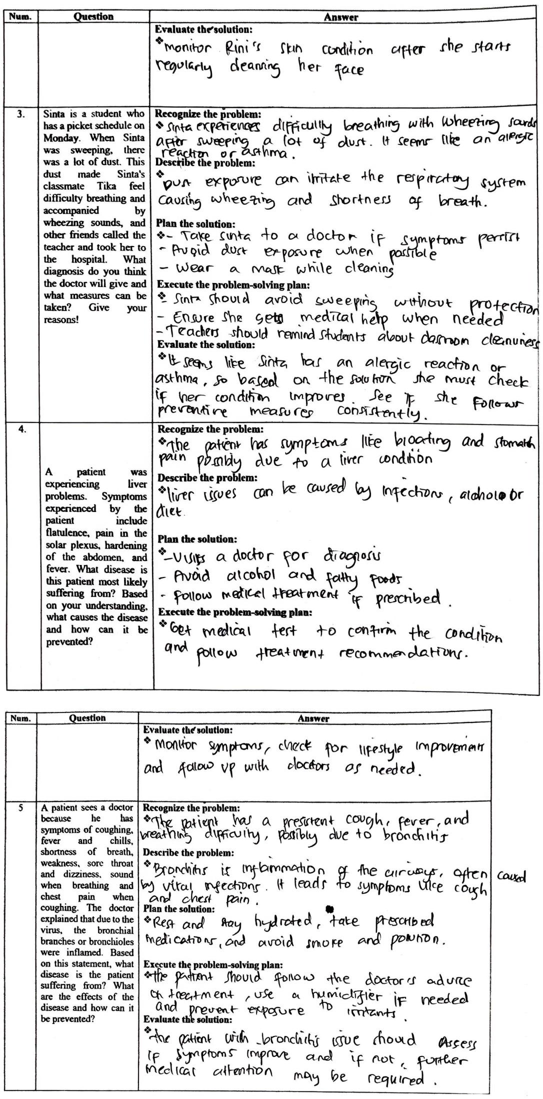
Num.	Question	Answer
1.	Andi had been hospitalized for several weeks and doctors identified that he had kidney failure. He has a bad habit of consuming high doses of alcohol. Based on this case, explain the relationship between Andi's bad habits and his kidney failure, and what efforts can be made to overcome and prevent the disease?	**Recognize the problem:** ❖Andi is experiencing kidney failure, most likely caused by his bad habit of frequently consuming alcohol in high doses. **Describe the problem:** ❖Alcohol in high doses can damage kidney function because the kidney must work harder to filter toxins entering the body. **Plan the solution:** ❖Some possible solutions include: completely stop consuming alcohol, adopt a healthier lifestyles and regularly consult a doctor to receive appropriate medical care. **Execute the problem-solving plan:** ❖Andi must attend regular medical check-ups to monitor the condition of his kidneys, and follow medical therapies as advised by the doctor, such as dialysis. **Evaluate the solution:** ❖Monitor Andi's health improvement, check if he successfully reduces or quits alcohol, and see if he consistently follows a heathier lifestyles.
2.	Rini is a teenage girl who likes to wear make-up. When she finished her activities, Rini did not immediately shower and clean her face. A few weeks later she felt itchy and sore on her face. The itchy part appeared bumps - small bumps. Based on the characteristics experienced by rini, in your opinion what disorder or disease is suffered by rini and how to prevent it?	**Recognize the problem:** ❖Rini feels itching and stinging on her face, along with small bumps appearing. This occurs due to her habit of not cleaning her makeup after activities. **Describe the problem:** ❖Not cleaning the face after wearing makeup can cause clogged pores due to leftover makeup and dirt. This leads to skin irritation, acne, or other skin infections. **Plan the solution:** ❖Rini should clean her face after wearing makeup, use a gentle cleanser suitable for her skin type and temporarily reduce makeup use. **Execute the problem-solving plan:** ❖Ensure that Rini regularly cleanses her face after using makeup, choose makeup removers that do not contain harsh chemicals, and if irritation continues see a dermatologist.



Num.	Question	Answer
		Evaluate the solution: ❖ monitor Rini's skin condition after she starts regularly cleaning her face
3.	Sinta is a student who has a picket schedule on Monday. When Sinta was sweeping, there was a lot of dust. This dust made Sinta's classmate Tika feel difficulty breathing and accompanied by wheezing sounds, and other friends called the teacher and took her to the hospital. What diagnosis do you think the doctor will give and what measures can be taken? Give your reasons!	**Recognize the problem:** ❖ Sinta experiences difficullty breathing with wheezing sounds after sweeping a lot of dust. It seems like an alergic reaction or asthma. **Describe the problem:** ❖ Dust exposure can irritate the respiratory system causing wheezing and shortness of breath. **Plan the solution:** ❖ - Take Sinta to a doctor if symptoms persist - Avoid dust exposure when possible - Wear a mask while cleaning **Execute the problem-solving plan:** ❖ Sinta should avoid sweeping without protection - Ensure she gets medical help when needed - Teachers should remind students about classroom cleanliness **Evaluate the solution:** ❖ It seems like Sinta has an alergic reaction or asthma, so based on the solution she must check if her condition improves. See if she follows preventive measures consistently.
4.	A patient was experiencing liver problems. Symptoms experienced by the patient include flatulence, pain in the solar plexus, hardening of the abdomen, and fever. What disease is this patient most likely suffering from? Based on your understanding, what causes the disease and how can it be prevented?	**Recognize the problem:** ❖ The patient has symptoms like bloating and stomach pain possibly due to a liver condition **Describe the problem:** ❖ liver issues can be caused by infections, alcohol or diet. **Plan the solution:** ❖ - Visits a doctor for diagnosis - Avoid alcohol and fatty foods - Follow medical treatment if prescribed. **Execute the problem-solving plan:** ❖ Get medical test to confirm the condition and follow treatment recommendations.

Num.	Question	Answer
		Evaluate the solution: ❖ Monitor symptoms, check for lifestyle improvements and follow up with doctors as needed.
5	A patient sees a doctor because he has symptoms of coughing, fever and chills, shortness of breath, weakness, sore throat and dizziness, sound when breathing and chest pain when coughing. The doctor explained that due to the virus, the bronchial branches or bronchioles were inflamed. Based on this statement, what disease is the patient suffering from? What are the effects of the disease and how can it be prevented?	**Recognize the problem:** ❖ The patient has a presistent cough, fever, and breathing difficulty, possibly due to bronchitis **Describe the problem:** ❖ Bronchitis is inflammation of the airways, often caused by viral infections. It leads to symptoms like cough and chest pain. **Plan the solution:** ❖ Rest and stay hydrated, take prescribed medications, and avoid smoke and pollution. **Execute the problem-solving plan:** ❖ the patient should follow the doctor's advice on treatment, use a humidifier if needed and prevent exposure to irritants. **Evaluate the solution:** ❖ the patient with bronchitis issue should assess if symptoms improve and if not, further medical attention may be required.

Fig. A1. Students' problem-solving ability answer sheet.

APPENDIX

The complete examples of students' problem-solving ability answers for Questions 1 to 5 can be seen in Fig. A1.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

MPS: conceptualization and design, data analysis/interpretation, statistical analysis, critical revision of manuscript, securing funding; GAM: statistical analysis, drafting manuscript, critical revision of manuscript; HS: data analysis/interpretation, securing funding; AH: conceptualization and design, drafting manuscript, securing funding; all authors had approved the final version.

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