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Implementation of a problem-based learning model assisted with scaffolding to improve scientific literacy and student cognitive learning outcomes

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Abstract

Scientific literacy needs to be developed to face the 21st century, but in Indonesia, students' scientific literacy is in the low category. The results of the preliminary study test for class Based on the facts and problems found, the research aims to improve students' scientific literacy and cognitive learning outcomes through the application of the PBL model assisted by scaffolding. This research is Classroom Action Research (CAR) with the stages of the plan, act observe, and reflection. This research was carried out for two cycles with material on the respiratory and excretory systems. The research was conducted from February to May 2023 in class XI MIPA 1 Malang Islamic High School with research subjects of 34 students. The instruments were five scientific literacy essay questions and ten multiple-choice test questions on cognitive process dimensions. The N-gain value calculates increased scientific literacy and cognitive learning outcomes. This research shows that students' scientific literacy increased from 70.4 to 81.3, so the N-gain value for scientific literacy was 0.37. Students' cognitive learning outcomes rose from 78.8 to 86.4, so the N-gain cognitive learning outcomes were 0.36. Mastery of high scientific and cognitive literacy makes students careful in making decisions with scientific considerations.

Abstrak. *Literasi sains perlu dikembangkan guna menghadapi abad ke-21, namun di Indonesia literasi sains siswa dalam kategori rendah. Hasil tes studi pendahuluan kelas XI MIPA 1 SMA Islam Malang rata-rata nilai literasi sains sebesar 48.5 dan rata-rata nilai ketuntasan hasil belajar kognitif hanya 15.0. Berdasarkan fakta dan masalah yang ditemukan maka tujuan dari penelitian adalah meningkatkan literasi sains dan hasil belajar kognitif siswa melalui penerapan model PBL berbantuan scaffolding. Penelitian ini merupakan Penelitian Tindakan Kelas (PTK) dengan tahapan plan, act and observe, dan reflection. Penelitian ini dilakukan sebanyak II siklus dengan materi sistem respirasi dan ekskresi. Penelitian dilakukan pada bulan Februari-Mei 2023 pada kelas XI MIPA 1 SMA Islam Malang dengan subyek penelitian 34 siswa. Instrumen yang dipakai adalah 5 soal essay literasi sains dan 10 soal tes pilihan ganda dimensi proses kognitif. Peningkatan literasi sains dan hasil belajar kognitif dihitung dengan nilai N-gain. Hasil penelitian ini memperlihatkan bahwa literasi sains siswa meningkat dari 70.4 menjadi 81.3, sehingga nilai N-gain literasi sains sebesar 0.37. Hasil belajar kognitif siswa meningkat dari 78.8 menjadi 86.4, sehingga hasil N-gain hasil belajar kognitif sebesar 0.36. Penguasaan literasi sains dan kognitif tinggi membuat siswa cermat dalam pengambilan keputusan dengan pertimbangan sains.*

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A. Introduction

Many complex problems must be faced in the 21st century and technological advances. Understanding science can help students overcome difficult issues in the 21st century (Ramdani & Badriah, 2018). One of the essential literacies developed in the 21st century is scientific literacy (Yusuf et al., 2022). Scientific literacy is students' ability to recognize, explain, apply scientific knowledge, and make decisions about scientific expertise in various complex life conditions (OECD, 2019). Scientific literacy involves asking questions about life and finding answers using science. Scientific literacy is an ability characterized by biology, so it benefits students (Mahanal et al., 2020). It is essential to empower literacy skills to prepare students to develop according to changes in social life (Zubaidah, 2019).

A survey conducted based on an assessment of the scientific literacy of Indonesian students and teenagers showed low results (Mawaddah et al., 2021). Based on data from The Program for International Student Assessment (PISA) published by the OECD (2019), Indonesian students have a scientific literacy score 396, much lower than the OECD average 489. Several relevant studies regarding the level of scientific literacy have also been carried out, such as the results of research by Erniwati et al. (2022), showing that the scientific literacy abilities of Class X students at SMAN 1 Kendari obtained a percentage score of 50.9% in the low category. Sutrisna (2021) said that the average scientific literacy score for Class.

Good mastery of scientific literacy will improve students' cognitive abilities (Yusuf et al., 2022). Knowledge dimensions and cognitive process dimensions shape cognitive learning outcomes (Anderson & Krathwohl, 2010). Cognitive learning outcomes are significant to develop as a goal at every level of education. Improving learning outcomes is one of the learning objectives. Research by Rijal & Bachtiar (2015) states that cognitive learning outcomes are related to independent learning.

One of the subjects at the high school level that requires mastery of scientific literacy and cognitive competence is Biology. Biology includes human behavior and environmental interactions (Khoirudin, 2019). Biology is always associated with investigating life and building relationships between one fact and another in every aspect of life (Mahanal et al., 2020). In Biology subjects, one of the respiration and excretion system materials is classified as complex material because the material is abstract and includes physiological processes that cannot be sensed directly (Sani et al., 2019; Simorangkir et al., 2020). Biology lessons require mastery of scientific literacy. Mastering scientific literacy makes students more critical in understanding and studying scientific phenomena to solve problems (Rohana et al., 2020).

Based on the test results in a preliminary study conducted at Malang Islamic High School on 34 classes, scientific literacy is 48.5, classified as low. The average basic competencies (BC) completeness score for the digestive system due to cognitive learning is only 15.0, included in the incomplete category. Interview results from Biology teachers show that scientific literacy has not been developed in learning. Teachers also encountered problems when implementing the Problem-Based Learning (PBL) model in class XI MIPA 1 because students were less active and did not find solutions. Based on the facts and problems in class XI MIPA 1, students' scientific literacy and cognitive learning outcomes still need to be trained and improved to face the challenges of the 21st century.

Innovative learning models are the best alternative to empower scientific literacy and cognitive learning outcomes. The definition of PBL is a problem-based and student-centered learning model as a basis for developing solutions and acquiring essential knowledge and concepts (Arends, 2012). The successful implementation of the PBL model can increase scientific literacy (Prastika et al., 2019). Lendeon & Poluakan (2022) shows that the PBL model can increase scientific literacy and positively affect students' cognitive abilities. Implementing PBL in class XI MIPA 1 is still not very effective. One alternative solution is assisted by scaffolding.

Scaffolding assists in the form of pictures, directions, encouragement, reminders, explanations of steps to approach problems, examples, and other assistance to help students learn independently (Muliastrini et al., 2019; Slavin, 2015). The purpose of providing this assistance is so that students can solve problems independently. In practice, scaffolding emphasizes discovering a concept and helping students at the beginning of the learning stage, then reducing the help slowly so that students find the concepts they are learning for themselves (Muliastrini et al., 2019).

Research by Puspitaningsih et al. (2018) stated that the scaffolding provided by teachers through the PBL model improved students' thinking abilities. Wibowo (2018) also proved that scaffolding in PBL can improve student learning outcomes. Implementing PBL accompanied by scaffolding and adjustments to designed learning objectives can make its implementation more effective (Masek & Yamin, 2011). Based on the background of the problem above, research is needed regarding applying the scaffolding-assisted PBL model to improve scientific literacy and cognitive learning outcomes for class XI MIPA 1 students at SMA Islam Malang with material on the human respiration and excretion system.

B. Material and method

Researchers use CAR with qualitative descriptive methods to improve the quality of learning through action. The CAR design uses the Kemmis & Mc Taggart's (2007) model is shown in Figure 1. The CAR research flow in each cycle consists of action planning (Plan), implementation of actions and observations (Act and observe), and reflecting on actions (Reflection). The research was carried out in two cycles, with material on the human respiratory system totaling three meetings and the human excretory system totaling four meetings.

Action planning I determines the focus of the problem-creating learning instruments and tools. Action planning II, namely improving learning tools and instruments from the reflection results on the implementation of the cycle I. Action and observation, namely in implementing planning and assessing actions from observers. Reflection on learning takes the form of a discussion about the action process that has taken place intending to improve action. The research was conducted from February to May 2023 at Malang Islamic High School on Jl. Kartini No.2, Kel. Klojen, District. Klojen, Malang City, East Java 65111. The research subjects comprised 34 XI MIPA 1 students, 19 women and 15 men.

The research instrument is composed of treatment instruments and measurement instruments. Syllabus, Learning Plan (LP) Implementation, Student Worksheets (SW), and PBL Learning Sheets (LS) Implementation assisted by scaffolding are treatment instruments. The measurement instrument consists of a scientific literacy test measured through 5 essay questions based on scientific literacy indicators and a student cognitive learning outcomes test measured through 10 multiple choice test questions, which refer to indicators of cognitive process dimensions according to Bloom's taxonomy as revised by Anderson & Krathwohl. Instruments in a study can be classified as suitable for measuring variables when they meet the validity and reliability test requirements. Test the validity of syllabus instruments, LP, SW, and questions at the beginning and end of the cycle, validated by expert validators of learning tools. The test questions created and validated are tested on classes that have received BC learning selected for research. The class used is class XII MIPA 1 Malang Islamic High School, totaling 32 students, to determine the reliability of the questions. Reliability analysis of test questions at the beginning and end of the cycle was carried out using the Anatest Application Software.

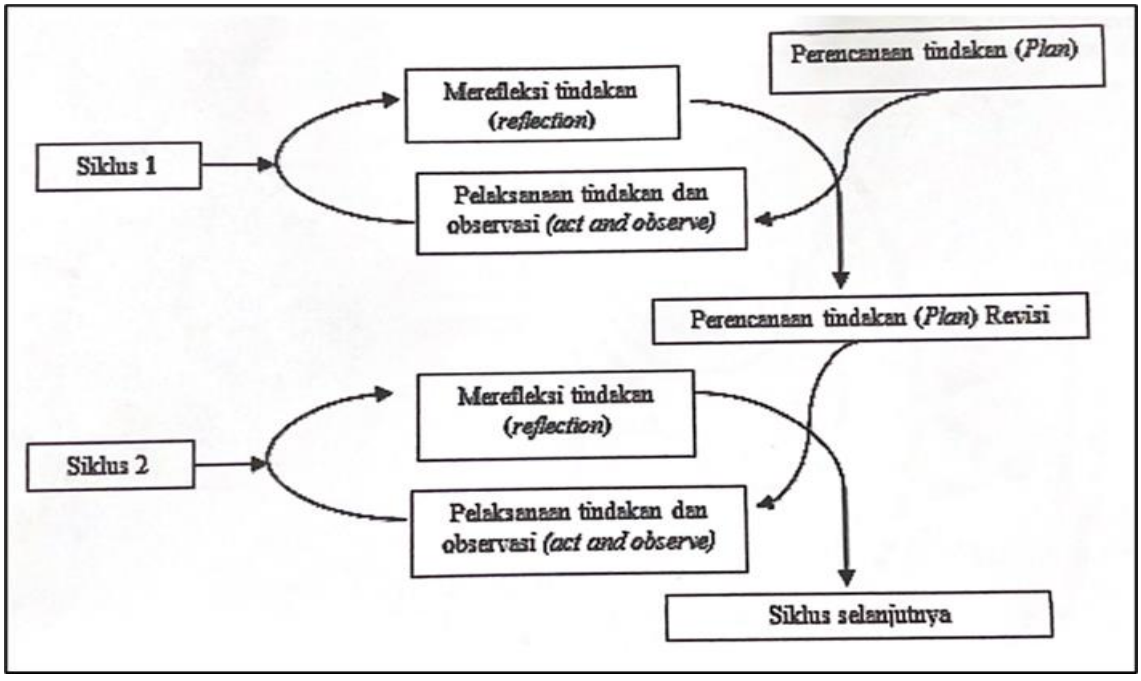

Figure 1 The CARs flow by Kemmis & Mc Taggart (2007) (in Indonesian)

Science Literacy Data Analysis

Scientific literacy questions are created based on the indicators that explain phenomena scientifically, design and evaluate scientifically, and interpret data and evidence scientifically. Each scientific literacy indicator requires mastery of content and procedural and epistemic abilities (OECD, 2019). PISA provides a framework for mapping question item scores against the knowledge and competence dimensions of scientific literacy (OECD, 2019). Each question can also be mapped based on the depth of the knowledge and competency dimensions of scientific literacy, which are categorized at high, medium, and low levels. The results of the literacy score analysis will

later provide an overview of students' scientific literacy abilities and the depth of their cognitive knowledge. The scientific literacy scores that students have obtained are categorized qualitatively so that conclusions can be drawn. Students' scientific literacy categories are presented in Table 1.

Table 1 Student scientific literacy category

Literacy Level	Qualification
Tall	Analyze complex data; collect or evaluate evidence; prove; reasoning from many sources; develop plans or steps to solve problems.
Currently	Apply conceptual knowledge to describe or explain phenomena; selecting the appropriate procedure with two or more steps; organize or display information; or interpreting or using data sets or graphs.
Low	Performing one-step procedures, such as remembering facts, statements, principles, or concepts, or finding summary information from a chart or table.

(Source: OECD, 2019:110)

Cognitive Learning Outcome Data Analysis

Cognitive learning outcome scores are obtained by calculating each cycle's initial and final test scores, using categorization techniques according to the Minimum Completeness Criteria (MCC) values and the completeness scores in the class. Indicators of success in cognitive learning outcomes are explained in Table 2.

Table 2 Category of cognitive learning outcomes

Data	Category
Individual completeness	Students are considered complete if the student's score meets the MCC value determined by the school of ≥ 78.
Classical completeness	A class has completed learning if 85% of all students have met the MCC score.

The N-gain (g) value determines increased scientific literacy and cognitive learning outcomes. The N-gain value is calculated using Formula 1 by Hake (1998). The obtained N-gain values are then interpreted based on Table 3.

$$(g) = \frac{\text{Sft II} - \text{Sft I}}{\text{Sm Ideal} - \text{Sft I}} \ldots\ldots\ldots\ldots \text{Formula 1}$$

Information:
(g) = Gain score
Sft = Score of final test
Sm = Maximum score

Table 3 N-gain value criteria

N-gain	Criteria
(g) ≥ 0.70	Tall
0.30 ≤ (g) < 0.70	Currently
(g) < 0.30	Low

(Source: Hake, 1999)

C. Results and discussion

Action Planning

Action planning (plan), namely identifying problems, analyzing the causes of problems and formulating them, and looking for ideas to solve problems. The research began by interviewing biology teachers and observing learning activities in class XI MIPA 1 for one week. From the results of interviews and observations, researchers found the problem that in class XI MIPA 1, scientific literacy had not been empowered, and students' cognitive learning outcomes were still lacking. Biology teachers have implemented the PBL model, but it is ineffective. Students still have not found a solution to solve the problem. As a result of discussions regarding the issues that arose, the researchers applied a PBL model assisted by scaffolding to increase students' mastery of scientific literacy and learning outcomes in cognitive aspects.

Researchers prepare the necessary actions to be carried out in the classroom, such as syllabus, LP, SW, and evaluation questions in the form of scientific literacy test questions and cognitive learning outcomes. Before use, researchers validated the instrument by a validator and tested the reliability of scientific literacy test questions and cognitive learning outcomes. The results of validating learning devices by validators are presented in Table 4.

Table 4 Learning device validation results

Syllabus	LP	SW	Scientific literacy question	Cognitive learning outcomes question
100%	96.3%	100%	100%	100%

Validation aims to provide an assessment so that the research instrument is suitable for learning. The higher the validation value, the better the quality of the device (Kuhn, 2010). The validation results show that the learning tool is very good and valid. It can facilitate learning of the human respiration and excretion system for students to increase scientific literacy and student cognitive learning outcomes.

Reliability testing is needed to assess the extent to which the instruments used can reliably assess test results (Clark & Watson, 1995). After analyzing and showing reliable results, the questions can be used as research measuring tools. However, if the analysis results are unreliable, the questions must be revised and tested again until they show reliable results. The results of the study of scientific literacy test questions

and students' cognitive learning outcomes, calculated using Anatest Application Software, show that they are reliable and ready to be used during research. The reliability results of scientific literacy test questions and cognitive learning outcomes are in Table 5.

Table 5 Reliability results of science literacy test questions and student cognitive learning results with Anatest

Data	Cycle	Results	Information
Scientific literacy	I	0.78%	Reliable
	II	0.94%	Reliable
Cognitive learning outcomes	I	0.72%	Reliable
	II	0.80%	Reliable

Implementation of Actions and Observations

Act and Observe cycle I went well and smoothly. At the beginning of the lesson, students were given an apperception about the respiratory system and showed interest by commenting and asking questions. The core activities are carried out according to the syntax of the PBL model assisted by scaffolding. Students are given SW that contains phenomena about the material being taught. From the phenomena presented, students begin to analyze the problems that arise and look for solutions using group discussions. The end of learning is marked by reflection activities and making conclusions about learning results. During the learning process, the model teacher was observed by Pak Angga, Cantik, and Fahrany. Observer activities do not interfere with the learning process at all.

Implementing actions and observations in cycle II also went well and smoothly. Just like cycle I, the teacher provides apperception to students to focus students' thinking on learning. Observers agree with the apperception used by the teacher because it is relevant to the learning objectives. In cycle II, we still use SW that contain phenomena about the human excretory system. Observers say students were more active during group discussions and class presentations. The variety of questions from students is starting to become complex and weighty. The conclusions made by students are also more complex, and the solutions obtained by students are appropriate to the problems found. The implementation stage is the implementation of the design results at the planning stage. The learning implementation stage is carried out following a predetermined plan. Implementing the PBL model with the help of scaffolding is carried out by following the five syntaxes according to Arends (2012), and scaffolding is provided (Belland et al., 2011) in the PBL syntax phase that requires it. The syntax of the scaffolding-assisted PBL model is clearly described in Table 6.

Table 6 Syntax of scaffolding-assisted PBL model

Scaffolding-assisted PBL model syntax	Explanation
Orienting students to the problem	The teacher provides motivation (scaffolding), provides problems and instructs students to create hypotheses regarding problem solving in order to connect concepts with problems (conceptual scaffolding).
Organizing students in learning	Teachers form heterogeneous small groups (strategic scaffolding) to guide students in approaching problems.
Guiding individual and group investigations	Teachers guide students in conducting experiments or investigations (strategic & procedural). This is done to help students solve complex problems.
Develop and present work results	The teacher has group representatives to present the results of their work to other groups and hold discussions (metacognitive scaffolding). This assistance is intended so that students can check and develop the results of their discussions.
Analyze and evaluate the problem solving process	Teachers help students to reflect or evaluate the process and results of the investigations they carry out (metacognitive scaffolding).

(Source: Arends, 2012; Belland et al., 2011)

The basis for developing the PBL model is Piaget's developmental theory, Vygotsky's social constructivist learning theory, Bruner's theory, discovery learning, and John Dewey's theory (Ardianti & Raida, 2022). The PBL model is designed to support students in simulating real-life situations and understanding how adults play a role (Arends, 2012). Previous research used the PBL model to increase scientific literacy and cognitive learning outcomes (Hafizah & Nurhaliza, 2021; Aliyana et al., 2019). Scaffolding is an instrument created by teachers to help develop experiences (Reiser & Tabak, 2014). Helping to increase students' activeness in learning and completing assignments independently is the goal of scaffolding (Kim et al., 2018; Van de Pol et al., 2019).

There are four types of scaffolding: conceptual, strategic, procedural, and metacognition (Belland et al., 2011). Conceptual scaffolding can create associations between new information and ideas that students have. Strategic scaffolding helps guide students on how to approach problems. Procedural scaffolding helps students solve complex problems. Metacognition scaffolding teaches students how to think about planning, examining, and evaluating problem-solving. Research by An & Cao (2014) proves

that students who learn to use scaffolding collaboratively with peers can work more effectively than if they know individually.

The PBL model assisted by scaffolding is learning that requires students to be directly involved in finding solutions to problems. Teachers provide a series of assistance to students to achieve learning goals. Research by Tiaradipa et al. (2020) stated that the PBL-scaffolding model improves higher-order thinking and problem-solving. The scaffolding-assisted PBL model in each syntax is related to each indicator of scientific literacy so that scientific literacy and students' cognitive learning outcomes increase.

The syntax of orienting students toward problems requires learning motivation (scaffolding), providing problems, and instructing students to create problem-solving hypotheses to connect concepts with problems (conceptual scaffolding). After implementing scaffolding assistance, students have motivation and interest in learning. Problem orientation can train students to describe and explain scientific knowledge and design predictions and hypotheses from phenomena according to scientific literacy indicators. Creating hypotheses and connecting concepts requires good cognitive abilities.

Explaining scientific phenomena requires more than memorizing, implementing theories, getting ideas, data, and facts (content knowledge). Interpreting science requires understanding what science is and a level of accuracy that can be accounted for. Therefore, students must have procedural knowledge to conduct scientific investigations, evaluate whether the conclusion is correct, and have supporting data and theories that include epistemic knowledge (OECD, 2019).

In cycle I, conceptual scaffolding assistance was given to all groups (five groups) because students still needed it. However, in cycle II, two groups at meetings three and four were not given conceptual scaffolding assistance because they could connect concepts with problems and create appropriate hypotheses independently. Tiaradipa et al. (2020) also proved that students' higher-order thinking abilities improved after implementing the PBL model assisted by procedural and conceptual scaffolding.

Syntax organizes students in learning; teachers form heterogeneous small groups (strategic scaffolding) to guide students in approaching problems. Teachers teach students to approach issues by directing them to design scientific research by identifying three or more scientific questions exported from a given scientific study. Students can then use scientific methods to develop, elaborate, and clarify ways to explore according to scientific literacy indicators.

Scientific literacy guides students toward the goal of science by understanding nature (Ziman, 1978). In this second syntax, students must be able to approach the problem to find the right solution. Strategic scaffolding in the syntax of these two PBL models is provided from the beginning to the end of the research because students still need help. Teachers can give strategic scaffolding by structuring the learning environment, asking questions that explore students' abilities, fully involving students in solving problems, modifying reflections, and clarifying them so that concepts are easier to understand. Research by Ismawati et al. (2017) stated that PBL with scaffolding effectively and efficiently increased learning completion and problem-solving.

Syntax guides individual and group investigations; teachers accompany students in conducting experiments or investigations (strategic & procedural). This is done to help students solve complex problems. Teachers assist students in scientific investigations based on methods, finding strengths and weaknesses of procedures, and improving investigation plans according to scientific literacy indicators. In cycle I, conceptual scaffolding assistance was given to all groups (five groups) because students still needed it. However, in cycle II, two groups at meetings three and four were not given conceptual scaffolding assistance because they could connect concepts with problems and create appropriate hypotheses independently. Research by Puspitaningsih et al. (2018) stated that the PBL model assisted by procedural scaffolding affected higher thinking skills based on the results of the post-test score of 42.5%.

The syntax is to develop and present the work results, and the teacher has group representatives to deliver the work results and conduct discussions (metacognitive scaffolding). This assistance is intended so that students can check and develop the results of their discussions. Students are trained to evaluate scientific investigations according to scientific literacy indicators at this stage. Designing and evaluating scientific research is related to content knowledge, investigative procedures commonly used during research, and knowledge about how these methods work in proving hypotheses through research is called epistemic knowledge (OECD, 2019).

Students are also trained to interpret and communicate scientific information orally and graphically in writing. The teacher helps students dare to express ideas or solutions that their group has found in the discussion forum. Using scaffolding strategies during the learning process prevents students from experiencing difficulties due to their abilities, so students are more confident in expressing their opinions and are independent in solving the problems they face (Astuti et al., 2016). The research results show that at this stage, each group and even individual students experience increased activity in the classroom, as evidenced by the observations that at each learning meeting, student activity rises, and the discussion forum improves. However, there was a problem: during the presentation discussion, several

students had the ambition to bring down the presenter with off-topic questions. The teacher's task is to limit and straighten out students' questions to be appropriate to the presented topic. Scaffolding is provided by the teacher from the beginning to the end of the research.

The syntax analyzes and evaluates the problem-solving process; the teacher accompanies students in carrying out the evaluation process and the results of the research (metacognitive scaffolding). Students describe and analyze the relationship between science, technology, and society and understand the application of scientific knowledge to life according to scientific literacy indicators. After students reflect on solutions to existing problems, they continue by making conclusions. Teachers continue to reinforce students so that students do not have misconceptions. According to research by Kamelia & Pujiastuti (2020), implementing metacognitive scaffolding can increase the quality of students' problem-solving skills. Interpreting data is an essential stage for students. Interpretation begins with finding patterns, such as creating a chart or graphic visualization. Schema knowledge must be used to read relationships or patterns in the data. All of this refers to content, procedural, and epistemic knowledge. The procedures that have been carried out must be by the proven hypothesis. Students must argue to corroborate data interpretations with reliable sources (OECD, 2019).

The observation stage was carried out by three observers: two 2019 FMIPA students and one Biology teacher. The observer is tasked with observing and assessing the implementation of the learning model used by the researcher. The observation results were obtained from the assessment of learning in the rubric by the observer while the research action took place. The assessment process will take place without disturbing the learning process. The implementation of learning from the results of observations in cycles I and II is very good. Cycle I and II experienced improvements; this was due to the impact of the reflection stage of cycle I, so in cycle II, the implementation of the scaffolding-assisted PBL model became better. The increasing implementation of the scaffolding-assisted PBL model proves that this learning model is implemented well and effectively in learning and shows that teachers and students are always trying to make improvements so they can face the challenges of the 21st century.

Reflecting Actions

The reflection stage is the conclusion of the observations and observer notes. The reflection stage helps look at the track record of classroom actions carried out by the researcher. Researchers and observers analyze and find solutions from the results of actions in cycle I to make improvements. The results of the first cycle reflection were still problems with students' questions during presentation discussions. There are still some students who ask questions outside the context presented. Students have not been able to carry out presentation discussions well and correctly. In the first cycle of class XI MIPA 1, learning in class had not yet been completed. Furthermore, some students lack focus and pay less attention when learning. In group discussions, some members already know the answer but do not reveal it to others. Therefore, it must be continued at the action stage in cycle II.

The results of the action-reflection in cycle II show that the implementation of learning actions is better and has improved the quality of learning from cycle I. The teacher tries to improve in cycle II and overcome problems in cycle I. The teacher tries to provide examples of how to make presentations well and correctly. Teachers also try to explain the rules for asking questions well in discussion forums, such as giving rules for raising your hand before expressing an opinion and asking questions according to the context discussed in the presentation. Next, motivate students to study at home first and study the material so they are better prepared for discussions. During group discussions, students are more active in helping and exchanging ideas with each other in their groups. During presentation discussions, there is no longer the characteristic of wanting to win alone over the answers produced by the group. Still, they complement each other and collaborate to find the right solution. Factors that contribute to increasing scientific literacy and cognitive learning outcomes include evaluation and reflection activities during each cycle during the learning process, creating happy classroom conditions, and active students and teachers during learning.

Implementation of the Scaffolding-Assisted PBL Model on Students' Scientific Literacy

Scientific literacy is an understanding of concepts as the foundation of scientific and technological frameworks, the way concepts are acquired, and the accuracy of the concept is supported by solid evidence. Therefore, according to Rychen & Salganik (2011), scientific literacy is a crucial competency defining interactive ability between the application of knowledge and information. In other terms, the level of mastery of science can change an individual's perspective on interacting with nature (National Research Council, 2012; Osborne, 2010). Science learning should be balanced with assessment questions to encourage students to practice reasoning and improve their ability to think about certain situations (Gormally et al., 2012). Science evaluation focuses on content knowledge, ability to think and carry out scientific processes in completion (Wang et al., 2018). The research results of Windyariani et al. (2017) show that using scientific literacy assessments in evaluations can provide students with

opportunities to train and improve their scientific literacy skills. Scientific literacy was measured using five essay questions (initial and final cycle tests) referring to the OECD's scientific literacy indicators. The test results were assessed using a scientific literacy test scoring rubric adapted from the OECD. The results of the cycle I and II scientific literacy analysis are in Table 7 and Table 8.

Table 7 Results of cycle I science literacy score calculation

Indicator	Sub Indicator	Cycle I average score		Enhancement
		Initial test	Final test	
Explain scientifically	Explain scientific knowledge	28.0	72.1	44.1
	Design predictions and hypotheses based on phenomena	44.9	70.6	25.7
Design and evaluate scientific inquiry	Designing scientific research and Evaluating scientific investigation designs	41.9	77.9	36.0
Interpret data and evidence scientifically	Interpret and communicate scientific information in writing, orally or graphically	33.8	66.9	33.1
	Describe and analyze one or more science-technology-society relationships and understand the application of scientific knowledge in everyday life	25.7	64.7	39.0
Average		**34.9**	**70.4**	**35.5**

Table 8 Results of cycle II science literacy score calculation

Indicator	Sub Indicator	Cycle II average score		Enhancement
		Initial test	Final test	
Explain scientifically	Explain scientific knowledge	42.6	80.9	38.3
	Design predictions and hypotheses based on phenomena	46.3	82.4	36.1
Design and evaluate scientific inquiry	Designing scientific research and Evaluating scientific investigation designs	57.4	83.1	25.7
Interpret data and evidence scientifically	Interpret and communicate scientific information in writing, orally or graphically	36.0	77.2	41.2
	Describe and analyze one or more science-technology-society relationships and understand the application of scientific knowledge in everyday life	35.3	83.1	47.8
Average		**43.5**	**81.3**	**37.8**

The research results on applying the PBL model assisted by scaffolding in cycle I and cycle II show that scientific literacy in XI MIPA 1 has increased. The scientific literacy of XI MIPA I students was raised in the initial and final cycle tests. The initial test result in cycle I was 34.9, rising to 43.5 in the initial test II. The result in the final test of the cycle I was 70.4, increasing in the final test of cycle II to 81.3. The results of the research that has been carried out are the same as the results of research by Aliyana et al. (2019) and Nurhairani et al. (2019), which shows that there is a positive influence on increasing students' scientific literacy with the PBL model. Choosing learning in education is one of the principles of learning activities that allow students to master and understand scientific literacy skills well (Hafizah & Nurhaliza, 2021).

In scientific literacy skills, students can determine the appropriate procedure to find a solution; students are also able to inform, interpret, and use data sets to strengthen research results. In explaining scientific phenomena, students' level of content knowledge is moderate. The teacher has provided problems relevant to real life; then, students also connect theory with scientific concepts. The level of procedural knowledge in explaining scientific phenomena is moderate. Knowledge of essential procedures and concepts is applied to scientific research as a foundation for collecting, analyzing, and interpreting scientific data (Roberts et al., 2010). Conducting scientific investigations and analyzing available evidence to support a hypothesis requires knowledge of concepts and procedures. The level of epistemic knowledge in explaining scientific phenomena is moderate. Epistemic knowledge is knowledge about the structures and characteristics (such as thinking, reasoning, and observation) that are the basis for creating scientific knowledge and help clarify knowledge obtained through research (Duschl, 2008). Students use epistemic knowledge to illustrate the differences between scientific research and scientific theories, or facts and observations, which are essential for building scientific knowledge.

The results of the research show that in the scientific literacy indicators of designing and evaluating scientific investigations, the content,

procedural, and epistemic knowledge level is in the medium category. Indicators of interpreting data scientifically occupy medium content knowledge and low procedural and epistemic levels. This is proven by the grades obtained and the description of students' understanding during discussions. However, there was improvement at each meeting in the cycle. Scaffolding assistance in PBL was provided more during the implementation of cycle I and decreased in cycle II.

Every individual needs to master scientific literacy to enter and solve problems in social life (Basam et al., 2018). Research by Abidin et al. (2021) stated that scientific literacy is essential to shaping students into active citizens who participate and are responsive to solving problems that arise (Abidin et al., 2021). The PBL model has the potential to recognize students' scientific literacy. The PBL model makes students active and interested in the learning process, develops their thinking abilities, and allows students to realize their learning knowledge in the learning process (Aiman et al., 2022). This research also shows that empowering scientific literacy can be done by implementing the PBL model assisted by scaffolding.

Implementation of the Scaffolding-Assisted PBL Model on Student Cognitive Learning Outcomes

Learning outcomes are one of the learning objectives. According to Jarre & Bachtiar (2017), an innovative teaching process is needed if students' cognitive learning outcomes are low; improving cognitive learning outcomes requires appropriate and flexible learning models (Kurniawati et al., 2019). Educators can also provide constructivism-based learning to train thinking processes in a balanced manner in students' cognitive development (Schunk, 2012).

Cognitive learning outcomes can be known, assessed, and measured using evaluations or tests (Rosyidi, 2020). One form of assessment test is a multiple choice test with several alternative answers and questions or statements, where students are tasked with choosing the most appropriate answer (Rosyidi, 2020). They are measuring student learning outcomes in the cognitive domain through ten multiple choice test questions (initial and final cycle tests), which refer to indicators of cognitive process dimensions by Anderson & Krathwohl (2010), Bloom's taxonomy revised including analyzing (C4), evaluating (C5), and creating (C6). Data on student cognitive learning outcomes are presented in Table 9.

Analysis of the data on students' cognitive learning outcomes during cycle I and cycle II showed that the application of the PBL model assisted by scaffolding increased students' cognitive abilities. The final test of cycle I from 78.8 increased to 86.4 in the final test of cycle II. In classical class completion in cycle I, students who achieved the MCC score (≥78) were only 64.8 students; this result was said to be incomplete because ≤ 85 students completed, while in cycle II, students who met the MCC score (≥78,) were 85.3 which was declared class. It is complete. This increase in cognitive learning outcomes can occur due to the process of PBL learning activities assisted by scaffolding in the classroom. Students' learning experiences by directly participating in solving problems will strengthen learning outcomes and have a good level of understanding. Student activity positively affects learning because it makes students more aware of the material they are studying (Asiyah et al., 2021).

Table 9 Data on student cognitive learning results

Cycle	Data	Mark	Classical completeness
Cycle I	Initial test	52.9	64.8 (incomplete)
	Final test	78.8	
Cycle II	Initial test	57.6	85.3 (complete)
	Final test	86.4	

N-gain Value of Scientific Literacy and Student Cognitive Learning Outcomes

The N-gain test is a test that can provide details of the increase in learning outcome scores (Hake, 1999). The N-gain value determines the exact increase in scientific literacy and cognitive learning from that calculated from the final test scores of cycles I and II. The results of the N-gain values are in Table 10. The N-gain value of students' scientific literacy was 0.37 in the medium category, and the N-gain value of students' cognitive learning outcomes was 0.36 in the medium category. It can be concluded that scientific literacy and cognitive learning outcomes have increased.

The assessment of scientific literacy in this research refers to the OECD (2019) framework for the dimensions of knowledge and competence. Besides assessing scientific literacy competency, content, procedural, and epistemic knowledge are evaluated. Overall, the scientific literacy scores of class XI MIPA I students have increased, but students still need teacher assistance (scaffolding) and are not 100% independent in learning. Each indicator of students' scientific literacy is in the medium category; some are low. So, in calculating the N-gain value, the results also show an increase in the medium category. It takes more time to train scientific literacy to reach a high level. Cognitive learning outcomes improved as indicated by student's mastery of the material, thinking skills, and learning completeness in class.

Scientific literacy and cognitive learning outcomes increased in research during cycle II. The preparations and actions taken by researchers have been implemented well. When collecting research data, the weaknesses in this research were that students were still found to be less than honest, and some students lacked focus in class. Teachers must create a good, enjoyable learning environment and

understand students' conditions so they are ready to learn. The results of calculating the N-gain value show an increase in the moderate category because the results of student data analysis are not all good. Each student has a different level of ability to find solutions to problems. Scientific literacy and cognitive abilities are also influenced by each student's focus and initial knowledge.

Table 10 N-gain value of scientific literacy and student cognitive learning outcomes

Data	Cycle	Mark	N-gain Value	Category
Students' scientific literacy	Final test of cycle I	70.4	0.37	Currently
	Final test of cycle II	81.3		
Student cognitive learning outcomes	Final test of cycle I	78.8	0.36	Currently
	Final test of cycle II	86.4		

The learning process using the PBL model assisted by scaffolding positively impacts students. Students can collaborate with classmates to empower scientific literacy and cognitive abilities to meet the demands of the 21st century. Problem-solving is related to learning outcomes and scientific literacy (Moraes & Castellar, 2010). Individual attitudes and concerns can be influenced by mastery of abstract problem-solving and occur spontaneously in each individual's brain (Whimbey et al., 2013). Fact analysis activities and finding solutions to problems are components of scientific literacy (OECD, 2019). Scientific literacy is closely related to students' cognitive abilities. Mastery of scientific literacy requires good cognitive abilities to understand concepts to find and formulate an appropriate solution according to the problem (Lestari, 2017). The results of this research are strengthened by research by Nufus et al. (2021), who stated that there is a significant influence between scientific literacy and learning outcomes. The better a student's mastery of scientific literacy, the better the student's cognitive abilities.

D. Conclusion

The PBL model, assisted by scaffolding, can improve scientific literacy skills and learning outcomes in the cognitive domain of XI MIPA 1 SMA Islam Malang. Scientific literacy increased from 70.4 (cycle I) to 81.3 (cycle II). The N-gain value for scientific literacy was 0.37 in the medium category. Students' cognitive learning outcomes increased from 78.8 (cycle I) to 86.4 (cycle II). The N-gain value of students' cognitive learning outcomes was 0.36 in the medium category. Classical class completion also increased from 64.8 (cycle I) students who were said to be incomplete to 85.3 (cycle II) students who were declared complete. The development of scientific and cognitive literacy aims to give students the ability to understand science well and participate socially in solving problems related to science and technology.

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