

Exploring the Implementation of Problem-Based Learning in Grade XI Biology at SMA Negeri 6 Medan

Eksplorasi Keterlaksanaan Model Problem-Based Learning pada Pembelajaran Biologi Kelas XI di SMA Negeri 6 Medan

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Abstract. This study aims to examine the implementation of the Problem-Based Learning (PBL) model in Grade XI biology learning at SMA Negeri 6 Medan. This study employed a qualitative case study approach involving one biology teacher and students of Class XI Merdeka 1. The focus was on the application of PBL syntax in classroom practices. Data were collected through document analysis, classroom observations, and questionnaires administered to both the teacher and students. Data validity was ensured through technique and source triangulation, while data analysis was conducted through data reduction, data display, and conclusion drawing. The findings indicate that PBL was systematically planned through teaching modules aligned with the Merdeka Curriculum. In practice, learning was generally implemented as planned and received positive responses, particularly in individual and group investigation activities, although several aspects were not yet fully optimal. Students demonstrated active participation and collaboration. However, challenges were identified in scientific communication skills, reflective activities, and assessment practices that were not fully aligned with the initial planning, which may limit the development of higher-order thinking skills. Overall, PBL shows potential to support students' critical thinking and collaboration, although the findings are limited to this context and should not be generalized.

Keywords: problem_based_learning; Merdeka_curriculum; planning; implementation; evaluation

Abstrak. Penelitian ini bertujuan untuk mengkaji implementasi model Problem-Based Learning (PBL) pada pembelajaran biologi kelas XI di SMA Negeri 6 Medan. Penelitian ini menggunakan pendekatan studi kasus kualitatif dengan melibatkan satu guru biologi dan siswa kelas XI Merdeka 1. Fokus penelitian adalah pada penerapan sintak PBL dalam praktik pembelajaran di kelas. Data dikumpulkan melalui analisis dokumen, observasi kelas, serta angket yang diberikan kepada guru dan siswa. Keabsahan data dijamin melalui triangulasi teknik dan sumber, sedangkan analisis data dilakukan melalui tahap reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa PBL direncanakan secara sistematis melalui modul ajar yang selaras dengan Kurikulum Merdeka. Dalam pelaksanaannya, pembelajaran umumnya berjalan sesuai rencana dan memperoleh respons positif, terutama pada kegiatan investigasi individu dan kelompok, meskipun beberapa aspek belum sepenuhnya optimal. Siswa menunjukkan partisipasi aktif dan kerja sama. Namun, masih ditemukan kendala pada keterampilan komunikasi ilmiah, kegiatan refleksi, serta praktik penilaian yang belum sepenuhnya selaras dengan perencanaan awal, yang berpotensi membatasi pengembangan kemampuan berpikir tingkat tinggi. Secara keseluruhan, PBL menunjukkan potensi dalam mendukung keterampilan berpikir kritis dan kolaborasi siswa, meskipun temuan ini terbatas pada konteks penelitian dan tidak dapat digeneralisasikan.

Kata Kunci: pembelajaran_berbasis_masalah; kurikulum_merdeka; perencanaan; pelaksanaan; evaluasi

1. Introduction

Education is a process of developing human physical and spiritual potential that takes place within the family, school, and community environments. In the school context, the learning process involves two main subjects, namely teachers and students (6). Teachers act as professional educators and learning facilitators, while students serve as both subjects and objects of education who actively participate in the learning process (13). Therefore, the relationship between teachers and students is a crucial factor in achieving educational goals.

Current educational developments are characterized by the emergence of various learning models aimed at overcoming the limitations of conventional teacher-centered learning, which tends to involve students less actively. The shift toward student-centered learning requires the implementation of more interactive learning models. One rapidly developing model is Problem-Based Learning (PBL), which places real-world problems at the core of the learning process.

PBL is a learning model that presents students with real-world problems at the beginning of instruction to encourage active engagement in problem-solving processes (3). This is supported by the findings which indicate that PBL is effective in improving students' critical thinking skills and creating more engaging, interactive, and relevant learning experiences (12).

Various previous studies have shown that Problem-Based Learning (PBL) is effective in enhancing critical thinking skills, student activeness, and the quality of biology learning when implemented fully and consistently according to its syntax (3; 9; 12). However, most of these studies focus primarily on learning outcomes, such as improvements in critical thinking abilities or student achievement, without providing an in-depth description of how PBL is actually implemented in real classroom contexts.

Preliminary findings at SMA Negeri 6 Medan indicate a gap between the ideal concept of PBL and its practical implementation in the field. Although teachers claim to understand and apply PBL, its implementation remains partial, selective, and highly dependent on class characteristics, time availability, facilities, and student readiness. Some PBL syntax stages are not optimally implemented, student participation is uneven, and students' perceptions of the learning process do not fully reflect a problem-based learning experience.

In addition, there are differences in perceptions between teachers and students regarding the implementation of PBL, an aspect that has rarely been examined in previous studies. Teachers tend to perceive that PBL has been implemented, whereas students still view the learning process as conventional instruction or merely group work. This condition highlights the need for studies that focus not only on the effectiveness of PBL but also on the fidelity of its implementation based on direct observation and data triangulation.

Thus, there remains a lack of research examining the actual implementation of the Problem-Based Learning (PBL) model in biology learning for Grade XI under the Merdeka Curriculum, particularly in revealing obstacles, inconsistencies in syntax application, and contextual factors influencing its implementation in schools.

The novelty of this study lies in its focus on examining the implementation fidelity of the PBL model across three interconnected aspects, namely planning, classroom implementation, and evaluation, rather than focusing solely on learning outcomes. This study also integrates multiple data sources, including document analysis, classroom observations, and teacher and student responses, to provide a more comprehensive and contextual

understanding of PBL practices in a real classroom setting.

Therefore, this study aims to describe and analyze the planning, implementation,

and evaluation of the Problem-Based Learning (PBL) model in Grade XI biology learning at SMA Negeri 6 Medan.

2. Methods

Time and Place of the Research

This study was conducted at SMA Negeri 6 Medan, located on Jalan Ansari No. 34, Sei Rengas I, Medan Kota, North Sumatra, from August to October 2025.

Prior to the implementation of the study, administrative permission to conduct the research was obtained from the school. Preliminary observations and interviews with the biology teacher and Grade XI students were carried out to gain an initial understanding of the learning conditions and the implementation of the Problem-Based Learning (PBL) model. The researcher also reviewed teaching modules and student worksheets used during the 2025/2026 academic year to ensure their relevance to the study.

Participation of the teacher and students was voluntary, and informed consent was obtained before data collection. All data were treated confidentially, and the identities of participants were anonymized to protect their privacy. The study adhered to ethical standards in educational research.

Research Approach

This study employed a qualitative method with a case study approach combined with document analysis. The case study approach was used to obtain a comprehensive and in-depth understanding of a specific phenomenon or case, while document analysis was utilized to examine relevant documents as supporting sources of research data.

Determination of Research Subjects

The selection of research subjects was conducted using purposive sampling, that is, deliberate sampling based on predetermined criteria. The criteria included: (1) biology teachers who implement the Problem-Based Learning (PBL) model in the learning process, and

(2) students who are directly involved in biology learning using the PBL model.

The research subjects consisted of one biology teacher and one Grade XI Merdeka 1 class comprising 35 students at SMA Negeri 6 Medan. The subjects were selected using a purposive sampling technique based on specific criteria, namely a teacher who implements the Problem-Based Learning (PBL) model and students who are directly involved in problem-based learning activities.

This study employed a single case study design focusing on one teacher and one class to obtain an in-depth understanding of the implementation of PBL. Therefore, the findings of this study are not intended for broad generalization, but rather to provide analytical insights within the specific context under investigation.

Data Collection Techniques

The data collection techniques in this study included document analysis, observation, and questionnaires. Document analysis was conducted to examine teaching modules, student worksheets, and assessment documents prepared by the teacher. Observation was carried out to monitor the implementation of learning based on the five stages of the PBL syntax during the biology learning process, using evaluation categories of Good, Fair, and Not Present on an ordinal scale.

The research instruments consisted of document assessment sheets, observation sheets, and questionnaires, all of which were developed based on a review of relevant literature on PBL implementation and appropriate assessment indicators. The document assessment sheets were used to analyze teaching modules, student worksheets, and assessment components, while the observation sheets focused on

capturing the actual implementation of PBL in the classroom.

Questionnaires were administered to both the teacher and students to obtain their perceptions of the PBL implementation. These questionnaires were structured based on six indicators with a total of 30 statements and employed a Likert-type checklist scale with response options of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). The questionnaire data were analyzed descriptively by tabulating the responses and converting the scores into categorical interpretations ranging from Very Not Good to Very Good.

All instruments were validated through expert judgment to ensure content validity. Furthermore, the questionnaire data were used as supplementary data to triangulate and strengthen the findings obtained from document analysis and classroom observations. Although the questionnaire employed a Likert scale, the analysis was intended to support qualitative interpretation rather than for statistical generalization.

Data Validity Techniques

3. Result and Discussion

Result

The results and discussion of this research are presented in three aspects which include the stages of learning planning with the PBL model, the stages of implementing learning with the PBL model and the stages of learning evaluation with the PBL model.

The validity of the data was ensured through technique triangulation and source triangulation. Technique triangulation was conducted by comparing data obtained from document analysis, classroom observations, and questionnaires. Source triangulation was carried out by comparing data from the teacher and students. Any discrepancies found in the data were further analyzed to obtain a more comprehensive understanding.

Data Analysis Techniques

Data analysis was conducted using the Miles and Huberman model, which includes data reduction, data display, and conclusion drawing. Data obtained from observations and document analysis were coded and categorized based on predetermined indicators of PBL implementation. The results of the analysis were then classified into the categories of Good, Fair, and Poor to facilitate data interpretation. Conclusions were drawn by integrating findings from multiple data sources, resulting in a comprehensive understanding of the implementation of PBL in biology learning.

1) Learning Planning with PBL Model

The results of the planning stage were obtained through document analysis in the form of Teaching Modules, Student Worksheet, and assessment instruments, as presented in Table 1, Table 2, and Table 3.

Table 1. Results of Analysis of Teaching Module Document Assessment

Appearance	Indicator	Teacher Teaching Module Assessment
General Information	Identity Module	Good
	Learning Outcomes	Good
	Learning Objectives	Good
	Learning Steps	Good
	Initial Competencies	Good
	Pancasila Student Profile	Good
	Facilities and Infrastructure	Good
	Target Learners	Not Good

Appearance	Indicator	Teacher Teaching Module Assessment
Core Components	Learning Model	Not Good
	Learning Resources/ Media	Good
	Learning Assessment	Good
	Problem Orientation	Good
	Identification of Problems by Students	Not Good
	Organizing Students to Learn	Good
	Collaborative Activities	Good
	Guiding individual and group investigations (teacher involvement)	Good
	Developing and Presenting Works	Good
	Learning Products	Good
	Analyzing and Evaluating the Problem-Solving Process	Good
	Reflection and Drawing Conclusions	Not Good
Appendices	Closing Activities	Not Good
	Glossary	None
	Bibliography	None
	Assessment Rubric	Good
	Student Worksheet According to PBL Syntax	Good

In this study, the assessment categories of Good, Poor, and Not Present were determined based on predefined indicators and qualitative rating criteria embedded in the document assessment instrument. Each indicator was evaluated using three levels. A rating of Good was assigned when the component was clearly and comprehensively presented in alignment with the expected criteria. A rating of Poor indicated that the component was present but insufficiently developed, unclear, or only partially aligned with the criteria. A rating of Not Present was given when the component was entirely absent from the teaching module. These criteria were consistently applied across all indicators, including general information, core components, and supporting attachments, to ensure methodological rigor, transparency, and consistency in the document analysis.

The findings show that the Biology teaching module generally fulfills the essential components of PBL-based lesson planning, particularly in terms of structural

completeness and alignment with key instructional elements such as identity, core components, and assessment design. This suggests that the teacher demonstrates a foundational readiness to implement the PBL model in classroom practice. However, a closer examination reveals several critical gaps. These include the limited clarity in defining target learners, insufficient elaboration of the PBL model and its syntax, suboptimal facilitation of student involvement in problem identification, and weak integration of reflection, conclusion-drawing activities, and closing procedures. These limitations indicate that while the planning appears structurally adequate, the pedagogical depth and explicit representation of PBL principles within the teaching module remain underdeveloped. Consequently, further refinement is required to ensure that the module not only meets formal requirements but also fully supports the effective and authentic implementation of PBL in classroom settings.

Table 2. Student Worksheet Document Assessment Analysis Results

Gentium basic	Indicators	Rating
Identification and Structure	The identity of the student worksheet (title, class, subject) is clearly displayed.	Good
	The structure of the student worksheet (initial competencies) is organized systematically and consistently, making it easier for students to understand the flow of activities.	None
Learning Objectives	The learning objectives are stated clearly, relevant to the material, and the competencies to be achieved.	Good
	The objectives of the student worksheet are aligned with basic competencies and support the achievement of learning outcomes.	Good
Instructions and Guidelines	The instructions are presented clearly, detailed, and easy for students to understand.	Good
	The guide to the steps of the work is structured and gives the right instructions to the students.	None
Content and Material	The content of the student worksheet is relevant to the subject matter and supports the achievement of learning outcomes.	Good
	The material is arranged clearly, neatly, logically, so that it is easy for students to understand.	None
Student Activities	Activities encourage students to be active, facilitating interaction, discussion, or exploration.	Good
	The activities are varied, interesting, relevant to the material, so as to make students enthusiastic about learning.	Good
Thinking Skills	The student worksheet provides challenges that encourage students to think critically and analytically.	Good
	Student worksheets facilitate activities that develop students' creativity.	Good
Assessment and Reflection	Assignments are designed to evaluate learning outcomes clearly and comprehensively.	Not Good
	The student worksheet provides instructions and space for students to reflect on the learning process.	None

In general, the results of the assessment of the student worksheet document show that the student worksheet prepared by the Biology teacher of grade XI of SMA Negeri 6 Medan has met important aspects, such as identity, learning objectives, and instructions for use. The presentation of the contents of the student worksheet is

systematically arranged, in harmony with the teaching modules, and relevant to the learning material so that it has the potential to encourage active student involvement. Although the initial competencies have not been listed, the learning objectives in the student worksheet have been adjusted to the objectives of the teaching module used.

Table 3. Results of the Analysis of Assessment Document Evaluation

Aspects	Indicator	Rating
Application of a Growth Mindset	Clarity of assessment supports growth mindset	Not Good
Problem Understanding and Research	Ability to identify and formulate problems	Good
	Problem analysis skills	Good

Aspects	Indicator	Rating
	Planning of investigation strategies	Not Good
Data Collection and Collaboration	Quality of information collection and analysis	None
	Effectiveness of collaboration and group contribution	Good
Development and Presentation of Results	Quality of the solution or product	Good
Integrated	Quality assessment of knowledge, skills, and attitudes	Good
	Quality assessment of the realm of attitudes	Good
	Quality of knowledge domain assessment	Good
	Quality assessment of collaboration skills domain	Good
	Quality assessment of the domain of communication skills	Good
	Quality assessment of the domain of critical thinking/problem-solving skills	Good
	Quality assessment of the domain of creative thinking skills	Good
Flexibility in Determining Assessment Time	Completeness of diagnostic, formative, and summative assessments	Good
Flexibility in Using Assessment Techniques	Variations of assessment techniques	Not Good
Flexibility in Processing Assessment Results	Assessment results processing guide	Good

Broadly speaking, the assessment results show that the assessment prepared by teachers is in accordance with the principles of PBL and is dominated by the Good category. The assessment has covered the realm of knowledge, skills, and attitudes in an integrated manner, with indicators that assess students' problem-solving, cooperation, communication, and activeness. The timing and flow of assessment (diagnostic, formative, and summative) are also clearly arranged.

However, there are still limitations in the aspect of developing growth mindset, especially in the depth of reflection, variety

of assessment techniques, and assessment of the investigation process and analysis of student information.

2) Implementation of Learning with PBL Model

The results and discussion of the implementation stage were obtained through the analysis of observation sheets of learning implementation; non-participant observations were carried out during biology learning using the PBL model. The results of the implementation stage are listed in Table 4 below

Table 4. Learning Observation Results with PBL Model

Aspects	Indicator	Obsv I	Obsv II	Obsv III
Student Orientation to the Problem	The teacher presents problems that are contextual and relevant to the Biology material.	Good	Good	Good
	Students are actively involved in understanding and discussing the given problem.	Good	Good	Good
	Teachers guide students in connecting problem with the concept of Biology.	Good	Good	Good

Aspects		Indicator	Obsv I	Obsv II	Obsv III
Organizing Students for Learning		The problems given motivate students to explore the concepts further.	Good	Good	Good
		Teachers facilitate initial discussions that encourage students' critical thinking.	Not Good	Not Good	Not Good
		The teacher divides students into effective working groups.	Good	Good	Good
		The teacher gives clear work instructions to the group.	Good	Good	Good
		Students understand each other's roles in the group.	Good	Good	Good
		Teachers provide support in managing group work.	Good	Good	Good
		Students can collaborate well in drafting problem-solving strategies.	Not Good	Not Good	Good
	Facilitating Individual or Group Investigation	Teachers motivate students to seek information from various sources.	Not Good	Not Good	Not Good
		The teacher guides the students in formulating a hypothesis or research plan.	Good	Good	Good
		Students conduct experiments or observations that are relevant to the given problem.	Not Good	Not Good	Good
		The teacher assists students in analyzing the data from the research results.	Good	Not Good	Good
Developing and Presenting Results		Students can draw conclusions based on the data obtained.	Good	Good	Not Good
		The teacher gives instructions in the preparation of the report or presentation of the results of the investigation.	Good	Good	Good
		Students present the results of the investigation in clear and scientific language.	Good	Good	Good
		The teacher guides the students in the use of media or aids in the presentation.	Good	Good	Good
		Students can explain the results of the investigation with confidence.	Good	Good	Not Good
		Students responded well to questions and discussions.	Not Good	Not Good	Not Good
Analyzing and Evaluating the Problem-Solving Process		The teacher guides the students to reflect on the learning process.	Not Good	Not Good	Not Good
		Students are able to identify difficulties experienced during the learning process.	Good	Good	Good
		The teacher provides feedback on the student's performance in problem solving.	Not Good	Good	Good
		Students can propose new improvements or strategies to deal with similar problems.	Not Good	Not Good	Not Good

Aspects	Indicator	Obsv I	Obsv II	Obsv III
	Teachers and students together conclude the learning outcomes.	Good	Good	Good

Overall, the observation results indicate that biology learning using the Problem-Based Learning (PBL) model in Grade XI Merdeka 1 at SMA Negeri 6 Medan has been implemented fairly well and aligns with the five main PBL syntax stages. The implementation is consistent with the lesson plans outlined in the teaching module, although several aspects still require improvement.

In the stages of problem orientation and student organization, the teacher was able to present contextual problems, utilize ICT media effectively, and form conducive learning groups. However, student participation was uneven, as only about half of the students actively contributed during the initial discussion, while the others remained passive. In addition, group dynamics were not fully balanced, as two out of six groups showed limited interaction and were dominated by one or two active members.

During the investigation stage, the teacher guided students effectively in designing investigation steps and analyzing data. Nevertheless, most students relied primarily on the resources provided by the teacher, with only a few attempting to seek additional references independently. Furthermore, around two groups experienced difficulties in linking the collected data to the problem context, indicating that students' scientific reasoning skills were not yet fully developed.

The development and presentation of results stage generally proceeded well. Most groups were able to organize and present their findings systematically using reasonably accurate scientific language. Four out of six groups delivered structured presentations, while the remaining groups were less organized. However, some conclusions were not fully supported by investigation data, and classroom discussions during the question-and-

answer session tended to be brief and less in-depth, partly due to limited instructional time.

In the stage of analyzing and evaluating the problem-solving process, reflective activities were relatively weak. The reflections conducted were mostly general and did not sufficiently encourage students to evaluate their thinking processes or problem-solving strategies at a metacognitive level. Although the teacher provided feedback and opportunities for students to express learning difficulties, only a few students were able to propose alternative strategies for future problem-solving.

Overall, the implementation of PBL shows strong potential in promoting student engagement and conceptual understanding. However, it still faces challenges related to the depth of discussion, students' independence in conducting investigations, and the quality of reflective learning.

3) Learning Evaluation with PBL Model

Based on the results of the documentation study of assessment documents in the teaching module, it was found that the implementation of learning evaluation had been designed according to the module but had not been fully executed optimally. The evaluation covered three assessment domains: knowledge, attitudes, and skills, demonstrating the teacher's effort to apply comprehensive assessment in line with competency-based learning principles.

In the knowledge domain, the teacher prepared a post-test consisting of ten multiple-choice questions with cognitive levels C2 to C4, systematically arranged in the teaching module. However, the written test could not be conducted as planned due to limited instructional time caused by school activities. The teacher decided to postpone the assessment and planned to

combine it with the competency test of the material in the next meeting.

In the attitude domain, assessment instruments for individuals and groups were available in the teaching module. Nevertheless, implementation was dominated by group attitude assessment, focusing on indicators such as cooperation, responsibility, tolerance, and discipline. Individual attitude assessment was still conducted, but not entirely using written rubrics. Instead, it was carried out through direct observation and informal recording of student behavior by the teacher during the learning process.

In the skills domain, the teacher used instruments outlined in the teaching module, which included aspects of content mastery and presentation skills. In addition to rubric-based assessment, the teacher also conducted direct observation of student engagement in discussions. Although not fully documented formally, this approach reflects the application of authentic assessment in line with the characteristics of Problem-Based Learning (PBL).

4) Teacher and Student Response to Learning with PBL Model and Supporting Factors Affecting Learning Success

In addition to observations, data were collected through questionnaires administered to the teacher and students of Grade XI Merdeka 1 to explore their perceptions of the implementation of the Problem-Based Learning (PBL) model and the supporting factors for its execution. The questionnaires were designed based on the five main PBL syntax stages: problem orientation, student organization, independent and group investigation, development and presentation of work, and evaluation of the problem-solving process.

The questionnaires also included indicators of supporting learning factors, such as the availability of facilities and infrastructure, readiness of assessments, and classroom conditions that facilitate collaboration. This instrument served to reinforce the data obtained from observations. The tabulated results of the teacher and student questionnaires are presented in Tables 5 and 6, showing their perceptions of PBL implementation in Grade XI biology learning at SMA Negeri 6 Medan.

Table 5. Student Questionnaire Tabulation Results

No.	Aspects	Category
1.	Orienting Students to Problems	Good
2.	Organizing Students to Learn	Very Good
3.	Developing and Presenting the Results of the Discussion	Very Good
4.	Guiding Independent and Group Investigations	Very Good
5.	Analyzing and Evaluating Processes and Outcomes	Good
6.	Learning Support Facilities	Good

Based on the results of the student response questionnaire regarding the implementation of the Problem-Based Learning (PBL) model in biology learning, students' responses generally ranged from Good to Very Good, indicating a positive perception of PBL. However, these positive responses should be interpreted cautiously because they primarily reflect students'

perceptions rather than directly measuring the effectiveness of the implementation.

Examining the indicators based on PBL syntax, the aspect of assisting independent and group investigations received the highest score and was categorized as Very Good. This finding suggests that students felt well supported in conducting investigations both individually and in groups, and that they

received adequate guidance throughout the learning process. In addition, the indicator of supporting learning facilities was also rated Very Good, which indicates that the use of student worksheets, visual media, and internet access effectively supported problem solving and understanding of the material.

Other indicators, such as orienting students to the problem, organizing groups, developing and presenting discussion results, and analyzing and evaluating the problem solving process, were rated Good. While this indicates that students were actively engaged in learning, it also shows that several aspects of PBL

implementation have not yet reached an optimal level. Challenges were still observed in group work management, scientific communication skills, as well as the depth of reflection and critical thinking.

These findings imply that although students perceive PBL positively, several core competencies expected from PBL, particularly higher order thinking and collaboration, are not yet fully developed. Therefore, further improvement is needed to strengthen collaboration, communication, and critical reflection in order to achieve more comprehensive PBL implementation in biology learning.

Table 6. Results of the Tabulation of the Teacher Questionnaire

No.	Aspects	Category
1.	Orienting Students to Problems	Very Good
2.	Organizing Students to Learn	Very Good
3.	Developing and Presenting the Results of the Discussion	Good
4.	Guiding Independent and Group Investigations	Very Good
5.	Analyzing and Evaluating Processes and Outcomes	Very Good
6.	Learning Support Facilities	Very Good

Based on the results of the teacher response questionnaire regarding the implementation of the Problem-Based Learning (PBL) model, it was found that the teacher provided a very positive assessment of the overall problem-based learning process applied in the class.

Examining each indicator, the syntax stages of Orienting Students to the Problem and Organizing Students received a Very Good rating, indicating that the teacher considered the initial stages of PBL to be implemented clearly, effectively, and systematically, particularly in presenting indicating that the teacher played an active role in guiding the investigation and evaluation processes.

Furthermore, the indicator of Supporting Learning Facilities also received a Very Good rating, reflecting that the availability of media and learning resources, student worksheets, utilization of digital tools, time management, and the alignment of materials with the problems effectively supported the optimal implementation of PBL in the class.

the problem, forming groups, providing guidance, and facilitating students during learning activities.

For the syntax stage of Developing and Presenting Work/Discussion Results, the teacher gave a Good rating, suggesting that students' ability to present discussion results still needs improvement, especially in terms of clarity of presentation and self-confidence. Meanwhile, the stages of Assisting Independent and Group Investigation and Analyzing and Evaluating the Process and Problem-Solving Outcomes were rated Very Good,

Discussion

1) Learning Planning with PBL Model

Learning planning using the Problem Based Learning (PBL) model has been carried out systematically by the teacher through the preparation of teaching modules, student worksheets, and assessment instruments. This planning aims to support student-centered learning and to develop critical thinking and

problem-solving skills (4). The teaching modules that were prepared include learning objectives, PBL syntax, learning activities, and assessments in accordance with the Merdeka Curriculum (10).

The results of the analysis show that all PBL syntax stages are sequentially included in the core learning activities, starting from problem orientation to the evaluation of the problem-solving process. The topics of plant tissues, organs, and organ systems are considered suitable for implementation through PBL because they are contextual in nature and closely related to students' everyday lives (7).

The PBL-based student worksheets prepared by the teacher include identity information, learning objectives, instructions for completion, and contextual problems that encourage students to think critically (15). However, the teaching modules have not yet been equipped with a glossary and a reference list, even though the presence of a glossary is important to help students understand scientific terms in biology learning (15). In addition, a reference list is needed to indicate source materials and to strengthen the scientific foundation of the teaching modules (14).

Although overall the learning planning can be categorized as good, several aspects indicate that it has not yet been fully optimal. The absence of a glossary may affect students' understanding of key concepts, as clear definitions play an important role in supporting the development of accurate scientific understanding (15). Furthermore, the absence of a reference list may limit the scientific credibility of the teaching modules, since references are essential to ensure the validity and reliability of instructional materials (14). Therefore, improving the completeness and quality of planning documents is essential to ensure that PBL implementation is supported by strong and comprehensive instructional design (4).

2) Implementation of Learning with PBL Model

The implementation of PBL-based learning has generally been carried out in accordance with the planned syntax. At the problem orientation stage, the teacher presented contextual problems supported by visual media, which were able to attract students' attention and increase their curiosity (5). The problems presented were closely related to students' experiences, thereby encouraging active involvement in the learning process (8).

At the student organization stage, the teacher formed heterogeneous groups and provided student worksheet as learning guides. Although group collaboration was established, there were still imbalances in roles within some groups, such as the dominance of certain students and low participation from other members (13).

During the independent and group investigation stage, the teacher played an active role as a facilitator by guiding students in analyzing problems and formulating solutions. However, some students were still dependent on the sources provided by the teacher and had not optimally searched for additional references independently.

At the development and presentation stage, students were able to present the results of their discussions through posters and presentations. Nevertheless, students' abilities to draw data-based conclusions and to communicate scientific arguments still need improvement. The reflection stage was conducted, but it remained general in nature and had not yet deeply explored students' thinking processes.

3) Learning Evaluation with PBL Model

The evaluation of PBL learning encompasses the assessment of cognitive, affective, and psychomotor domains. Students' basic abilities in the cognitive (intellectual), attitudinal (affective), and behavioral (psychomotor) domains greatly influence the determination of their learning outcomes (11). In the cognitive domain, the teacher has prepared a post-test to measure students' ability to understand and apply concepts. However,

most of the questions are still oriented toward low to moderate cognitive levels and do not fully target higher-order thinking skills (HOTS), which are a characteristic of PBL.

The implementation of the cognitive evaluation was also constrained by limited time, preventing the test from being conducted according to schedule. In the affective domain, attitude assessment was carried out through observation during the learning process. Although rubrics were prepared, their implementation has not been fully documented systematically.

In the psychomotor domain, assessment was conducted through group discussion and presentation activities. These activities support the development of communication skills, collaboration, and active student participation in accordance with PBL characteristics (1). Overall, the evaluation has been well-designed, but its implementation still needs to be improved to more comprehensively reflect students' learning achievements (2).

4) Teacher and Student Response to Learning with PBL Model and Supporting Factors Affecting Learning Success

The teacher's response to the implementation of PBL is generally very

positive. The teacher assessed that most of the PBL syntax had been carried out well and was supported by the availability of facilities and learning media. However, at the result presentation stage, the teacher noted that students' ability to communicate ideas in an organized and confident manner still needs improvement.

Despite these positive perceptions, classroom observations revealed differences in students' levels of participation and the dominance of certain roles within groups. This discrepancy indicates a gap between the teacher's perception of implementation and the actual learning experiences of students. Teachers tend to evaluate based on instructional design and delivery, while students experience the dynamics of group work directly, including unequal participation and limited engagement of some group members.

These findings highlight the importance of data triangulation to obtain a more comprehensive and objective understanding of PBL implementation. Furthermore, they indicate that improving classroom management strategies and ensuring more equitable participation are important to enhance the effectiveness of PBL in practice.

4. Conclusion

Based on the findings, the implementation of the Problem-Based Learning (PBL) model in Grade XI biology learning at SMA Negeri 6 Medan can be summarized into four aspects.

In terms of planning, learning tools such as teaching modules, student worksheets, and assessment instruments were systematically prepared in accordance with the Merdeka Curriculum. In implementation, PBL activities were carried out and supported students' engagement, although challenges in group participation and communication were still found. Regarding fidelity, the PBL syntax

was generally implemented according to the expected stages, but not all aspects were carried out optimally. In the evaluation aspect, the teacher has applied cognitive, affective, and psychomotor assessments; however, their implementation was not fully aligned with the initial planning, which may limit the completeness of measuring students' competencies.

Overall, PBL shows potential to support students' critical thinking and collaboration. However, these findings are limited to the context of this study and should not be generalized to other settings.

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