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DEVELOPMENT OF PROBLEM BASED LEARNING MODEL TO IMPROVE STUDENTS' PROBLEM SOLVING ABILITIES

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Abstract: *This study aims to develop an effective Problem Based Learning (PBL) learning model in improving students' problem-solving abilities. This model was developed through the stages of design, validation, and limited trials with the Research and Development (R&D) approach using the Borg & Gall development model. The subjects of the study were grade XI students at a public high school. Data were collected through observation, interviews, validation questionnaires, and problem-solving ability tests. The results of the study showed that the developed PBL model had high validity and practicality based on expert assessments and teacher and student responses. Limited trials also showed a significant increase in students' problem-solving abilities after the implementation of this model. Thus, this PBL model is feasible to be applied in learning to support the development of critical thinking and problem-solving skills in students.*

Keywords:*Problem Based Learning, problem solving, model development*

INTRODUCTION

21st century education demands a paradigm shift in the learning process, from teacher-centered to student-centered. In this context, high-level thinking skills, especially problem-solving skills, are the main competencies that students must have. This ability is very important not only for academic success, but also in facing complex and dynamic real-life challenges. However, the reality in the field shows that learning in many educational units is still teacher-centered and textual, with conventional approaches such as lectures and memorization.(Afif, 2023, p. 87)

This causes low active involvement of students in the learning process and the lack of development of critical thinking and problem-solving skills. Students tend to be passive, only receiving information without being trained to analyze, evaluate, and find solutions to existing problems. This condition has an impact on the low quality of learning outcomes, especially in high-level cognitive aspects. One learning approach that is believed to be able to answer these challenges is Problem Based Learning

(PBL). PBL is a student-centered approach, where learning begins with a complex real problem. Through the process of exploration, discussion, collaboration, and reflection, students are required to build their own knowledge, develop critical thinking skills, and find solutions to the problems they face. Thus, PBL provides an authentic and meaningful learning experience, and can increase students' motivation and learning independence.(Angelica, 2021, p. 21)

Although PBL has been widely discussed in various literatures as an effective approach, its implementation in schools still faces various obstacles. Among them are the lack of teacher understanding of the systematic steps of PBL implementation, the unavailability of learning models or tools that are in accordance with student characteristics and the applicable curriculum, and limited training or assistance for teachers in implementing this approach optimally. Based on these problems, it is necessary to develop a PBL learning model that is tailored to the needs and context of learning in schools, especially in order to improve students' problem-solving abilities. The development of this model is expected to be an innovative solution to improve the quality of the learning process and outcomes, as well as provide practical guidance for teachers in implementing problem-based learning effectively. Therefore, this study focuses on the development of a structured and valid Problem Based Learning model to improve students' problem-solving abilities. This study also aims to determine the feasibility, practicality, and effectiveness of the developed model, so that it can be an applicable alternative in the world of education, especially at the high school level.(Anggi & Soesanto, 2016, p. 90)

METHOD

This research is a research and development (R&D) study aimed at producing and testing the feasibility of a learning model based on Problem Based Learning (PBL) to improve students' problem-solving abilities. The approach adopted in this study refers to the development model proposed by Borg and Gall (1983),which has been modified to suit the needs and context of educational research in secondary schools. As an R&D type of study, the goal is to develop an educational product in this case, a learning model that is valid, practical, and effective. This approach was chosen because it enables researchers to follow a systematic process starting from needs analysis to evaluating the effectiveness of the developed product (Azka & Santoso, 2015, p. 90).

The development procedure followed several key stages. It began with a preliminary study or needs analysis conducted through observations, teacher interviews, and analysis of learning documents to identify field problems and assess the necessity of implementing a PBL model. Following this, a planning phase was carried out where an initial draft of the PBL learning model was developed, including model components, learning steps, syntax, supporting tools such as lesson plans (RPP), student worksheets (LKS), teacher guides, and evaluation indicators. This initial draft, referred to as the prototype, encompassed the conceptual design of the model, learning tools, and research instruments (Batubara, 2016, p. 32).

The next stage involved validation testing by experts. The draft product was reviewed by subject matter experts, instructional design experts, and education practitioners to assess its content validity, construction, and usability. Based on the feedback received, revisions were made to improve the model and its accompanying tools. The revised version was then subjected to a limited trial involving a small group of students to examine the model's implementation, practicality, and the responses from both students and teachers. Subsequently, the model underwent main field testing in a larger group setting to evaluate its effectiveness in enhancing students' problem-solving abilities. This stage also included both quantitative and qualitative data collection. The final product was revised and finalized based on the analysis of the results from this comprehensive trial.

The study involved Grade XI students from a state senior high school selected purposively, along with subject teachers who played a crucial role in the validation and implementation phases of the model (Habibinsyah, 2016, p. 76). Data collection techniques employed in this study included classroom observations to monitor model implementation, interviews with teachers and students to explore their responses, questionnaires to measure practicality and user satisfaction, and problem-solving ability tests to assess model effectiveness in improving critical thinking.

The instruments used in the study included a learning model validation sheet, an observation sheet for learning implementation, student and teacher response questionnaires, problem-solving test items designed around high-order thinking indicators, and interview guides (Hala, 2015, p. 32). Data analysis involved both qualitative and quantitative methods. Qualitative data from observations, interviews, and expert feedback were analyzed to interpret meaning, relevance, and model usability. Quantitative data from expert validations, questionnaires, and problem-solving tests were processed using descriptive statistics (e.g., means, percentages) and inferential tests (e.g., t-tests or gain scores) to determine model effectiveness.

The success of the developed PBL learning model was evaluated based on three main indicators: validity, practicality, and effectiveness. The model was considered valid if expert evaluations rated it at a score of 3 or higher on a 1–4 scale. Practicality was determined through positive feedback from teachers and students and successful implementation in the classroom. Finally, the model was deemed effective if there was a significant improvement in students' problem-solving abilities, as evidenced by pre-test and post-test results.

RESULTS & DISCUSSION

Is the Developed Problem Based Learning Model Effective in Improving Students' Problem Solving Abilities?

The effectiveness of a learning model is determined by how well it achieves the predetermined learning objectives. In this study, the effectiveness of the developed Problem Based Learning (PBL) model is assessed based on the improvement in students' problem-solving abilities following its application in the learning process. The evaluation is conducted through a comprehensive approach that integrates both quantitative and qualitative methods. Theoretically, PBL is grounded in the principles of constructivism, emphasizing that students actively construct their own knowledge by engaging in real and contextual problem-solving. According to Barrows and Tamblyn (1980), PBL promotes higher-order thinking skills such as analysis, synthesis, and evaluation core components of effective problem-solving. In practice, PBL encourages students to identify problems, gather relevant information, explore possible solutions, make decisions based on evidence, and reflect on the process. This model nurtures several problem-solving aspects, including the ability to recognize and define problems, seek relevant information, design and evaluate alternative solutions, and reflect critically. These skills are developed through collaborative, project-based, and reflective learning experiences facilitated by the PBL approach.

The effectiveness of the PBL model in this research was evaluated using several indicators. These include the improvement of students' cognitive learning outcomes in the area of problem-solving, which was measured using pretest and posttest instruments; the achievement of problem-solving competencies based on the Higher Order Thinking Skills (HOTS) taxonomy; the level of student engagement in the learning process observed during class discussions, group activities, and presentations; and the responses from students and teachers regarding the learning experience, particularly in terms of motivation, independence, and perceived benefits. Additionally, the effectiveness was assessed by comparing gain scores between students taught using the PBL model and those taught with conventional methods, if a quasi-experimental design was employed (Hayati, 2020, p. 43).

To test the effectiveness, a quasi-experimental design was utilized, either through a one-group pretest-posttest design or a pretest-posttest control group design, depending on classroom conditions. The PBL model was implemented across several learning sessions, after which students' problem-solving abilities were measured and analyzed. Inferential statistical tests, such as paired t-tests, independent t-tests, or N-Gain analyses, were used to determine the significance of differences in student performance before and after the implementation. In parallel, qualitative data collected through observations and interviews were analyzed to identify changes in classroom dynamics and student behavior. The findings are expected to demonstrate a significant increase in students' problem-solving abilities, evidenced by improved posttest scores. Furthermore, students are anticipated to respond positively, feeling more challenged, motivated, and actively engaged in learning. Teachers are also expected to find the model easy to implement and beneficial in enhancing learning outcomes and classroom interactions. Students' active participation is reflected in their ability to express ideas, ask questions, provide arguments, and formulate systematic solutions (Hero & Sni, 2018, p. 31).

If proven effective, the PBL model developed in this research can serve as a strategic solution to enhance learning quality, particularly in developing 21st-century skills such as critical thinking, collaboration, communication, and problem-solving. The model can also function as a reference tool for teachers, both in training programs and in practical classroom settings. The research specifically aims to develop a structured, valid, practical, and effective PBL model that enhances students' problem-solving skills at the senior high school level. To achieve this, the study begins by analyzing the initial conditions and needs of the target school, including teaching styles, student motivation, engagement levels, and existing obstacles in cultivating problem-solving skills. The analysis also identifies gaps between conventional teaching practices and the ideal principles of PBL.

Following this, a conceptual framework for the PBL model is designed, which includes model syntax, roles of teachers and students, learning resources, and assessment instruments. Supporting tools such as lesson plans (RPP), student worksheets (LKS), evaluation rubrics, and teacher guides are also developed. The model is then validated by experts in content, instructional design, and educational practice, who assess its construct and content validity. Qualitative feedback is collected to refine the model and its instruments (Imelda & Tulak, 2021, p. 66). To assess practicality, a limited trial is conducted with a small group to evaluate the model's usability, implementation flow, and ease of use. Data are collected through observations and questionnaires, and responses from teachers and students are analyzed.

The effectiveness of the model is tested through a main field implementation using a quasi-experimental design (pretest-posttest and control group). Data analysis includes both quantitative techniques (e.g., paired t-tests and gain scores) and qualitative methods (e.g., interviews and observations) to assess the model's impact on student learning. Finally, the research aims to develop implementation recommendations by formulating operational guidelines and strategies for applying the PBL model in various biology topics. It also includes suggestions for teacher training and ongoing professional development to ensure broader adoption of the model across different schools. Thus, this study does not merely focus on developing a learning model, but also emphasizes its validation, implementation, and dissemination ensuring that the PBL model is practical, applicable, and impactful in improving students' problem-solving competencies.

How is the Process of Developing a Problem Based Learning Model that is Appropriate to Student Characteristics and Learning Context in Secondary Schools?

Needs and Context Analysis Survey and Field Observation Conduct classroom observations to see teacher-student interaction patterns, methods applied, and obstacles that arise in learning. Distribute initial questionnaires to students and teachers to measure learning motivation, cognitive styles, and perceptions of biology learning problems. Interviews with Stakeholders In-depth interviews with biology subject teachers to understand curriculum pressures, time allocation, and availability of resources (laboratories, books, media). Focus group discussions (FGDs) with students to capture learning needs, readiness levels, and difficulties experienced in problem solving.(Rahim, 2020, p. 21)

Curriculum Analysis and Competency StandardsMapping core competencies (KI) and basic competencies (KD) on the relevant biology syllabus.Determining indicators of problem-solving abilities (e.g., formulating hypotheses, evaluating alternative solutions) based on the revised Bloom's taxonomy.Initial Planning and DesignFormulating Specific Learning ObjectivesDrafting operational objectives that lead to cognitive (analysis, evaluation) and affective (cooperation, responsibility) domains.Determining PBL Model SyntaxUsually includes the steps of Problem OrientationIdentifying and Formulating ProblemsCollecting InformationPreparing Hypotheses and Alternative SolutionsGroup Analysis and DiscussionDeveloping and Presenting Solutions

Reflection and Evaluation of Learning Device DesignLearning Implementation Plan (RPP): contains objectives, PBL steps, assessments, and time allocation. Student Worksheets (LKS): presents problem scenarios, step guides, and note space. Teacher Guide: discussion facilitation instructions, guiding questions, and assessment criteria. Assessment Rubric: performance indicators for each aspect of problem solving. Expert Validation and Product Revision Content and Construct Validity AssessmentDistribute instruments and devices to biology subject matter experts, instructional design specialists, and senior teachers. Assess clarity of syntax, appropriateness of problem scenarios, and suitability of evaluation tools. Collecting Qualitative InputInterviews or written discussions to obtain suggestions for improvement for example, simplifying the LKS language, adjusting the working time, or adding supporting media.(Sahrudin, 2014, p. 67)

Revision and RefinementImprove the problem scenario to be more contextual (using local examples or current issues).Improve the rubric to be easy to use and reliable.Limited TrialImplementation in Small GroupsSelect one or two small classes (10–15 students) that are heterogeneous.The implementing teacher monitors step by step and records technical and pedagogical obstacles.Collection of Practicality DataObservation of the course of each PBL syntax: duration, student involvement, and discussion dynamics.Practicality questionnaire for students and teachers: ease of understanding instructions, time required, and suitability of materials.Analysis of Limited Trial ResultsIdentify stages that require adjustment (for example, the problem is too complex or the discussion is too short).

Formulate revision recommendations to improve practicality. Main Field Testing Quasi-Experimental Design Determine experimental classes (using the PBL model) and control classes (conventional methods) with similar characteristics. Conduct a pretest to measure baseline problem-solving skills. Implementation of the PBL Model Trained teachers apply the model in several meetings according to the lesson plan. The facilitator (researcher) supervises and records field notes. Posttest and Data Analysis Measure posttest scores in both groups. Statistical analysis (paired t-test for PBL classes, independent t-test between groups) and N-Gain calculation to see effectiveness. Qualitative Data Collection In-depth interviews with teachers and students regarding experiences, benefits, and challenges of implementing PBL. Documentary observations (photos, videos, discussion notes) to support quantitative findings.(Tambak et al., 2020, p. 90)

Finalization and Preparation of Final Product Synthesis of Development Results Summarizes improvements from all stages, including expert validation, limited testing, and extensive testing. Model Documentation Compiling a complete guidebook for the PBL model: basic theory, procedures, teaching tools, and evaluation rubrics. Compiling Implementation Recommendations Teacher training strategies, workshop modules, and integration proposals in continuous development (in-service training). Dissemination Seminars, teacher training, and publication of scientific articles to disseminate the model to other schools. With the series of stages above—starting from needs analysis to dissemination the PBL model developed is expected to be not only valid and practical, but also effective and adaptive to the unique characteristics of students and the context of secondary schools.

Describe the initial conditions of PBL learning in the target class through observation, interviews, and document analysis. Realize the obstacles and opportunities that exist, so that the design of the model will truly answer the needs of teachers and students. Design a conceptual framework and PBL syntax that includes practical steps, actor roles (teachers/students), and reflection flow. Provide a 'roadmap' of the learning process so that each stage (orientation, identification, investigation, etc.) can be carried out consistently and systematically. Develop teaching support tools, including adaptive RPP, LKS containing contextual problem scenarios, HOTS assessment rubrics, and teacher facilitation guides. This tool ensures that teachers do not need to design from scratch, but can directly use modules that have been adjusted to student characteristics and biology syllabus.

Validate the model and tools through input from content experts, instructional design experts, and practicing teachers. Initial validation is important to gather feedback on: content appropriateness, clarity of instruction, and appropriateness to the secondary school context. Assess the practicality of implementing the model in a limited pilot measuring syntax feasibility, implementation time, and teacher/student perceptions of ease of use. This test identifies weak points in the model's operation so that they can be fixed before being tested on a larger scale. Measuring the effectiveness of the model through a quasi-experimental design (pretest-posttest and/or control group): analyzing the improvement in problem-solving scores, gain scores, and statistical significance.

This quantitative evidence serves as an objective measure that the model actually improves students' abilities.a compared to conventional methods(Riyono & Retnoningsih, 2015, p. 4)

Document and synthesize the results of all stages of development to compile a comprehensive guidebook and ongoing implementation recommendations.This final documentation ensures the sustainability and dissemination of the PBL model, facilitates adoption in other schools and can be used as teacher training material.How Each Goal is Integrated From Analysis to Design: The results of observations and interviews (Goal 1) guide the design of syntax and tools (Goals 2 & 3). From Design to Validation: The draft model is verified by experts (Goal 4), providing clarity that the implementation prospects will be successful. From Validation to Testing: The refined model is tested in real-world settings first on a small scale (Goal 5), then on a larger scale (Goal 6).

From Pilot to Dissemination: Data and field experiences are finalized into a complete guide (Objective 7), so that the results of the research do not stop at the paper, but also help build the capabilities of other teachers and schools. With this structure, each objective is not just a statement of “what” is to be achieved, but also “why” and “how” it contributes to the validity, practicality, and effectiveness of the PBL model. The following is a broad and in-depth Strategy for the development and implementation of the Problem Based Learning (PBL) Model, divided into five main domains: planning, capability building, implementation, monitoring & evaluation, and sustainability and dissemination. Planning and Initial Conditioning Strategy Core Team Formation Form a cross-functional development team (researchers, biology teachers, instructional specialists, laboratory technicians). Assign roles and responsibilities: project manager, validation coordinator, training facilitator, data analyst. Stakeholder and Needs Analysis(Ashadi, 2016, p. 11)

Map stakeholders (education office, principal, teachers’ council, school committee, parents). Conduct initial workshop to align vision and identify resource needs (classrooms, equipment, teaching materials). Development Roadmap PreparationCreate a detailed timeline for each stage: needs analysis (month 1), product design (months 2–3), validation (month 4), limited trial (month 5), extensive trial (months 6–8), evaluation & revision (month 9), finalization & dissemination (months 10–12). Insert periodic checkpoints (weekly/monthly) to review progress. Capacity Building Strategy Teacher Training and MentoringIntensive Workshop: PBL training module (theory, syntax, discussion facilitation, HOTS assessment).

On-the-Job Coaching: Mentor assistance in 2-3 meetings in class when PBL is implemented. Development of Supporting Modules and Media Create a “best practice” portfolio based on demonstration videos and local case examples. Provide a digital platform (e.g. Google Classroom or school LMS) for the distribution of LKS, RPP, rubrics, and teacher discussion forums. Simulation and Role-Play Schedule a teaching simulation between teachers to practice facilitating PBL steps, followed by a structure feedback session. Implementation Strategy for Pilot Projects in Limited Classes Select 1-2 heterogeneous representative classes for a limited trial.

Implement the model for 4–6 biology learning meetings with a specific topic (e.g. ecosystem or cell cycle). Time and Facility Management Allocate more flexible time (e.g. 2×45 minutes to 3×40 minutes) for the discussion and presentation phases.

Prepare group discussion rooms and access to learning resources (internet, books, laboratories). Teacher-Student Collaboration Model Form groups of 4–5 students with heterogeneous abilities. Implement a “jigsaw” pattern for task distribution and individual accountability. Use of Technology Utilize mind-mapping applications (bubble.us, Coggle) to formulate and visualize problems. Record group presentations for reflection and peer feedback. Monitoring & Evaluation Strategy Layered Measurement Instruments Pretest–posttest problem-solving tests. Structured observations using engagement rubrics (on-task behavior, initiative, collaboration). Questionnaires and in-depth interviews to capture teacher and student perceptions. Periodic Data Analysis Conduct weekly analysis of class activity logs (e.g. observation notes, difficulties that arise).(Muhalli, 2023, p. 89).

CONCLUSION

Based on validation by material experts, instructional designers, and education practitioners, the developed Problem Based Learning (PBL) model has met the eligibility criteria in terms of both content and construction. The PBL syntax components, teaching tools (RPP, LKS, rubrics), and facilitation guides are considered clear, relevant, and in accordance with the characteristics of high school students and the demands of the biology curriculum. Practicality of Implementation The results of the limited trial showed that teachers and students were able to implement each stage of the PBL model smoothly within the time allocated. Positive responses from the practicality questionnaire confirmed that the LKS instructions were easy to understand, the supporting media were adequate, and the group collaboration process was effective. Minor revisions such as simplifying the LKS language and adjusting the discussion duration have improved the smoothness of implementation.

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