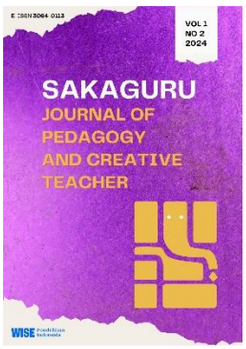

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Research Article

The Influence of the Problem-Based Learning Model Assisted by Liveworksheets on the Critical Thinking Skills of 11th-grade Students in Biology Subjects

Raicha Oktafiani*, Nukhbatul Bidayati Haka, Aryani Dwi Kesumawardani and Novi Eka Lestari.

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Abstract

Education equips individuals with intellectual intelligence, good attitudes, and skills that benefit both themselves and their surroundings in the future. The problem-based learning model encourages students to develop critical thinking skills. In biology learning, a shift is necessary from teacher-centered instruction to student-centered learning. This study aims to examine the influence of the problem-based learning model assisted by Liveworksheets on the respiratory system material. Liveworksheets introduce an innovative and engaging approach to problem-solving through features like video and audio clips, designed to maximize students' critical thinking skills. This quantitative research employed a quasi-experimental method. The population consisted of all 105 11^{th}-grade science students at SMA N 08 Bandar Lampung, distributed across four classes. The sample was selected using cluster random sampling, with class XI IPA 2 as the control group and class XI IPA 4 as the experimental group. Data were analyzed using an Independent Sample T-Test to test the hypotheses. The normality test was conducted using the Shapiro-Wilk test to determine whether the data followed a normal distribution, while the homogeneity of variance test assessed the uniformity of data variances. The results revealed a significant influence of the problem-based learning model assisted by Liveworksheets on the critical thinking skills of 11th-grade students studying the respiratory system at SMA N 08 Bandar Lampung. This was indicated by a significance value of 0.000 (< 0.05), leading to the rejection of H_0 and acceptance of H_1. These findings demonstrate the effectiveness of the problem-based learning model assisted by Liveworksheets in enhancing students' critical thinking abilities.

Keywords: Critical Thinking Skills; Liveworksheet; Problem Based Learning.

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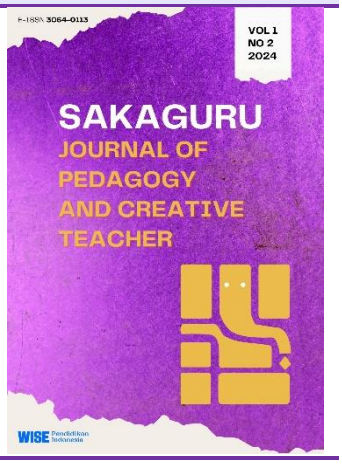


INTRODUCTION

In life, education plays an immensely significant role [1], [2]. It equips individuals with intellectual intelligence, positive attitudes, and skills that benefit not only themselves but also their surrounding environment. Education embodies the aspirations and ideals of a nation [3], [4]. Therefore, for education to serve as a means of realizing national aspirations, educational activities must be conducted and organized in a structured and purposeful manner. Education involves the pursuit of knowledge, necessitating interaction between students and educators—a process that is deeply embedded within the realm of education [5], [6].

Education plays a crucial role in the rapid advancement of technology, which inevitably brings both positive and negative effects [7], [8], [9]. Education should not only aim to equip students with knowledge but also address all aspects of learning, including cognitive, affective, and psychomotor domains [10], [11], [12]. Education is inseparable from other scientific fields, particularly psychology [13], [14]. As a discipline focused on the teaching and learning process (knowledge transfer) [15], [16], [17]. psychology is vital in understanding the educational process and the condition of learners [18]. Education plays a critical role in the learning process by integrating key concepts of teaching and learning [19].

Although educational quality has improved, unsatisfactory outcomes are still evident in the learning of certain subjects, including biology. This may be due to students' lack of critical thinking skills, resulting in low-quality learning and comprehension in biology. A lack of diverse teaching methods contributes to poor critical thinking abilities. To address these challenges, students must develop higher-order thinking skills, particularly critical thinking. Reform in biology education is necessary, transitioning from teacher-centered learning—where the educator serves as the primary knowledge source—to student-centered learning, where the teacher acts as a facilitator and students take an active role in their learning [20].

The Problem-Based Learning (PBL) model encourages students to be more active by presenting them with authentic problems. Students solve these problems through investigation and apply problem-solving approaches based on their experiences. PBL is believed to foster critical thinking skills, both individually and in groups, as each step demands active student participation. The success of PBL relies heavily on the availability of learning resources for students. Knowledge gained through PBL can be applied to a broader range of contexts and careers [21].

PBL is a teaching model that creates a learning environment conducive to critical thinking [22], [23]. It revolves around perplexing problem situations that stimulate curiosity, prompting students to investigate. During their investigation, students use critical thinking stages to explore the problem, analyze evidence, and make decisions based on their findings. This process enhances students' mental activity and engagement [24]. PBL encourages students to think deeply and critically, particularly when presented with a problem or learning new concepts [25], [26], [27]. The learning process should present real-world, meaningful phenomena that challenge students to solve them, fostering critical thinking and problem-solving skills [28].

Mastery of Information and Communication Technology (ICT) has become an essential competency requirement for educators, both to support their duties—such as

planning, delivering lessons, conducting evaluations, and analyzing results—and as a tool for sourcing and downloading learning materials. Therefore, educators at all levels must be prepared to continually learn ICT to meet these competency demands.

The Problem-Based Learning (PBL) model assisted by Liveworksheets is expected to reduce paper usage, archive materials in digital formats for easy access and review in the future, and optimize learning time. Liveworksheets is an engaging and interactive educational medium that can serve as an effective tool for independent learning. This aligns well with the needs of a learning process where educators must communicate with numerous students. The Liveworksheets platform offers features such as embedding instructional videos from YouTube, creating multiple-choice questions with clickable answers, providing essay questions with text boxes for direct typing, matching tasks using arrows, and even including voice-based questions and responses—all within its interactive web environment.

Critical thinking is defined as reasonable and reflective thinking focused on deciding what to believe or do. *Reasonable* refers to the ability to connect critical thinking with existing facts and draw conclusions, while *reflective* entails actively, persistently, and carefully considering alternatives before making decisions. Critical thinking skills train students to make decisions and develop their ability to search for, process, and evaluate various information critically [29].

Research conducted by Hayuna Hamdalia Herzon, Budijanto, and Dwiyono Hari Utomo (2018) titled *"The Effect of Problem-Based Learning on Critical Thinking Skills of 11th Grade Social Studies Students at SMA Negeri Barabai"* concluded that Problem-Based Learning (PBL) effectively improves critical thinking skills in geography lessons. The study found that traditional geography teaching methods often failed to engage students or stimulate critical thinking. By focusing on maritime axis material, the quasi-experimental design demonstrated a significant improvement in critical thinking skills, with a significance value of 0.00, confirming the positive impact of PBL [30].

While the study by Herzon et al. focuses on geography and 11th-grade social studies students, this research examines the application of PBL assisted by Liveworksheets in a biology context, targeting critical thinking skills in 11th-grade science students. Furthermore, the integration of digital tools like Liveworksheets represents a novel approach, providing an interactive medium to enhance student engagement and critical thinking. This study also aims to explore the usability of such tools in fostering learning outcomes, which were not addressed in Herzon et al.'s research. Thus, this research fills a gap by combining innovative technology with the PBL framework to analyze its effectiveness in a different subject and learning environment.

The primary aim of this study is to examine the effect of the Problem-Based Learning (PBL) model assisted by Liveworksheets on the critical thinking skills of 11th-grade students in Biology. By implementing this innovative teaching approach, the research seeks to determine its effectiveness in fostering students' analytical abilities, enhancing their engagement, and improving their understanding of complex biological concepts. This study also aims to provide empirical evidence on the role of interactive digital tools in facilitating student-centered learning and promoting higher-order thinking skills.

METHODS

The study employs a quantitative approach. The type of research used is a quasi-experimental method. A key characteristic of quasi-experimental research is that it includes a control group but does not fully control external variables that may influence the experiment's implementation. The population of this study comprises all 105 students of grade XI science (IPA) at SMA N 08 Bandar Lampung, distributed across four classes. The sample was selected using a cluster random sampling technique, resulting in class XI IPA 2 being designated as the control group and class XI IPA 4 as the experimental group.

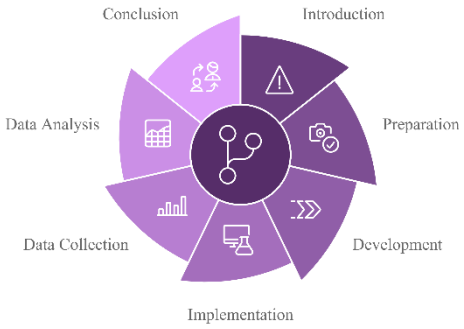


Figure 1. Comprehensive Research Process

The Comprehensive Research Process diagram illustrates a systematic and interconnected approach to conducting research, divided into six key stages. The process begins with the Introduction, where the research problem is identified, observations are conducted, and the problem statement is formulated, laying the foundation for the study. This is followed by the Preparation phase, involving obtaining necessary permissions, preparing research instruments, and determining the sample to ensure readiness for subsequent stages. In the Development phase, essential tools such as syllabi, lesson plans, and digital worksheets (E-LDPD) are created, refining the research framework. The Implementation stage focuses on conducting the research, with experimental and control classes being executed using distinct methods to gather comparative data. During Data Collection, information is systematically gathered through tests, observations, or other methods, which is then analyzed in the Data Analysis phase to interpret findings and test hypotheses. Finally, in the Conclusion phase, the results are summarized, conclusions drawn, and the research report compiled, emphasizing the study's outcomes and implications. This structured process ensures a comprehensive and effective approach to research execution.

The impact of this research was evaluated using pretest and posttest assessments to measure students' critical thinking skills before and after implementing the Problem-Based Learning (PBL) model assisted by Liveworksheets. Statistical tests, including the Independent Sample T-Test, were conducted to determine the model's effectiveness. Observations during classroom activities assessed student engagement, collaboration, and motivation. Feedback from students and teachers further evaluated the practicality of Liveworksheets in enhancing critical thinking and interactive learning. This approach provided valuable insights for improving teaching practices and fostering innovation in education.

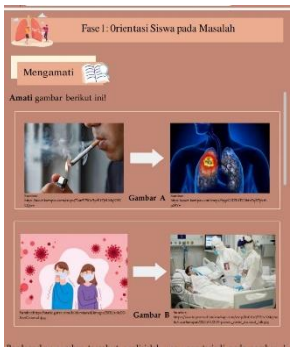
The study employs a quantitative approach. The type of research used is a quasi-experimental method. A key characteristic of quasi-experimental research is that it includes a control group but does not fully control external variables that may influence the experiment's implementation. The population of this study comprises all 105 students of grade XI science (IPA) at SMA N 08 Bandar Lampung, distributed across four classes. The sample was

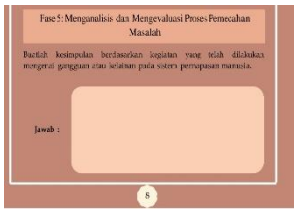
selected using a cluster random sampling technique, resulting in class XI IPA 2 being designated as the control group and class XI IPA 4 as the experimental group.

RESULT AND DISCUSSIONS

Based on research conducted at SMA Negeri 08 Bandar Lampung during the second semester of the 2022/2023 academic year, the application of the problem-based learning model assisted by Liveworksheets demonstrated an influence on the critical thinking skills of 11th-grade biology students. Below is a detailed explanation of the data obtained during the study:

Table 1. Research Findings

No	Problem-Based Learning Syntax	Photos and Explanations
1	Orienting students to the problem during learning.	 At this stage, students observed problems displayed on the Liveworksheets platform.
2	Organizing students for learning.	 At this stage, students formulated questions related to the problems presented in the previous step, such as: 1. What harmful substances are contained in cigarettes? 2. Continuous inhalation of cigarette smoke can lead to respiratory system disorders. In addition to active smokers, passive smokers are also at risk of harm from cigarette smoke. In fact, passive smokers have a three times higher risk of developing repiratory diseases compared to active smokers. Why is this so? Explain!
3	Guiding individual or group investigations.	

No	Problem-Based Learning Syntax	Photos and Explanations
		The teacher instructed students to gather accurate information, seek explanations, and propose solutions.
4	Developing and presenting the results of their work.	 Students presented their group-produced work in the form of posters displayed on Liveworksheets.
5	Analyzing and evaluating the problem-solving process	 The teacher instructed students to summarize their findings, followed by evaluating the conclusions made.

This study utilized Liveworksheets within the five syntaxes of problem-based learning (PBL). The material covered in the study focused on the human respiratory system, including subtopics such as the structure and function of respiratory system organs, the mechanism of human respiration, and respiratory system disorders. The scope of the material is characterized by its abstract nature, as the human respiratory system is not directly visible. In the context of the 2013 curriculum, the human respiratory system is aligned with Basic Competence (Kompetensi Dasar) 3.9: *Analyzing the human respiratory system, understanding its disorders, and identifying efforts to maintain respiratory health*. Additionally, Basic Competence 4.9: *Presenting projects on efforts to maintain respiratory health and creating posters about the dangers of smoking for health*, further supports the integration of appropriate learning models, such as PBL. This model aligns particularly well with Basic Competence objectives, as it includes the fourth syntax, *developing and presenting work*, and the fifth syntax, *analyzing and evaluating the problem-solving process*.

The advantages of the PBL model include its ability to enhance students' critical thinking skills, foster independent problem-solving abilities, and increase students' motivation to learn. Critical thinking skills can be effectively developed through PBL because it adopts an authentic problem-based learning approach, requiring students not only to understand the problem but also to collaborate in solving it. This approach stimulates students' abilities and skills, particularly their critical thinking capabilities, making it a powerful method for engaging learners in meaningful and impactful educational experiences.

Problem-based learning (PBL) is a model that introduces students to real-life cases relevant to the material being studied. What sets PBL apart from other teaching models is its emphasis on open-ended solutions—students are not required to produce a specific product, and there is no definitive right or wrong answer. Instead, students are encouraged to freely express their perspectives and engage in critical thinking. In both the experimental and control classes, observational practices were conducted on the material being studied. During the learning process, students engaged in observation activities regarding the mechanism of

respiration. This process involved questions from the teacher, which students were required to answer. An example of such an exchange is as follows:

Table 2. Example of Teacher-Student Interaction on Respiratory Mechanisms

Role	Interaction
Teacher	After demonstrating the mechanisms of chest and abdominal breathing, what have you understood about the mechanism of human respiration?
Student	I have understood the mechanism of human respiration. Chest breathing involves the intercostal muscles, while abdominal breathing involves the diaphragm muscles located between the thoracic and abdominal cavities.

Session 1

In the first session, the researcher introduced themselves and explained the Liveworksheets media. Before beginning the lesson, a pretest was distributed to the students. The introductory activities started with a prayer, followed by attendance checking, and an introduction that linked the learning material or theme with the students' prior knowledge and experiences. Students were encouraged to pay attention to the teacher, recall prerequisite material through questioning, and pose questions related to the topic. Motivation was provided by illustrating the relevance of the material to real-life applications. The learning objectives for this session were to identify the location and structure of respiratory organs, explain their structure and function, and discuss efforts to maintain respiratory health.

Table 3. Implementation of Problem-Based Learning in Sessions 1

Activity	Description
Introduction and Pretest	Researcher introduced themselves and explained Liveworksheets. Students completed a pretest before starting the lesson.
Orientation	Teacher oriented students to the topic: *Impact of Air Pollution on Respiratory Health*, showing a video (https://youtu.be/A764atwxUu80). Students identified and defined problems to solve using E-LDPD.
Organizing Students	Students were grouped into teams of three, accessed worksheets (https://bit.ly/3Y81oTy), and worked collaboratively.
Guiding Investigations	Students gathered data and resources using textbooks, online modules (https://bit.ly/3Pc61I1), and other references to examine pollution-related respiratory issues.
Developing and Presenting Work	Groups presented findings through discussions and created posters or reports.
Analyzing and Evaluating Results	Teacher evaluated students' work, provided feedback, conducted reflections, and rewarded outstanding groups. Assignments for the next session were distributed.

Session 2

The second session began with prayer, attendance checking, and an introduction linking the current material to previous knowledge. Students were motivated by learning the benefits of the material and its real-life applications. The session's objectives were to explain the mechanism of oxygen and carbon dioxide exchange from alveoli to capillaries, identify harmful substances in cigarettes, and understand the respiratory mechanisms in humans. The teacher oriented the students by showing images, videos, or animations of the respiratory

system to provoke critical thinking and brainstorming. Students identified problems based on the media, such as:

- *Why do people smoke? Does it have any benefits?*
- *What are the effects of polluted air on respiratory health?*

Table 4. Implementation of Problem-Based Learning in Sessions 2

Activity	Description
Introduction and Motivation	Activities began with prayer, attendance, and an introduction connecting current material to prior knowledge. The topic focused on *Oxygen and Carbon Dioxide Exchange in Respiration* and *Harmful Substances in Cigarettes*.
Orientation	Teacher presented images/videos to provoke brainstorming. Questions included: *Why do people smoke? What are its effects? How does air pollution impact health?*
Organizing Students	Teacher guided students in defining and organizing tasks related to respiratory disorders. Groups worked on non-experimental activity sheets.
Guiding Investigations	Students collaborated to gather information, explore solutions, and develop ideas. Teacher facilitated discussions and addressed challenges.
Developing and Presenting Work	Students answered activity sheet questions, compiled written reports, and presented their findings in discussions.
Analyzing and Evaluating Results	Teacher guided analysis of problem-solving processes, discussed findings, and reviewed concepts like lung capacity and respiratory mechanisms.

Session 3

In the third session, the introductory activities began with greetings, prayer, attendance checking, and motivational questions about respiratory disorders. The teacher outlined the core competencies (KI, KD), indicators, and learning objectives for the session. Students observed images, videos, or animations related to smoking and air pollution, which raised questions like:

- *Why do people smoke? What are the effects on respiratory organs?*
- *What factors cause air pollution, and how does it impact respiratory health?*

Table 5. Implementation of Problem-Based Learning in Sessions 3

Activity	Description
Introduction and Motivation	Session began with prayer, greetings, and questions on *Respiratory Disorders*. Core competencies, indicators, and objectives were outlined. Students observed media on smoking and air pollution, raising questions such as: *What causes air pollution? What are its effects on respiratory health?*
Organizing Students	Students worked in heterogeneous groups to discuss activity sheets on respiratory disorders caused by smoking and air pollution.
Guiding Investigations	Groups researched information, developed solutions, and identified alternatives. Teacher facilitated and supported students throughout the process.
Developing and Presenting Work	Students completed activity sheets, documented findings in reports, and presented conclusions in discussions.
Analyzing and	Teacher evaluated students' work, discussed observations, and reviewed key topics:

Activity	Description
Evaluating Results	disorders of the respiratory system, polluted air's impact, and respiratory mechanisms. Feedback and rewards were provided.
Closing Activities	Teacher reviewed completed work, provided a summary, and conducted a posttest on Liveworksheets (20 multiple-choice questions) to evaluate understanding. Outstanding students or groups were recognized, and tasks for the next session were assigned.

Based on the pretest data, the highest critical thinking score in the experimental class was 55, while the control class scored 40. The lowest pretest scores were 20 and 15 for the experimental and control classes, respectively. The average pretest score for the experimental class was 31.4, slightly higher than the control class's 25.6. In the posttest, the experimental class achieved a highest score of 95, compared to 90 in the control class. The lowest posttest scores were 80 for the experimental class and 70 for the control class. The average posttest scores were 85.2 for the experimental class and 79.5 for the control class, indicating a noticeable improvement. These results show that the experimental class consistently scored higher than the control class, suggesting a slightly greater enhancement in critical thinking skills. The significant difference in average scores between the two classes is attributed to the differing learning processes. The experimental class, which utilized the problem-based learning model supported by Liveworksheets, showed a far greater improvement in critical thinking skills compared to the control class.

To compare the critical thinking skills of students in the experimental and control classes, a t-test was conducted. The results showed a significance value of $0.000 < 0.05$, indicating that the hypothesis was accepted. This confirms a significant improvement in students' critical thinking skills after the treatment, with the experimental class, taught using the Problem-Based Learning model supported by Liveworksheets, outperforming the control class, which used the Discovery Learning model.

The findings align with previous research by Fitri Sholehah, titled *"Development of Contextual E-LDPD Using Liveworksheets on Social Arithmetic Material for 7th Grade at SMP Ahmad Dahlan, Jambi City"*. Sholehah's study, which employed the Research and Development (R&D) method using the ASSURE model and purposive sampling, involved developing E-LDPD materials for online learning. Her research focused on creating contextual teaching materials based on observations and interviews to address the needs of social arithmetic lessons [31]. The similarity between this study and Sholehah's lies in the use of Liveworksheets as a teaching medium. The differences include the dependent and independent variables, the year of research, and the study location.

CONCLUSION

Based on the research and discussion, it can be concluded that the Problem-Based Learning (PBL) model assisted by Liveworksheets has a significant effect on the critical thinking skills of 11^{th}-grade science students in biology, specifically on the respiratory system topic at SMA N 8 Bandar Lampung during the 2022/2023 academic year. The improvement in critical thinking skills among students taught using Liveworksheets was higher compared to those taught using the Discovery Learning model without media assistance. In light of these findings, several recommendations are

proposed. First, Liveworksheets can serve as an effective alternative for enhancing students' critical thinking skills. However, its implementation should be accompanied by proper time management to ensure that the allocated time is used effectively to achieve optimal outcomes. Second, for students, the use of this approach can foster positive attitudes towards learning, stimulate curiosity, and enhance cognitive learning outcomes. Third, for educators, it is essential to carefully select appropriate and engaging media for teaching biological concepts, aligning with the topics being studied. Liveworksheets, as an alternative, can be integrated into lessons to make learning more effective and interesting. Fourth, for schools, it is recommended to organize training sessions on the application of educational media, such as Liveworksheets, to ensure the successful achievement of learning objectives. This approach can be instrumental in enhancing students' critical thinking skills. Finally, for future researchers, it is suggested that they explore and further refine the use of the Problem-Based Learning model assisted by Liveworksheets to maximize its potential in improving students' critical thinking abilities.

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CONFLICT OF INTEREST

"The authors declare no conflict of interest."

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