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PBL-BASED STUDENT WORKSHEET TO IMPROVE CRITICAL THINKING ABILITY IN SCIENCE LEARNING IN ELEMENTARY SCHOOLS

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ABSTRACT

This study aims to create a student worksheet based on the Problem-based Learning (PBL) model in science learning, test its feasibility, and identify student and teacher responses to the implementation of the student worksheet. The instruments were validation sheets and student and teacher response questionnaires. The research data were descriptively and qualitatively analyzed based on the criteria score. Material expert validation obtained an average of 0.8409 with "high" criteria. An average of 0.8036 with "high" criteria was obtained for language expert validation. Media expert validation obtained an average of 0.7522 with "moderately high" criteria. According to the findings of the field trial, the average response of teachers was 86% with the criteria "excellent," and the average response of students was 85% with the criteria "excellent and highly suitable." Furthermore, the n-gain value obtained was 0.7 in the "moderate" category. As a result, the developed student worksheet can be used to improve students' critical thinking skills. Thus, teachers are advised to create student worksheets based on other materials.

LEMBAR KERJA SISWA BERBASIS PBL UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS PADA PEMBELAJARAN IPA DI SEKOLAH DASAR

Kata Kunci:

Berpikir kritis
Problem-based learning
Lembar kerja siswa

ABSTRAK

Penelitian ini bertujuan mendesain student worksheet berbasis Model Problem Based Learning (PBL) pada pembelajaran IPA, menguji kelayakannya, dan identifikasi tanggapan peserta didik dan pendidik pada pemakaian student worksheet. Penelitian ini menggunakan model pengembanan ADDIE. Instrumen yang digunakan ialah lembar validasi, angket tanggapan peserta didik, dan kuesioner respon pendidik. Data penelitian dianalisis secara deskriptif kualitatif berdasarkan skor kriteria. Hasil validasi ahli materi diperoleh rata-rata 0,8409 kriteria “tinggi”, validasi ahli bahasa diperoleh rata-rata 0,8036 kriteria “tinggi”, validasi ahli media dengan rata-rata 0,7522 kriteria “cukup tinggi”. Hasil uji coba lapangan diperoleh respon pendidik dengan rata-rata 86% kriteria “sangat baik” dan respon peserta didik dengan rata-rata 85% kriteria “Sangat baik dan Sangat Sesuai”. Selanjutnya diperoleh n-gain dengan skor 0,7 kategori “sedang”. Dengan demikian student worksheet yang dikembangkan dapat digunakan untuk meningkatkan kemampuan berpikir kritis peserta didik.

Disarankan kepada pendidik untuk mengembangkan student worksheet pada materi lainnya.

1. INTRODUCTION

Meaningful learning may be achieved through an effective learning process that can be performed by identifying the correct learning model, with the usage of teaching materials being one of the key supporters [1]-[9]. Learning can be performed more meaningful by using proper instructional materials [10]-[13]. Therefore, the instructional materials must be quality, interesting, enjoyable, and up-to-date [6], [14]. One of the initiatives aimed at finding breakthroughs in the learning process is the development of quality teaching materials that aims to insert the value of comprehension, character, and national culture in line with the times [15]-[17]. The development of times in the twenty-first century, which occupies the era of industrial change 4.0, leads to the rapid development of technology and information, making it a challenge for the government and executives to increase the quality of learning [2], [14], [18], [19].

According to the NSTA (National Science Teachers Association), 21st-century education requires students to possess the capacity to reason and solve problems [20], [21]. Furthermore, other opinions state that critical reasoning skills, communication, leadership, cooperation, adaptability skills, productivity as well as accountability, innovation, ability to compete in the global realm, entrepreneurial skills, and information analysis and management skills are 21st-century education skills that students must master [14], [19], [20]. However, looking at the TIMSS (Trends in International Mathematics and Science Study) 2015 findings and the PISA survey [22], [23], Indonesia placed 64th out of 65 countries in 2012, with a score of 382 [23]. In 2015, Indonesia ranked 64th out of 72 countries with a score of 403 [23], [24]. Furthermore, Indonesia ranked 74th out of 79 nations in 2018, with a score of 396 [11], [12], [23]. The three PISA survey scores for three consecutive years, from 2012 to 2018, show that Indonesia remained in the bottom ten. Therefore, we can conclude that science achievement or science learning in Indonesia falls into the low group [18], [25]. Improving students' scientific and technical skills is vital to improving quality through quality instruction [26].

Quality learning also necessitates good learning theories that enhance the learning process's success [27], [28]. Learning, according to Constructivism theory, is a dynamic and social process in which students actively design their experiences based on prior information and social standards [3], [13], [29]. According to the constructivist approach to learning, students do not arrive at science class like a blank sheet of paper but rather with many organically developed ideas. According to the constructivist school of thought, students should no longer be passive recipients of teachers' insights, and teachers should no longer be the primary givers of insights in the classroom [29]. According to this viewpoint, learning is a process of gaining new insights, both active and complex. The learning process needs to be backed by an appropriate learning model to obtain an active interaction relationship in the main cognitive process between teachers and students through trying activities, understanding what is taught, and learning experiences [3], [11], [30].

The PBL model best fits this constructivism learning theory [29]. PBL is a modern learning model that connects problem orientation with knowledge collection based on real-life learning experiences [5], [24]. Constructivist theory can be argued to be the theoretical foundation of the PBL model because students must construct and transform

knowledge in a complex manner [29]. This theory is consistent with constructivism theory, which states that humans can grasp and apply information by addressing various problems by attempting to create experiences and ideas stored in individuals in every learning process [27], [29].

A quality and meaningful learning process necessitates learning resources that adhere to the learning model [11], [29], [30]. Using student worksheets as acceptable teaching material is one technique to improve students' critical reasoning skills [3], [14]. Student worksheets can be carefully, successfully produced and tailored to complement the learning process and activities [31]. A student worksheet is also constructed and produced to correspond with the circumstances and situation of the next learning activity. It contains task sheets that students must complete [32], [33]. Student worksheets typically offer instructions and processes for completing a task. Using this student worksheet allows teachers to learn more easily, while students can learn independently and understand when completing written tasks [8], [34].

PBL-based student worksheet forms a learning environment in which: students play an active role in the learning process, students have responsibility for the learning process, and students improve in terms of time management skills as well as expertise in interpreting topics and accessing diverse learning resources [3], [35]. According to the needs analysis findings, the teacher directed the learning process, and the science learning and teaching materials used were less varied. Also, students did not actively participate in the learning process [14], [18]. The PBL model's implementation in the learning process has not been optimized. As a result, there is a need for a student worksheet based on the PBL model, which strives to increase critical thinking abilities through problem-solving learning activities [24], [36].

Students must learn critical thinking skills to handle many problems encountered in everyday life [28], [37]. Students' lack of critical thinking skills is a problem that must be addressed. Because critical thinking abilities have strategic significance in life, solutions are required to strengthen them. Students with critical thinking skills can think neutrally, objectively, fairly, or logically, become powerful thinkers and reliable problem solvers, and develop conclusions to accomplish anything [24], [38]. Some researchers agree on measuring critical thinking skills [8], [24]. Facione, in [39], argues that critical thinking skills consist of six components: interpretation, analysis, evaluation, inference, explanation, and self-regulation. The lack of teaching materials that might stimulate critical thinking, such as the utilization of student worksheets, is one of the main causes of students' lack of critical thinking abilities in learning activities. Teachers are expected to help and guide students in mastering 21st-century skills as learning facilitators [40]. Educational resources with 21st-century skills are still lacking [41]. Many studies on worksheet development have been conducted.

On the other hand, this research and development of student worksheets was conducted in the fifth grade of elementary school with several factors and referred to as independent curriculum learning. Therefore, this research aims to develop a PBL-based student worksheet that may be used in plant reproduction material in the fifth grade. This worksheet is expected to help elementary school students enhance their critical thinking skills.

Research on student worksheet development have been conducted, including the development of PBL-based student worksheet on thematic learning [3], [9], the development of ethnoscience-based digital student worksheet [11], the development of PBL-based student worksheet on static fluid material [31], and the development of

student worksheet based on chemo-education [32]. Some of these research differ regarding the learning model and the learning material.

Although the PBL-based student worksheet has been created, this research covers many topics. This research focuses on creating a student worksheet for plant reproduction material in science and social subject. This research aims to provide science and social teaching resources to make the learning process more creative and imaginative by generating teaching materials in the form of a PBL-based student worksheet to promote students' critical thinking skills.

2. METHOD

Based on the problems presented in the problem formulation, the type of research employed was research and development. The goal of developing instructional materials of a student worksheet with the PBL model was to improve the critical thinking skills of fifth-grade students at SDN 1 Rajabasa Raya. The research procedures modified the ADDIE model with five stages: analysis, design, development, implementation, and evaluation. The ADDIE development model's design framework is depicted in the figure below.

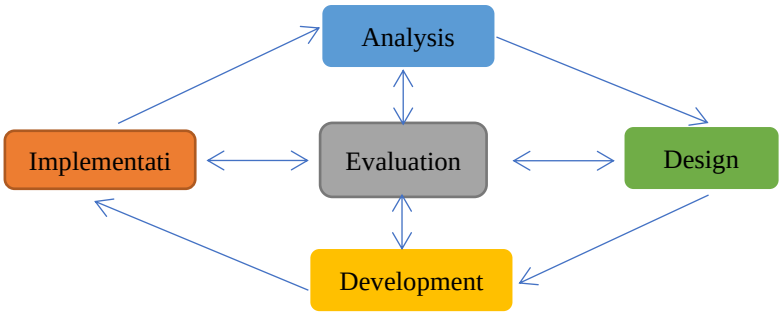


Figure 1. The Framework of ADDIE Development Model [42]

This research covered the feasibility and attractiveness testing during the implementation stage. A student and teacher response questionnaire was utilized to collect data to validate and test the product's attractiveness. The descriptive qualitative analysis technique exposed all opinions, ideas, and evaluator responses gathered on the instrument sheet. This technique defined product development results to increase critical thinking skills, specifically PBL-based student worksheets in plant reproduction material. This design was a reference in creating the PBL-based student worksheet to improve students' critical thinking skills. The following diagram depicts the research procedure.

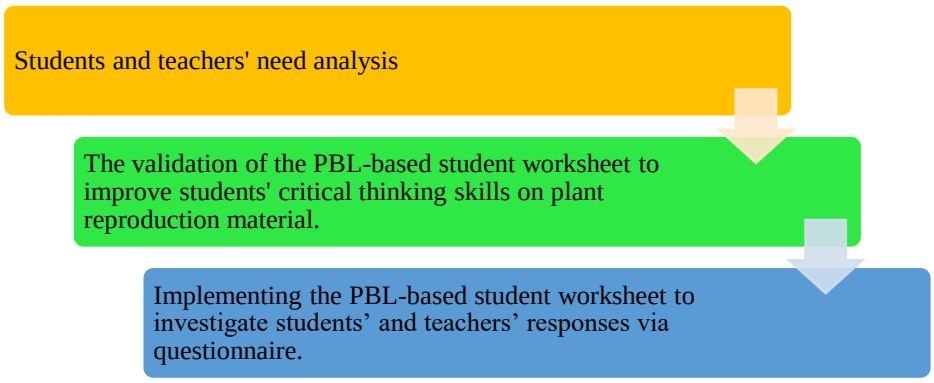


Figure 2. The Research Procedure

3. RESULTS AND DISCUSSION

The results and discussion in this research are based on the findings during the research process of applying the ADDIE model in developing a PBL-based student worksheet. This article's discussion describes activities in the ADDIE model stages utilized in developing the PBL-based student worksheet to increase students' critical thinking skills.

3.1 Analysis

At this stage, researchers have undertaken several analyses to provide an overview of the needs of the developed teaching materials. The analyses carried out to support this development process were an analysis of the needs of teaching materials, an analysis of the scope of the material, and an analysis of the existing curriculum. Researchers performed observations and interviews with mathematics teachers and several fifth-grade students at SDN 1 Rajabasa Raya at the stage of analyzing the needs for instructional materials. This step tried to determine what teaching materials students at SDN 1 Rajabasa Raya required. Based on the findings of the needs analysis conducted at SDN 1 Rajabasa Raya through student observations and interviews with teachers about learning using student worksheets, curriculum, approaches, methods, and learning strategies, it was known that in the implementation of learning, teachers continued to use traditional methods and models. The students were less actively involved in the learning process, and they did not participate in the learning process. Some students found it challenging to develop critical thinking skills due to these problems. On the other hand, the application of instructional materials remained limited because it was based solely on books provided by the government. After the observations and interviews, the researchers developed a solution to the problems they discovered at SDN 1 Rajabasa Raya, namely teaching materials known as student worksheets.

Researchers identified the material to be developed in the student worksheet during the material analysis step. The researchers chose the materials after consultations with the fifth-grade teacher at SDN 1 Rajabasa Raya. Based on this discussion, it was discovered that students were still having problems with plant reproduction material. At the curriculum analysis stage, a study of the mathematics curriculum was conducted, which included an analysis of the subject matter, Core Competencies, Basic Competencies, and indicators that students must acquire. This stage was completed to ensure that the student worksheet developed met the needs of students at SDN 1 Rajabasa Raya.

3.2 Design

The researchers developed the overview, content design, and assessment instruments at this stage. The student worksheet outline was an initial concept consistent with the previous analyses. The developed student worksheet included examples and practice problems linked to daily problems that students frequently face. Students are asked to solve challenges on their own. Practical tasks and work instructions also pique students' interest in the learning process.

Table 1. The Content Design of the PBL-based Student Worksheet

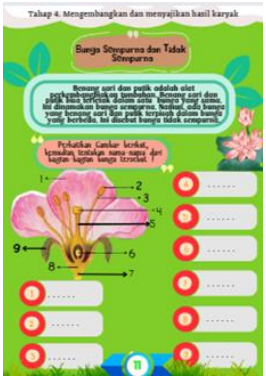
PBL Stages	Rubrik of the Student Worksheet
Presenting a problem	Looking at the problem
Discussing a problem	Analyzing the problem
Solving a problem	Solving the problem
Sharing information	Group presentation
Presenting a solution	Presenting the solution
Reflecting	Let's try

Table 1 shows the content design of the PBL-based student worksheet. Cover, author profile, prologue, table of contents, core competencies and basic competencies, indicators of competence, instructions for usage, student activities, and table of contents are all included in a PBL-based student worksheet. Student activities include problem presentation, problem-solving discussion, and skill development activities.

Several tasks were carried out in the design stage. Developing a storyboard at the design stage was a key step in developing student worksheets. The storyboard depicted a visual representation of the developed learning materials. The storyboard incorporated content, multimedia principles, and multimedia components (animation, video, audio, text, and graphics) for the student worksheet. Two experts validated the storyboard to assess the clarity and depth of the material to be provided in the student worksheet.

Table 2. The Storyboard of the PBL-based Student Worksheet

No	Subsection	Display	Description
1	Cover		The cover is an opening image of the student worksheet comprising material illustrations. This cover includes the title of the material and illustrations of plant reproduction for fifth-grade students of elementary schools.
2	The first stage of PBL syntax (student orientation toward the problem)		The problem to be solved in groups is presented by the teacher. Students observe and comprehend the problem presented by the teacher or derived from the reading material presented in the student worksheet with their group members.
3	The second stage of PBL syntax (Organizing students to study)		The teacher ensures that each member understands their respective tasks. Students discuss and divide tasks to find data/materials/tools needed to solve the problem.

4	The third stage of PBL syntax (Guiding individual and group investigations)		The teacher monitors students' involvement in data/material collected during the investigation. Students conduct investigations (search for data/references/sources) for group discussion materials.
5	The fourth stage of PBL syntax (Develop and present work)		The teacher monitors the discussion and guides the report's preparation so that each group's work is ready to be presented. The group discusses developing a problem-solving solution and presenting the results.
6	The fifth stage of PBL syntax (Analyze and evaluate the problem-solving process)		The teacher guides the presentation and encourages groups to give awards and feedback to other groups. The teacher, together with the students, summarize the material. Each group makes a presentation, and the other groups give appreciation. The activity continues by summarizing/making conclusions according to the input from other groups.

3.3 Development

During the development stage, the design of the PBL-based student worksheet in the storyboard was created as a student worksheet. During the development stage, the student worksheet was created depending on the design that was created. This stage seeks to create the first draft of the student worksheet. The steps in this stage were as follows. First, the researchers gathered sources for material based on the independent learning syllabus in compliance with the material to be generated. Second, the researchers began to construct student worksheets based on the outline of student worksheets created during the design stage. The Canva for Education program was used to create and arrange the student worksheet. Third, the researchers developed the instruments, which include material expert questionnaires, media expert questionnaires, and student response questionnaires. Questionnaires were employed during the validation before testing the student worksheet on students, material, and media experts.

Product validation was carried out once the designed product had been completed. Product validation was done to ensure that the developed product received expert evaluation and input. Material experts' and media experts' inputs were used to improve the PBL-based student worksheet. Material experts' contribution was related to the concision of concepts to be more adapted to the curriculum and indicators, including the solution technique and the necessity to provide students flexibility at the beginning of a discussion about the problems in the student worksheet. Experts and teachers verified the student worksheet. The description of the development stage is as follows:

A team of experts validated the PBL-based student worksheet through three steps: content validation, presentation validation, and critical thinking skills validation. Aiken's V validity was used to calculate the expert validation analysis. The Aiken's V validity result is listed in the table below.

Table 3. Material Expert Validation Result

Assessed Aspects	Aiken's Value	Aiken's Coefficient Criteria
Content Feasibility	0,8485	High
Presentation Feasibility	0,8333	High
Average	0,8409	High

Table 3 shows that validation by a team of material experts obtained a value of 0.8409, which is included in the high category (more than 0.80) and is considered valid. Therefore, the PBL-based student worksheet for the fifth-grade elementary school students on plant reproduction material is valid in terms of material. The content feasibility aspect received a high score of 0.8485, and the presentation feasibility received a score of 0.8333. These results indicate that the student worksheet developed followed the material's content, fulfilled all PBL syntax, and covered the indicators of critical thinking skills well. This student worksheet also contained all indicators of critical thinking skills, such as analyzing, synthesizing, solving problems, concluding, and evaluating. Each skill indicator had an interrelated relationship to ensure that the student worksheet was more structured, systematic, and clear in its relationship between PBL components on critical thinking skill indicators. Table 4 shows the validation results of the media experts.

Table 4. Media Experts Validation Result

Assessed Aspects	Aiken's Value	Aiken's Coefficient Criteria
Technical	0,7024	Moderate
Construction	0,8021	High
Average	0,7522	Moderate

Table 4 shows the results of media expert validation are 0.7522 with moderate criteria and can be considered valid. Validation was carried out by media experts who focused on technical and construction aspects. Technical aspects get a score of 0.7024 with moderate criteria and are considered valid. Meanwhile, the construction aspect scored 0.8021 and was considered valid with high criteria. The construction aspect obtained a higher score than the technical aspect. Furthermore, the language validation analysis results can be seen in Table 5.

Table 5. Language Experts Validation Result

Assessed Aspects	Aiken's Value	Aiken's Coefficient Criteria
Language	0,8036	High

Table 5 shows that the language aspects validation obtained a score of 0.8036 in the high criteria; therefore, it can be categorized as valid.

3.4 Implementation

The implementation stage aims to determine the practicality of using the PBL-based student worksheet and the effectiveness of the results of the application of the PBL-based student worksheet on plant reproduction material to improve students' critical thinking skills. The field trial was conducted on May 25 in the fifth grade of SDN 1 Rajabasa Raya with 30 students.

The learning process took place offline in two meetings, one in the control and one in the experimental classes. Learning with the PBL-based student worksheet began with class conditioning activities. In addition, students were directed to complete a pretest consisting of 5 description questions. After the pretest, the learning continued with the core activities outlined in the PBL syntax, which included orienting students to the problem, organizing students to learn, guiding individual and group investigations, developing and presenting work, and analyzing and evaluating the problem-solving process. The following is an explanation of the learning process using the PBL model. In stage 1, the orientation of students to the problem, the teacher explained the learning objectives and the teaching materials required, proposed phenomena or stories to raise problems, and motivated students to participate in solving the problems they chose.

Figure 3. The First Stage of Learning

In stage 2, organizing students to learn, the teacher helped students define and organize learning tasks related to the problem.

Figure 4. The Second Stage of Learning

In stage 3, guiding individual and group investigations, the teacher encouraged students to gather appropriate information and carried out experiments to obtain explanations for solving problems.

Figure 5. The Third Stage of Learning

In stage 4, developing and presenting work, the teacher assisted the students in planning and preparing appropriate works, such as reports, videos, and models. Also, the teacher helped them to share tasks with their peers.

Figure 6. The Fourth Stage of Learning

In stage 5, analyzing and evaluating the problem-solving process, the teacher helped students to reflect or evaluate their investigations in the processes they used.

Figure 7. The Fifth Stage of Learning

Based on the explanation, students have completed the learning process using a PBL-based student worksheet. By applying the worksheet, the students understood the concept of plant reproduction. Learning activities began with problem orientation, collaboration between students through group discussions and investigations of the parts and functions of flowers as a means of reproduction in plants, and reflection on the

results of learning experiences. Some benefits of using this student worksheet were that students felt they understood the material of flower parts better, the process of plant reproduction, and the relationship between animals and the process of generative plant reproduction.

Table 6. Learning Observation Result

No	Meeting	Obtained Score		Maximum Score	Percentage
		Experimental Class	Control Class		
1	First Meeting	65	67	75	89,33%
2	Second Meeting	70	74	75	98,67%
	Total	135	141	150	94%
	Average Score	67,5	70,5	75	94%

Based on the data above, the score at the first meeting of the experimental class (65) and the control class (67), with a maximum score of 75, had a percentage of 89.33%. At the second meeting, the experimental class scored 70, and the control class scored 74, with a maximum score of 75 and a percentage of 98.67%. The average score obtained was 70.5 out of a maximum of 75 and a percentage of 94%. The data shows that learning in both classes had improved. At the implementation stage, the researchers conducted a field trial through a posttest to test the effectiveness of using the student worksheet that had been developed. This stage aimed to assess the effectiveness of the student worksheet and to find out the students' responses to the student worksheet. The effectiveness test was carried out through a pretest and posttest using ten multiple-choice questions and five description questions. The pretest was conducted before the start of learning to determine students' initial ability, and the posttest was conducted after learning to determine the student's ability after using the student worksheet. The results of data analysis on both tests are presented in the following figure.

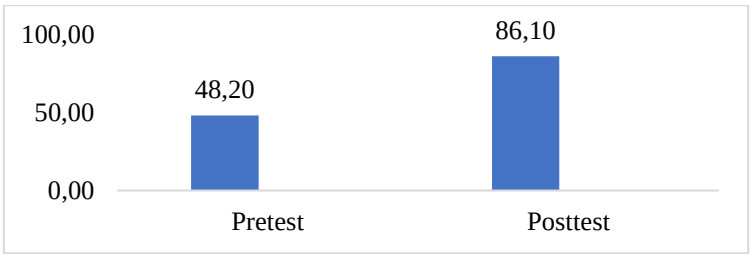


Figure 8. Pretest and Posttest Results

Figure 8 shows students' abilities before and after using the student worksheet improved. After that, the results of the two tests were analyzed using the n-gain standard. The analysis showed that the n-gain was moderate (0.7). Hake (1999) states that a moderate increase level is indicated by an n-gain score between 0.3 and 0.7. The n-gain score shows an increase. Students' critical thinking skills increased significantly after using the PBL-based student worksheet. This finding aligns with the study's results [26] that learning using a PBL-based student worksheet provides critical thinking skills compared to learning without a PBL-based student worksheet in plant propagation material. This study's findings align with previous research, which shows that PBL-based student worksheets can improve students' critical thinking skills [5], [43].

PBL-based student worksheets are said to be feasible to use to improve students' critical thinking skills [30]. PBL-based student worksheets are valid based on expert validation with minor revisions and get positive responses from teachers [18]. Students

gave positive responses that PBL-based student worksheets can improve students' critical thinking skills. The PBL-based student worksheet can improve students' critical thinking skills based on the results of the N-Gain test analysis of 0.824 in the high category.

3.5 Evaluation

The evaluation stage is the final stage in implementing research and development with ADDIE design. At this stage, the researchers distributed questionnaires to students to find out their responses to the products that had been developed. Student responses are used as input for improvement in addition to the effective value obtained from the implementation stage.

The trial stage was conducted in a group setting. Learning begins with the teacher explaining how to use a PBL-based student worksheet. Next, the teacher gave a stimulus to improve the learning process. After that, students are asked to read the text in the worksheet to better understand the concepts to be learned. Teachers also provide exercises on concepts explained at the previous meeting so that they can remember the learning that has been learned before. The results of student and teacher responses after using the student worksheet can be seen in Table 7.

Table 7. Teacher's Responses

Assessed Aspects	Percentage (%)	Category
Implementation	88	Excellent
Time Efficiency	80	High
Display	86	Excellent
Ease of Use	88	Excellent
Average value	86	Excellent

Based on the teacher's response, the PBL-based student worksheet on plant reproduction to improve student's critical thinking skills obtained a percentage of 86% in an excellent category. the student worksheet can increase students' interest, activity, and critical thinking skills [44]. Thus, teachers can make students more active in the learning process and improve students' critical thinking skills.

Practicality was assessed by distributing student response questionnaires for implementing the PBL-based student worksheet. The finding can be seen in Table 8.

Table 8. Students' Responses

Assessed Aspects	Percentage (%)	Category
Implementation	88	Excellent
Time Efficiency	86	Excellent
Display	82	Excellent
Ease of Use	86	Excellent
Average value	85	Excellent

According to the percentage score, the students' response to the product is excellent. The students were enthusiastic and found no difficulty in using the worksheet. This finding demonstrates that the student worksheet is simple to use, beneficial to students, and visually appealing. worksheets make students' learning activities more active, fun, and interactive [45]. It provides opportunities for students to practice and improve their critical thinking.

4. CONCLUSION

Based on the results of research and discussion about the development of the PBL-based student worksheet to improve critical thinking skills on plant reproduction material in elementary schools, it can be concluded the PBL-based student worksheet is effective in improving the critical thinking skills of elementary school students at SDN 1 Rajabasa Raya. A PBL-based student worksheet solves the problem in pre-research, where students had difficulty understanding the material of generative plant reproduction. It is supported by the results of hypothesis testing, which shows that the PBL-based student worksheet effectively improves the creative thinking skills of students in elementary schools. Thus, the PBL-based student worksheet is proven to answer the needs of students for teaching materials that can make it easier for them to understand the concept of generative plant reproduction following the demands of the times and learning needs in the independent curriculum.

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