



## **Effects of Worksheets Base the Levels of Inquiry in Improving Critical and Creative Thinking**

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The purpose of this study is (1) examining the effectiveness of worksheets based the three levels of inquiry in improving the critical and creative thinking skills of biology education students, (2) analyze implementation worksheets are based on the three levels of inquiry. The research was quasi-experimental: pre-test post-test non-equivalent control group design. The sample of this research consists of 80 students of biology education from Pattimura University, Indonesia. The data were collected by using critical thinking and creative tests an observation sheet. The data were analyzed by using hypothesis testing by using the Mann-Whitney U-test. The research results indicate that there is a significant difference in the effectiveness between the three levels of inquiry based worksheets and the conventional strategy in improving the critical and creative thinking skills of biology education students. The results of the analysis showed that the experimental class had a significantly higher difference in the average critical and creative thinking skills compared to the control class. The implementation of the worksheets based on three levels of inquiry is very good.

Keywords: critical, creative thinking, worksheets, the three levels of inquiry, biology education students

## **INTRODUCTION**

The process of learning has three domains, namely knowledge, skills and attitudes. In learning, students should be involved in the process of high-level thinking therefore professors should create an active learning which helps student understand the complex

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problems of science through inquiry in order to find the solutions of the problems (Kubiato, 2017). Science education today must use instructional strategies that put more emphasis on the students' understanding and employs scientific knowledge, ideas and the process of investigation under constructivist theory (Ferreira et al., 2013). The use of different science learning strategies can show a different correlation between student attitudes toward science and students' cognitive learning outcomes (Khristiani et al., 2015). This explanation implies the importance of using inquiry-based science learning strategies that develop high-level thinking skills enhanced by constructivist views to overcome the problems.

Learning in Higher Education is not just aimed at the understanding of knowledge, but also the ability to solve problems is more complex, requiring professional competence of lecturers. One of the doesn't professional competencies is being able to develop learning resources or media in accordance with the characteristics of students and teaching material. Lecturers must be creative in choosing and present learning resources or media that can be used in learning. One of the efforts made is to use the Student worksheet in developing concepts and implementing work procedures. Using can activate students in the learning process to achieve learning and help students understand the concept lecture material. The function of teaching materials is a guide to direct its activities in learning process, guidance to achieve competence and evaluation learning tools achievement. Based on this description, the implementation of worksheets in the learning process should be based on the inquiry process in order to develop high-level thinking skills.

The reason of using three levels of inquiry based-worksheet is because it activates students in the learning process, promotes better understanding of concepts (Kubicek, 2005), and help students integrate the concepts that they have mastered with phenomena they are observing in the laboratory (Mustachfidoh et al., 2013). Inquiry-based worksheets used in learning encourage students to understand facts or phenomena. There are several factors that influence this outcome, such as the implementation of inquiry strategies which provide students greater responsibility in completing experiments rather than employing conventional strategies (Artayasa et al., 2017; Yanto, Subali & Suyanto, 2019). The application of inquiry strategies encourages students to think more critically (Fuad et al., 2017). Besides, the contribution of critical thinking is to improve students' understanding of science process in the experiments they are carrying out (Azizmalayeri et al., 2012; Kitot et al., 2010).

Learning activities using inquiry-based worksheets can develop concepts and high-level thinking skills. High-level thinking skills need to be possessed by students in order to be able to face and solve problems in daily life in accordance with the advancement of science and technology. Brookhart (2010) defines high-level thinking into terms of transfer, critical thinking, and problem solving. High-level thinking is a learning process that can direct students to not only be able to remember subject matter but also be able to apply learning material in their daily lives. This is also in accordance with the objectives of science learning, which includes conducting scientific inquiry to foster high-level thinking skills of students which includes critical thinking skills (Iman, 2017).

The learning process that is applied at this time has not been too touching the cognitive, affective, and psychomotor domains of students. This situation is very inversely proportional to the purpose of science education, namely conducting scientific inquiry to foster high-level thinking skills of students which includes critical and creative thinking skills.

Based on observations in a preliminary study at Pattimura University, Indonesia, learning problems were found, namely the difficulties experienced by students in understanding and designing research because of a lack of student creativity. The implementation of biology learning does not encourage the achievement of critical and creative thinking skills. This is supported by Anderson (2010) there are two factors causing the thinking ability of not the developed during the learning is curriculum is generally designed with the target of extensive material so that the lecturer is more focused on the completion of the material and the lack of understanding of teachers about teaching methods can improve thinking skills. In carrying out learning, some lecturers choose to use conventional worksheets models, so that worksheets based on inquiry need to be implemented. In general, each subject has characteristics related to competencies that are developed as well as the characteristics of the teaching material, which courses will be chosen which are suitable for using inquiry-based worksheets. Considering that in one subject there are many studies that lead to the development of the competence and the making of teaching materials.

One effort to overcome the problem above is to develop learning resources in the form of worksheet based on three levels of inquiry that are suited to the characteristics of the learning materials. Biology learning process should be carried out by promoting scientific inquiry to foster the ability to think, work, be scientific and communicate it as an important aspect of life skills. The learning is expected to accommodate students to perform independent learning by utilizing inquiry-based worksheet learning media. The use of three levels of inquiry-based worksheet is expected to improve the critical and creative thinking ability of Biology Education department students.

Based on this explanation, the question in this research is how the effectiveness of the three levels of inquiry-based worksheets to improve the ability to think critically and creatively? The purpose of this research is to find out the effectiveness of inquiry-based worksheet in improving the critical and creative thinking skills of Biology Education Department students. This research offers some benefits for students. First, the research is expected to improve high-level thinking skills therefore the students will be independent in solving various problems in the daily life by employing genuine thinking. Second, it trains students to develop critical and creative thinking skills. Third, it helps students make a practical guide for courses specifically in the subjects of plant ecology, plant morphology, and plant physiology.

## **METHOD**

### **Research Design**

The design of this research was a quasi experiment pre-test and post-test non-equivalent control group design. In this study the effectiveness of using three inquiry based

worksheets is determined by student learning achievement. Before and after the field trial, pre-test and post-test were conducted to determine student achievement by comparing the experimental class and the control class. As shown in Table 1.

Table 1  
Research Design

Group	Pre-test	Treatment	Post-test
Experiment	O <sub>1</sub>	X <sub>1</sub>	O <sub>2</sub>
Control	O <sub>1</sub>	X <sub>0</sub>	O <sub>2</sub>

Information:

O<sub>1</sub> : Pre-test of critical and creative skill.

O<sub>2</sub> : Post-test of critical and creative skill.

X<sub>1</sub> : Learning treatment in the form worksheet base structured inquiry, guided inquiry and free inquiry.

X<sub>0</sub> : Learning treatment in the form of strategy conventional.

The research investigated Science Education lecture for 3 months from February to April 2018. There were ten topics of science that students learned during this research namely, roots, stems, leaves, flowers, forest ecosystems, biomes, vegetation, estuary ecology, photosynthesis, transpiration, diffusion and osmosis. The inquiry classes and the conventional class learned the 12 topics. The implementation of the three-level inquiry-based worksheet strategies and conventional strategy was the independent variable, while the learning results, namely critical and creative thinking skills, were the dependent variable. Class meetings were held once a week which last for 120 minutes.

Inquiry-based worksheet on plant morphology, plant ecology and plant physiology are designed by considering the appropriateness of content, suitability of presentation. The three-level inquiry based worksheet design of learning activities consist of formulating problems, submitting hypotheses, collecting data, analyzing and drawing conclusions. The worksheet is designed as a teaching material used by students that has never been used in learning at all. Each worksheet material is arranged in a sequent order which includes material descriptions, material summaries, practice questions, and assignments. The following is presented the syntax of several inquiry-based worksheets including structured inquiry-based worksheets, guided inquiry-based worksheets, and open inquiry-based worksheets

Table 2  
Activities Learning of Worksheet base the Three Levels of Inquiry

Syntax	Base Worksheet Structured Inquiry	Base Worksheet Guided Inquiry	Base Worksheet Open Inquiry
Formulate problem	Lecturers direct students to formulate questions	Provide an introduction to formulate a problem Guiding students to form hypotheses	Directing students to formulate questions Directing students to form hypotheses
Submit hypothesis	Lecturers help students to submit hypotheses to problems	Guiding students to be able to collect data	Directing students to collect and organize data
Do observation data collection	Helps students collect and organize data	Guiding students to draw conclusions based on data	Directing students to draw conclusions
Draw conclusions	Make conclusions together		
Material	Roots, stems, leaves flowers, seeds	Forest ecosystem biome vegetation estuary ecology	Photosynthesis transpiration diffusion osmosis

### Participants and Research Sample

The population in this study are all students of the 2017/2018 academic year study program. The sample in this study were 80 fourth semester students at the Pattimura University biology education study program, Indonesia. There are 40 students in each experimental group and control. In the research, the sampling technique called cluster sampling. This research was conducted for three months through February to April 2018. The implementation of the three-based worksheets inquiry strategies and conventional strategies were the independent variables, while learning outcomes were the critical thinking and creative skills dependent variables.

### Data Collection and Analysis

The research data were collected from test results and observation sheets, and validated by a curriculum expert and science material experts. In order to measure the change, the pre-test and post- test were conducted to both experiment and control classes. Based on the test on 30 essays items, the score of the essay test item indicated a grade of 0-2. All test items were valid based on the content validity of the test instrument carried out by measuring the expert judgement indicated with index with the Aiken (V) index of 0.85. ( $p < .05$ ). The Cronbach's alpha coefficient of the test was 0.60. It means that the test was reliable (Sarwono, 2015). Meanwhile, the observation instrument validity was 0.75 and the Cronbach's alpha coefficient of observation sheet was 0.64. The three level inquiry-based worksheets on the cronbach's alpha coefficient was 0.66 indicating good categories and meeting reliable requirements. The students' test was to measure critical and creative thinking skills before and after the learning.

Table 3  
The Grille for Critical and Creative Thinking Skills Test Instrument

Aspect	Indicator	Number of Item
Critical	1. Identify the elements in the case that are considered in particular the reasons and conclusions	1,2,3
	2. Identify and evaluate assumptions	4,5
	3. Clarifying and interpreting statements and ideas	6,7
	4. Assess acceptability especially credibility and claims	8,9,10
	5. Evaluate various types of arguments	11,12
	6. Make arguments	13,14,15
Creatif	1. Identifying and analyzing data	16,17,18,19
	2. Identifying objects	20,21,22,23,24
	3. Designing ways to overcome problems	25,26,27,28,29,30

The observation sheet instrument was used to analyze the implementation of learning based on the stages of learning according to the indicators presented below.

- a. Introducing concepts and forming conceptual understanding;
- b. Lecturers provide motivation for creativity, creating interest in prior knowledge;
- c. Lecturers direct students to formulate questions based on the phenomenon presented;
- d. The guiding lecturer formulates a hypothesis about the problem;
- e. Helps students collect and organize data;
- f. Guiding students to analyze data;
- g. Directing students to draw conclusions based on data.

The Analyzed the data was descriptively the non-parametric statistical test used in this research is the mann-whitney u-test, used to test means and groups.

## FINDINGS

### **Increasing Critical and Creative Thinking Ability by Applying worksheets -Based Structured Inquiry in the field of plant morphology**

The results of a comparative statistical description of the value of critical and creative thinking skills between the experimental class and the control class, in the table below.

Table 4  
Comparison of the Value of Critical and Creative Thinking Skills by Applying a Structured Inquiry Worksheets

Aspect	Experiment Class		Control Class	
	Mean Pre-test	Mean Post-test	Mean Pre-test	Mean Post-test
Critical	35	76	36	53
Creative	35	77	34	54

Based on the table above, the ability to think critically by using Structured Inquiry based worksheets in the experimental class obtained an average pre-test value of 35, there was a posttest average value of 76. While the ability to think creatively in the experimental class was obtained the pre-test average is 35 and has a posttest average value of 77. The

control class critical thinking skills by using conventional worksheets pre-test value of his average by 36, pre-test to post-test an average value of 53. While the ability to think creatively in the control class obtained an average pre-test value of 34 and at the post-test the average value was 54. Based on the normality testing of the data in the experimental class and the control class, the Asymp. Sig value is obtained (2-tailed) 50.05, the data are not normally distributed. The homogeneity test results are known to be 0.26 at the pre-test and 0.11 at the post-test. Based on these results, the data has been homogeneous because the significance of the data is greater than the significance value of 0.05 (5%). The hypothesis test used the Mann-Whitney U-Test when the prerequisite test (normality test) was not met to test the averages of the two groups. So, used a non parametric test assumption.

Table 5  
Mann-Whitney U-Test Test Results Critical and Creative Skills

Aspect	Test results	Pre-test	Post-test
Critical	Mann-Whitney U	740,000	241,000
	Asymp. Sig. (2-tailed)	.510	.000
Creative	Mann-Whitney U	742 .000	240 .000
	Asymp. Sig. (2-tailed)	.510	.000

From the table above, the result of the Mann-Whitney U-test can be seen as the Asymp value. Sig. (2-tailed) at 0.51 at the pre-test value, and 0.00 at the post-test. Thus it shows that the average critical and creative thinking abilities of students from the post-test results using structured inquiry and conventional learning worksheets are different and higher than those using conventional learning.

#### **Increasing the Critical and Creative Thinking Skills by Applying Guided Inquiry-Based Worksheets in Plant Ecology**

The results of a comparative statistical description of the value of critical and creative thinking skills between the experimental class and the control class, in the table below.

Table 6  
Comparison of the Value of Critical and Creative Thinking Ability by Applying a Guided Inquiry Based Worksheets

Aspect	Experiment Class		Control Class	
	Mean Pre-test	Mean Post-test	Mean Pre-test	Mean Post-test
Critical	33	79	36	55
Creative	39	80	39	51

Based on the table above, the ability to think critically by using a guided Inquiry based worksheets in the experimental class obtained an average pre-test value of 33, in the post-test the average value was 79. While the ability to think creatively in the experimental class obtained an average value the pre-test average was 39 and in the post-test the average score was 80. In the critical thinking ability control class using the conventional worksheets the average pre-test value was 36, in the post-test the average value was 55. Whereas the ability to think creatively in the control class obtained an

average pre-test value of 39 and in the post-test the average value was 51. Based on the normality test of the data in the experimental class and the control class the Asymp was obtained. (2-tailed ) 50.05, the data are not normally distributed. The homogeneity test results are known as 1.00 at the pre-test and 0.88 at the post-test. Based on these results, the data has been homogeneous because the significance of the data is greater than the significance value of 0.05 (5%). The hypothesis test used the Mann-Whitney U-Test when the prerequisite test (normality test) was not met to test the averages of the two groups. So, used a non parametric test assumption.

Table 7  
Mann-Whitney U-Test Test Results Critical and Creative Skills

Aspect	Test Results	Pre-test	Post-test
Critical	Mann-Whitney U	629.000	105.000
	Asymp. Sig. (2-tailed)	.072	.000
Creative	Mann-Whitney U	786.500	325.000
	Asymp. Sig. (2-tailed)	.889	.000

From the table above the result of the critical Mann-Whitney U-test ability can be seen as the value of Ash mp. Sig. (2-tailed) at 0.72 at the pre-test value, and 0,00 at the post-test. While the creative ability of the value of Asymp. Sig. (2-tailed) of .889 in the pre-test, and .000 in the post-test. Thus it shows that the average critical and creative thinking ability of students from the post-test results by using guided inquiry and conventional learning based worksheet is different and higher than those using conventional learning.

#### **Increased Critical and Creative Thinking Ability by Applying Open Inquiry-Based Worksheets in Plant Physiology**

The results of a comparative statistical description of the value of critical and creative thinking skills between the experimental class and the control class, in the table below.

Table 8  
Comparison of the Value of Critical and Creative Thinking Skills by Applying an Worksheets Based on Open Inquiry

Aspect	Experiment Class		Control Class	
	Mean Pre-test	Mean Post-test	Mean Pre-test	Mean Post-test
Critical	35	79	36	56
Creative	38	82	35	54

Based on the table above, the ability to think critically by using open Inquiry based worksheets in the experimental class obtained an average pre-test value of 35, in the post-test the average value was 79. While the ability to think creatively in the experimental class obtained an average value the pre-test average is 38 and the post-test average value is 82. There is a critical thinking ability control class using conventional worksheets with an average pre-test value of 36, in the post-test the average value is 56. While the ability to think creatively in the control class was obtained by the average pre-test value of 35 and in the post-test the mean score was 54. Based on the normality

testing of the data in the experimental class and the control class, the Asymp. Sig value is obtained (2-tailed ) 50.05, the data are not normally distributed. The homogeneity test results were known to be 0.24 at the pre-test and 0.33 at the post-test. Based on these results, the data has been homogeneous because the significance of the data is greater than the significance value of 0.05 (5%). The hypothesis test used the Mann-Whitney U-Test when the prerequisite test (normality test) was not met to test the averages of the two groups. So, used a non parametric test assumption.

Table 9  
Mann-Whitney U-Test Test Results Critical and Creative Skills

Aspect	Results of Test	Pre-test	Post-test
Critical	Mann-Whitney U	749.000	182.000
	Asymp. Sig. (2-tailed)	.582	.000
Creative	Mann-Whitney U	627.500	294.500
	Asymp. Sig. (2-tailed)	.70	.000

From the table above the result of critical Mann-Whitney U-test abilities can be seen as the Asymp value. Sig. (2-tailed) at 0.582 at the pre-test, and 0.00 at the post-test. While the creative ability of the value of Asymp. Sig. (2-tailed) of .70 in the pre-test, and .000 in the post-test. Thus it shows that the average critical and creative thinking ability of students from the posttest results by using worksheets based on open inquiry and conventional learning there are differences and are higher than those using conventional learning.

#### Implementation of Learning with three level of Inquiry based worksheets

In the implementation phase with inquiry-based worksheets, observations were also made to measure the level of implementation of learning. Through observation of the activities of lecturers as respondents who apply learning. The results of inquiry-based worksheets implementation analysis showed that there were differences in the application of three structured inquiry, worksheets based inquiry and open inquiry worksheets. In the picture presented the results of the analysis of inter-observer reliability using the Cohen's Kappa ( $k$ ) Coefficient formula as follows.

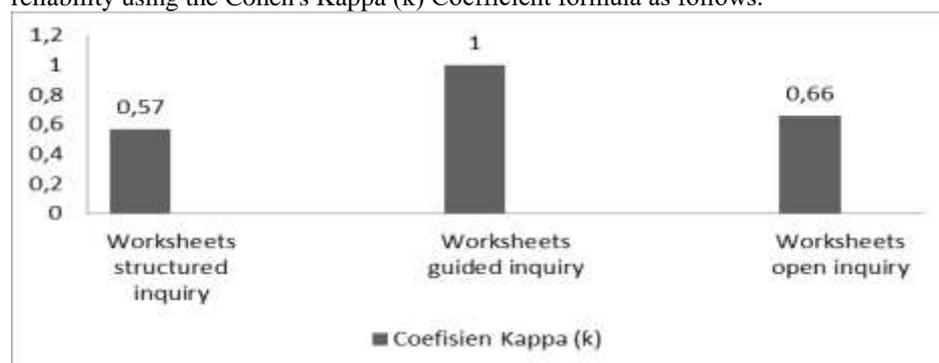


Figure 1  
Implementation Results of Learning with Worksheets Based on Inquiry

Description of rating:

$K < 0.40$  : Less  
 $0.40 < K < 0.75$  : Well  
 $K > 0.75$  : Very Well

Based on the picture above, the results of the observation show that the Kappa coefficient value is 0.57 on the application of the *Structured inquiry* based worksheets, 1 on the implementation of the *guided inquiry* based worksheets, while the application of the *open inquiry* based worksheets is 0.66. The average value of the Kappa coefficient index of the three observations is 0.74, this value is included in the good category.

## DISCUSSION

Based on the data that the ability to think critically and creatively by using three levels of inquiry based worksheets on plant morphology, plant ecology and plant physiology shows that there is an increase in the average post-test value after being treated higher than the pretest value. Results of Mann-Whitney U-Test from the ability to think critically and creatively shows the value of Asymp. Sig. (2-tailed) of 0.00 hypothetically accepted. This shows that there is a significant difference between the value of the pre-test and the post-test before and after the use of three-level worksheets based on inquiry. The effectiveness of three-level inquiry based worksheets compared to conventional worksheets based on the results of data analysis it can be concluded that there is an increase in the critical and creative abilities of the experimental group higher than the increase in the control group in learning.

It is important for teaching and learning that emphasizes the development of students' thinking (Ab Kadir, 2015). This further emphasizes the previous explanation about coursework is still dominated by lectures. Critical thinking re-emerges as a component to prepare for the 21st century generations to survive with the changing era (Berliner, 2009). The implication for teacher education is critical thinking skills, but also dispositions such as the enjoyment of effortful thinking and willingness to revise one's beliefs (in opinions on the face of evidence) (Haran et al., 2013). That is the knowledge of what critical thinking is, how and when it applies to effective material teaching (Ab Kadir, 2017). In addition, since 2015 all teacher education has a curriculum in the form of National Curriculum Framework of Indonesia (NCFI) (Kusaeri & Aditomo, 2019). With NCFI, teacher education institutions that can improve critical thinking skills of teacher candidates (Kemendikbud, 2014).

Based on data analysis of the three applications of three-level inquiry based worksheets in learning plant morphology, plant ecology and plant physiology, it can be concluded that the results are significantly effective in improving the ability to think critically and creatively. Learning is said to be effective if the learning objectives for each student can be achieved. The learning objective with the use of this worksheets is that students can improve their competencies in critical and creative thinking. At the beginning of learning all students have not mastered the indicator competencies of critical and creative thinking skills. During participating in inquiry-based worksheets learning developed, student competency gradually increases. At the end of learning, each student

stated that he had experience in working on test questions of the ability to think critically and creatively independently. This can be seen from the results of the tasks undertaken by students. These results are supported some research results that students' work can increase learning success and make students more active and efficient in learning , besides that it can help students understand the material and provide broad opportunities to show their knowledge and develop process skills, creative thinking skills and can enhance experience student learning (Karsli & Sahin, 2009; Trewet at al., 2013; Kibar at al., 2010; Susantini & Lisa, 2016; Bakirci at al., 2011; Crespo & Pozo, 2010).

Science student worksheets are designed to help students improve their scientific literacy, so they can apply their knowledge in everyday life (Ekantini & Wilujeng, 2018). Student worksheets are sheets that contain the tasks that students must do include: title, basic competency, completion time, materials needed to complete the task, brief information, work steps, tasks to be done, and reports that must be done. Student worksheets are printed material in the form of sheets of paper containing material, summaries, and instructions for carrying out learning tasks that must be done by students.

Criteria for evaluating teaching materials can be used as guidelines for evaluation including components of feasibility of content. In addition, Chappell and Craft (2009) and Susantini at al. (2016) which states that student worksheets are part of teaching materials that can be used to develop thinking skills, answer questions, and assess improvement in student learning outcomes. Teaching materials and worksheets that can develop students' learning experiences are devices that inform learning objectives, there are learning strategies, clearly formulate learning experiences, motivations, exploration to help learners make new discoveries. In addition, the ideal worksheet can make students more active, interesting and provide experience (Bakirci at al., 2011; Cilikler at al., 2012).

Teaching materials are said to be effective if they can help students achieve the desired competencies. The achievement of the quality of the worksheets aims to improve critical and creative thinking skills. Based on this description, it can be concluded that the teaching materials for inquiry-based worksheets have valid and effective qualities because they have succeeded in helping students and lecturers achieve learning goals. The use of worksheets greatly helps the effectiveness of the learning process, helps students improve understanding, present data, and facilitate analysis to form conclusions. Student Worksheets as guidance for students are used to carry out investigative activities with stages of problem-based learning in addition to training the development of cognitive aspects.

The results of data analysis indicate that the use of worksheets with inquiry models can foster high-level thinking skills of students. This is proven by the results of the students' pretest and posttest. The inquiry-based worksheets are effective in improving critical and creative thinking skills. The stages of activities using the inquiry model begin by selecting the topic of the problem, formulating questions, conducting investigations, making observations and collecting data and analyzing and drawing conclusions. The stages of these activities can foster high-level thinking skills of students based on

indicators of the ability to think critically and creatively when students do work procedures and communicate their understanding logically and objectively. Based on the results of the study, it was concluded that inquiry-based worksheets are effective in enhancing critical and creative thinking skills.

### **CONCLUSION AND IMPLICATION**

The application of three levels of inquiry based-worksheets in learning of plant morphology, plant ecology and plant physiology are significantly effective in improving the ability to think critically and creatively. Learning is said to be effective if the learning objectives can be achieved. The implication of this result is that the teaching materials of inquiry-based worksheets have valid and effective qualities since they successfully help students and lecturers achieve learning goals. The use of worksheets greatly fosters the effectiveness of the learning process, helps students improve understanding, present data, and facilitate analysis to draw conclusions. Student worksheets as guidance for students are used to carry out investigative activities with stages of problem-based learning in addition to training the development of cognitive aspects.

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