THE FEASIBILITY OF LEARNING CYCLE 5E STUDENT WORKSHEETS ON ENVIRONMENTAL CHANGE MATERIAL USING KENJERAN COASTAL LEARNING RESOURCE FOR TRAINING STUDENTS' CRITICAL THINKING SKILLS-BASED ON VALIDITY AND EFFECTIVENESS

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Abstract

This research aimed to produce Learning Cycle 5E Student Worksheets on environmental change material using Kenjeran coastal learning resource for training critical thinking skills of grade X of senior high school which were feasible based on their validity and effectiveness. This was a development research with a 4D model consisting of define, design, develop, and disseminate steps. This research conducted until "develop" step. The worksheet development was carried out in Biology Department, Mathematics and Natural Science Faculty, Universitas Negeri Surabaya. A limited trial was held at SMAN 19 Surabaya using fifteen students of grade X. The student worksheets' validity was determined based on validation results, while and their effectiveness was determined based on students' learning outcomes and their positive responses. The results showed that the worksheets got an average score of 3,77 with the very valid category. Students learning outcomes got percentage of 100%, the average of indicator mastery of water pollution sub-topic was 87% and soil pollution sub-topic was 93% with very mastery category, the average score of student critical thinking skills on sub-topic of water pollution was 93% and sub-topic of soil pollution was 97% with very good categories. The student's positive response also got 99%. Based on the data of students learning outcomes and their positive responses, these worksheets were expressed effectively. It can be concluded that the worksheets were feasible based on their validity and effectiveness.

Keywords: student worksheets, learning cycle 5E, environmental change, critical thinking
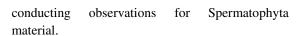
INTRODUCTION

Biology is one of subjects matter which are included in Natural Science's subject. Definition of Natural Sciences, according to Sastrawijaya (1993), is a study of substance's world, both of living and non living thing that can be observed. Sukarno and Kertiasa (1981), explained that natural science can be used as a tool to educate students in order to have an objective attitude when they have faced problems by involving scientific method. The application of biology learning using scientific method can train soft and hard skills of students. The use of scientific method in a learning may affect how students think, act, and behave when they face to daily problems. This is consistent with the essence of biology learning adopted from the values of science education in the school curriculum by

Sukarno *et al.* (1981) that students can have the thinking skills, skills, and scientific attitudes.

Some schools in Indonesia are using the curriculum 2013. The subject of biology in 2013'curriculum can be considered as a tool that bridge teacher to train students in their high order thinking skills. Learning activities can stimulate students to think and become active learners. One of aspects of high order thinking skills is critical thinking skills. Critical thinking skills are the skills of thinking logically which are needed to be trained in order to help students solve their problems. According to Onions (2009), critical thinking skills are ways of thinking, and series of skills that encourage students to inform, be aware, think systematically, consider and think logically to decide what they believe and will do.

One of materials in the biology subject matter which can accommodate training for critical

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thinking skills is a chapter of environmental change. Basic competencies of this materials are 3.11 and 4.11 which is the part of environmental change material, that are included in Permendikbud number 24 in the year of 2016, Appendix 7. The competencies require students analytical skill as one of critical thinking skills in order to build the concept of environmental change material. Therefore, in the chapter of environmental change, environmental pollution sub-topics is used as materials to train students' critical thinking skills.

Based on the results of pre-study questionnaire, to solicit information about the students' critical thinking skills of 39 respondent students in grade X of a certain school, it is known that the students' skills in arguing and analyzing issues get good enough category with the range of 55% - 69%. Arguing and analyzing problems are parts of the activities to train critical thinking skills. One of biology teachers at the school said that most of the students still get problems in asking or arguing about the lessons they learn and analyzing the problems of learning and making conclusions on the results of lab or learning activities. The explanation above shows that students' thinking skills need to be improved. One way to develop their critical thinking skills in learning is by implementing science investigation activities.

Science investigation activities require tools to guide students in doing structured activities to achieve their learning objectives. Student worksheet is a learning tool that can be used in this activity. Student worksheet is divided into two types, they are experimental and non-experimental worksheet. Maryati *et al.* (2015) said that experimental worksheet is a worksheet as a guidance to do an experiment, while non-experimental worksheet is a worksheet as a guidance to understand an abstract concept without doing an experiment. Related to the environmental change subject matter that was used in this study is a concrete material, so learning in this chapter can use an experimental student worksheet. Experimental activity in learning can be showed by activities of observation or experiment, suited with materials and purposes of learning. One of the examples of experimental worksheet is observation worksheets compiled by Zulfa *et al.* (2012) show the worksheets serve as students guide in

conducting observations for Spermatophyta material.

Using worksheet is expected to provide learning experiences for students in order to formulate concepts through interaction with their environment. When learned about environmental change material, one of schools in Surabaya also use worksheet. The worksheet do not contain the written instructions to guide students practice their critical thinking skills in accordance to basic competence 3.11 and 4.11 on environmental change material.

Obstacles of critical thinking skills development can be facilitated by the presence of worksheets with learning cycle 5E model. The learning cycle 5E model is a learning model that implements instructional learning strategies and consists of five phases. These phases are engagement, exploration, explanation, elaboration, and evaluation. Bybee *et al.* (2006) explains that the instructional approach that is used in the learning cycle 5E model is based on students' experience and ability to think using hands-on and minds-on activities because learning does not involve hands-on activities only. Therefore, phases of learning cycle 5E directing students to conduct investigation activities in learning can be used to train their critical thinking skills.

Learning activities in engagement and exploration phases require a relevant learning resource that can provide instructional information to support students' understanding of the concept. The definition of learning resources according to Association for Educational Communications and Technology or the abbreviated words AECT (1977) are all sources (data, people, objects) that may be used by learners either separately or in combination to facilitate learning activities. In connection with the use of environmental change material in the development of worksheet to train critical thinking skills, this study used Kenjeran coastal as a relevant learning resource around students.

Kenjeran coastal environment is one of the important environment where human live and do their activities. The impact of this situation is the Kenjeran coastal environment become polluted due to household waste produced around the coastal population and other waste carried by the flow of river water from Kalimas and Wonorejo rivers which empty to the Kenjeran beach. The

presence of water contamination that occurs at the Kenjeran beach is supported by a statement of Sudarmaji *et al.* (2004), that Kenjeran coastal waters in fishing and shellfishing area have been contaminated by household waste that is carried by the flow of the river water and flows into the Kenjeran beach. Fluctuations of macroinvertebrate diversity in a coastal environment can be used as a simple bioindicator at Kenjeran to measure represent the level of water pollution. Natural conditions in the Kenjeran coastal environment including water, soil and air can be used as resources to support the learning environment pollution sub material for students of class X.

Based on the background above, this study was conducted to develop student worksheets using learning cycle 5E model on environmental change material using learning resources of Kenjeran coast in order to train critical thinking skills of class X of Senior High School. The purpose of this study was to produce worksheets of learning cycle 5E environmental change material using learning resources of the Kenjeran coastal environment to train critical thinking skills that are feasible based on their validity and effectiveness.

METHOD

This research aimed to produce Learning Cycle 5E student worksheets on environmental change material. These worksheets using Kenjeran coastal learning resource to train students' critical thinking skills which are feasible based on their validity and effectiveness. This is a development research using 4D model consisting of define, design, develop, and disseminate steps. This research only did until "develop" step. The limited trisl of worksheet samples inclded fifteen students of grade of X SMAN 19 Surabaya who were heterogeneous.

Student worksheets with Learning Cycle 5E on environmental change material using Kenjeran coastal environment learning resource to train critical thinking skills of class X of senior high school developed in the Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. A limited trial of them was held at SMAN 19 Surabaya.

The research instruments used in this study were worksheet validation, achievement test and the student questionnaire response sheets. While the data were collected using validation and test methods. The worksheets were valid if the worksheets' validation results obtain an average score of $\geq 2{,}51$ with valid or very valid category. The worksheets are effective if the cognitive learning of students gains mastery percentage of $\geq 61\%$, the mastery percentage of $\geq 61\%$ of learning indicators, the percentage of students' critical thinking skills of $\geq 70\%$, and the percentage of positive responses of students of $\geq 61\%$. These worksheets are expressed feasible if they were rated valid and effective based on the validity and effectiveness.

RESULTS

The research results of this development were The Learning Cycle 5E Student Worksheet Using Kenjeran Coastal Learning Resource For Training Critical Thinking Skills for grade X of senior high school students.

1. Worksheets Validity

Worksheet validity was assessed using worksheet validation instruments. They were validated by validators which consist of a lecturer who experts in education, a lecturer who experts in biological materials, and a biology teacher of SMAN 19 Surabaya. The recapitulation of validation results can be seen in Table 1 below.

Table 1. Validity of Learning Cycle 5E Student Worksheet Using Kenjeran Coastal Learning Resource For Training Critical Thinking Skills For Grade X Of Senior High School Students.

Number	Aspect	Score				Interpretation
		1	2	3	Average for every crierion	
	DIDACTIC					
1	The emphasis on the process of finding concepts	4	3	4	3,67	**Very Valid**
2	Variation of stimuli through various media and student activities	2	3	4	3	**Valid**
	CONSTRUCTION					
	IDENTITY					
1	Title	4	4	4	4	**Very Valid**
2	Learning objectives	3	4	4	3,67	**Very Valid**
3	Time	4	4	3	3,67	**Very Valid**
4	Learning procedure	4	4	4	4	**Very Valid**
	LINGUISTIC					

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Number	Aspect	Score			Interpretation
		1	2	3	Average for every crierion
1	Suitability of language that is used in the worksheets with the maturity level of students	4	4	4	4	Very Valid
2	Suitability of sentences with language qualification	4	4	4	4	Very Valid
	CONTENT					
1	Suitability of material with Main Competence and Basic Competence of 2013's Curriculum	4	4	4	4	Very Valid
2	Authenticity of concept	3	3	4	3,33	Very Valid
3	Learning activities accordance with the demands of the curriculum 2013	4	4	4	4	Very Valid
4	References	4	4	4	4	Very Valid
	TECHNIQUE					
1	Writting	4	3	4	3,67	Very Valid
2	Pictures	4	3	4	3,67	Very Valid
3	Worksheet appearance	4	4	4	4	Very Valid
	WORKSHEETS CHARACTERISTICS					
	Comfirmity with Learning Cycle 5E Phase					
1	Engagement phase	4	4	4	4	Very Valid
2	Exploration phase	4	4	4	4	Very Valid
3	Explanation phase	4	4	3	3,67	Very Valid
4	Elaboration phase	4	4	4	4	Very Valid
5	Evaluation phase	4	4	3	3,67	Very Valid
	Critical Thinking Components					
1	Training interpretation skill	4	4	4	4	Very Valid
2	Training analytical skill	4	4	4	4	Very Valid
3	Training inference skill	4	4	4	4	Very Valid
4	Training evaluation skill	4	4	4	4	Very Valid
	Average score of validation				3,67	Very Valid

Information:
V1   = First Validator
V2   = Second Validator
V3   = Third Validator
Assesment Criteria:
1,00-1,75 = Not Valid
1,76-2,50 = Valid Enough
2,51-3,25 = Valid
3,26-4,00 = Very Valid

Number	Students	Water Pollution Test Scores	Soil Pollution Test Scores	Mastery
1	Student 1	88	86	**Mastery**
2	Student 2	88	100	**Mastery**
3	Student 3	92	100	**Mastery**
4	Student 4	88	86	**Mastery**
5	Student 5	92	86	**Mastery**
6	Student 6	80	77	**Mastery**
7	Student 7	88	100	**Mastery**
8	Student 8	76	77	**Mastery**
9	Student 9	76	100	**Mastery**
10	Student 10	76	100	**Mastery**
11	Student 11	84	91	**Mastery**
12	Student 12	84	86	**Mastery**
13	Student 13	92	96	**Mastery**
14	Student 14	76	96	**Mastery**
15	Student 15	92	96	**Mastery**
	Average	**85**	**92**	**Mastery**

Table 1 shows that the average validation score achieved of these worksheets obtained a score of 3.77 and classified as very valid. The highest average score was 4 with very valid category and the lowest average score was 3 with valid category.

2. Worksheets Effectiveness

The worksheet effectiveness was determined based on students learning outcomes and responses. The results of students' learning and responses analyzed in this study were the mastery of learning outcomes, mastery of learning indicators, indicators achievement of students' critical thinking skills, as well as the positive response of students. Data of student learning outcomes mastery can be seen in Table 2 below.

Table 2. Mastery of Student Learning Outcomes

Table 2 shows that 15 students of class X MIPA 1 were categorized as mastery because the gained score of each individual test was ≥ 75. The percentage of classical mastery was 100% with mastery category. The average score of students after learning using worksheet 1 was 85 with the highest score of 92 and the lowest score of 76. The other average score of students after learning using worksheet 2 was 92 with the highest score of 100 and the lowest score of 77. Based on the mastery of student learning outcomes that are ≥ 61%, the worksheets were expressed effectively.

In addition to measurement of the student learning outcomes mastery, their achievement test also can be used to determine the mastery of

Num-ber	Indicator	Mastery (%)
1	Interpreting the results of observations about the condition of the soil pollution in the Kenjeran coastal environment.	100
2	Describing the effects of soil pollution on plant growth.	100
3	Explaining the causes of soil pollution in the Kenjeran coastal environment.	80
4	Creating solutions to prevent/overcome the effects of soil pollution.	100
5	Formulating the scientific problem of soil pollution impact on plant growth.	91
6	Taking measurements of plant growth on soils with different levels of pollution.	100
7	Organizing data of plant growth.	89
8	Analyzing data of the influence of polluted soil on plant growth.	82
9	Analyzing data of the influence of polluted soil on plant growth.	93
10	Summing up the science investigation result of soil pollution.	91
11	Evaluating the effect and cause of soil pollution.	100
Average of learning indicator's mastery (%)		93

student cognitive indicators. Scores were obtained by analyzing the mastery indicator of an achievement test that has been done by students. The mastery of learning indicators were presented in the following table.

Table 3. Mastery of Learning Indicators
(Sub-topic of water pollution)

Number	Indicator	Mastery (%)
1	Interpreting the results of observations about the water conditions in Kenjeran coastal environment.	100
2	Explaining the impact of water pollution on macroinvertebrate diversity in Kenjeran coastal environment.	100
3	Explaining the causes of water pollution in Kenjeran coastal environments.	78
4	Creating solutions for reducing water pollution.	90
5	Formulating the scientific problem of the impact of water pollution on the survival of Kenjeran coastal macroinvertebrates.	100
6	Organizing data of types of macroinvertebrates that can survive at different points of the Kenjeran coastal.	91
7	Analyzing environmental changes of polluted water in coastal Kenjeran using bioindicators of macroinvertebrates at different locations.	93
8	Summing up the results of science investigation of water pollution.	93
9	Evaluating the causes and effects of water pollution.	67
10	Designing coastal environmental conservation activities to prevent/overcome the effects of water pollution.	58
Average of learning indicator's mastery (%)		**87**

Table 3 shows that nine indicators of learning for sub-topic of water pollution were categorized as mastery, while the last indicator (designing coastal environmental conservation activities to prevent/overcome the effects of water pollution) was not categorized as mastery. The average percentage of indicator mastery of water pollution sub-topic was 87%. The low percentage of mastery was 78% contained in the third indicator, and 58% for the tenth indicator. The highest percentage of learning indicator was 100%

Num-ber	Critical thinking skills and indicators	Achievement of (%)	
		1 (water pollution sub-topic)	2 (soil pollution sub-topic)
1	**Interpretation**		
	Interpreting condition of Kenjeran coastal environment (engagement phase)	100	100
2	**Inference**		
	Making formulation of scientific problem (engagement phase)	100	95
	Making conclusion (explanation and elaboration phases)	95	98
3	**Analysis**		
	Analyzing the impact and causes of pollution (explanation and elaboration phases)	95	98
	Creating a bar chart (explanation and elaboration phases)	-	88
4	**Evaluation**		
	Evaluating the effect and cause of pollution (evaluation phase)	75	100
Average of Student Critical Thinking (%)		93	97

for the first, second, and fifth indicators.

Table 4. Mastery of Learning Indicators
(Sub-topic of soil pollution)

Based on the data in Table 4, all learning indicators on the sub-topic of soil pollution get the average percentage of 93% which was categorized as mastery. The lowest percentage of mastery was 80% for the third indicator (the causes of the soil pollution in the Kenjeran coastal environment). The highest percentage was 100% for the first, second, fourth, sixth, and eleventh indicators.

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In addition to the mastery of learning indicators, achievement test also shows the students' critical thinking skills. Evaluation results of students' critical thinking skills obtained from students achievement test. The skills that were tested including interpretation, analysis, inference, and evaluation. Students are determined to have the ability to think critically in the category of good or very good if the critical thinking skills percentage is ≥ 70%.

Table 5. Indicators Achievement of Critical Thinking Skills

Table 5 shows that the average percentage of students' critical thinking skills of sub-topic 1 (water pollution) reaching a score of 93% and sub-topic 2 (soil pollution) reaching a score of 97% with very good category.

The effectiveness of student worksheets developed was measured using other ancillary aspects, namely student's response. A student's response is a response to the developed worksheets. Student responses were obtained by giving the responses questionnaire to students after learning activities. Students should choose one of two answers, "yes" and "no". The "yes" shows the positive response. The student worksheets are determined to be effective if the student positive responses obtain percentage of ≥ 61%. Data of students positive responses showed in the following table below.

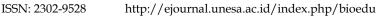**Table 6.** Student Positive Responses on Learning Cycle 5E Worksheet

Num-ber	Aspect	Student Positive Response (%)	
		Sub topic 1	Sub topic 2
1.	**Didactic**		
	Instructions activities contained in the worksheets guide you in learning the pollution material.	100	100
	Reading and drawing assists you in learning the pollution material.	100	100
2	**Construction**		
	There is a worksheet's title in each worksheet	100	100
	There is an allocation of time in each worksheet	93	100
	There are activities procedure	100	100
	The language used is not confusing	100	100
	The material presented is suitable with the	100	100

Num-ber	Aspect	Student Positive Response (%)	
		Sub topic 1	Sub topic 2
	environmental pollution material on lesson books for X grade		
3	**Technique**		
	The type and font size are readable	100	93
	Images displayed are clear and colorful	100	100
	Worksheets appearances are interesting (worksheet appearance include of cover design, drawing on passage, colors of worksheets)	93	100
4	**Worksheet characteristics**		
	Engagement phase directs you to formulate questions	100	100
	Exploration phase provides an opportunity for you to be more active in collecting information of learning materials	100	93
	Explanation phase trains you to analyze the results of the collected information	100	100
	Elaboration phase trains you to apply the knowledge acquired to other similar problems	100	100
	Evaluation phase trains you to measure the knowledge gained	100	100
	Worksheets can train you to formulate the problem	100	100
	Worksheets can train you to formulate scientific questions	100	100
	Worksheet can train you to make hypotheses	100	100
	Worksheets can train you to make conclusions	100	100
	Worksheets can lead you to give solution of a problem	100	100
	Average (%)	**99**	**99**

Continuation of Table 6

Table 6 shows the average overall of positive response of students that was 99%, with the highest positive response of 100% and the lowest positive response of 93%. The results of the analysis above show that the worksheets developed in this study were effective based on the percentage of learning outcomes and students positive responses on learning cycle 5E worksheets reaching a score of ≥ 61%.

DISCUSSION

Worksheets validation results show in Table 1 were based on the requirements of didactic,

construction, technical, and characteristics. Worksheets got a score of 3.77 with a very valid category. Therefore, based on the aspect of worksheet validity was found that the worksheets of learning cycle 5E on environmental change material using Kenjeran coastal learning resource for training students' critical thinking skills were feasible to be used in learning.

The first requirement which has to be interested to create a worksheet is a didactic requirement. This requirement relates to the presence of an effective learning through the use of developed worksheets. Aspects in didactic requirements on worksheet creating is the emphasis on the process of finding concepts using variations of stimulus through various media and student activities. Aspects of finding concept of didactic requirement on worksheet creating got an average validation score of 3.67 categorized as very valid. Aspects of stimuli variation of didactic requirement on worksheet creating got the lowest average score i.e. 3.00 categorized as valid. This aspect was getting the lowest average score in the didactic requirement because the developed worksheet (worksheet 1) did not use a relevant images media that stimulate students to associate the initial knowledge with learning concept. The developed worksheet (worksheet 2) also did not use relevant research results that were taken from any journal to stimulate students in applying their understanding concepts and critical thinking skills which have been obtained.

Image is one of aspect that needs to be observed in the worksheets creating. Darmodjo and Kaligis in Widjajanti (2008) define about good image is an image that can convey the message or content of the picture effectively to users. Therefore, an image must be informative and appropriate for the concept of learning. Images of sea foam being less relevant are replaced with the image of wastewater flow from the ditch leading to the Kenjerancoastal environment. The second aspect is the use of relevant research results in elaboration phase of worksheet that are taken from any journals. The definition of elaboration phase according to Wena (2009), is the phase where the students apply concepts and skills they have learned in a new situation or different context. Therefore, the results of a research journal is placed in the elaboration. The changed sentence of any

information on elaboration phase of the first worksheet former is "read the following **passage** carefully!" changed into "read the following **studies** carefully!".This changing has been done in order to inform the reader that the passage is the result of a research.

Second requirements in the worksheets creating according to Darmodjo and Kaligis in Widjajanti (2008) is fulfill the construction requirements. This provision regards to use language, sentence structure, vocabulary, and level of difficulty and clarity, that must be appropriate and understandable for students. Construction requirement in this study was divided into three aspects. They are identity, language, and content. Aspect of identity consists of sub-aspects of title, learning objectives, allocation of time and procedure. All aspects of the construction requirement are included in the category of very valid. This because of worksheets developed are suitable with the good requirements criteria. According to the Ministry of Education (2008), a good format of worksheets contains elements i.e. title, basic competence that will be achieved, time of completion, equipment/materials required to complete the task, brief information, action steps, tasks to be completed, and report that must be done.

The third requirement of the worksheet creating is a technical requirement. This requirement relates to the text, images, and appearance of the worksheet. Aspects of writing got the lowest average score of 3.67, and categorized as very valid. One of the validator suggestion is the font size in the message section should have been increased again. Based on this suggestion, the size of the letters contained in the message section is enlarged so that students would be easier to read the delivered message on the worksheet.

The other worksheet validity criteria besides those 3 requirements are characteristics of developed worksheet in this study. The characteristics of worksheet are the suitability of worksheets with the learning cycle 5E model and critical thinking skill components. Based on the validation result, these worksheets get a very valid category. It means that the worksheets are suitable to the learning cycle 5E and can train students' critical thinking skills.

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Worksheet suitability criteria with the learning cycle 5E model in the five phases (engagement, exploration, explanation, elaboration, and evaluation) obtain very valid category. These results indicate that the developed worksheets are suitable for the phase of learning cycle 5E. The explanation and evaluation phases get the lowest average score of 3,67. The definition of explanation phase according to Byebee et al. (2006) is a combination of concepts, processes, and skills. Ajaja (2013) also explains that the activities carried out in explanation phase are student activities to explain and answer the settlement of the issues raised on the topic of learning, try to understand the teacher's explanations by linking the observation of the students in the previous stage with the results obtained in explanation phase in order to reach a correct conclusion. According to one of validators, the developed worksheet still could not encourage students to explain the concept of the material and evaluate the rightness of statements related to the concept. As a consequence, the validator assessed students' ability to explain and evaluate as did not optimal
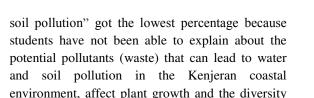
The other worksheet characteristics is critical thinking skill components. Critical thinking skill defined by Hasruddin *et al.* (2015) is a decision-making process that regulates oneself to solve problems and make useful decisions. Facione (2013) divides the critical thinking skills into six core elements. They are interpretation, analysis, evaluation, inference, explanation and self-regulation skills. Characteristics of critical thinking skills trained in this study are interpretation, inference, analysis and evaluation. Table 1 shows that all aspects of critical thinking skills trained in this research had an average score of 4 with very valid category. It means that developed worksheet of thinking skills can train interpretation, inference, analysis, and evaluation skills of students.

Worksheets' effectivity criterion was determined based on students' learning outcomes and responses after learning activities using worksheets. Student learning outcomes were obtained by assessing student achievement test. Data of learning outcomes mastery, learning indicators mastery, indicators achievement of students' critical thinking skills was obtained using students achievement test. While student responses were obtained by the student questionnaire.

Based on the results in Table 2, it is known that all students can do the test and get the classical mastery of student learning outcomes of 100%. All students were categorized as mastery. The learning cycle 5E worksheets that had been used in the learning activities have a contribution in the gaining score of student learning outcomes. The influence of using learning cycle 5E model on the students learning outcomes was also showed in studies by Tuna and Kacar (2013). They reported that the post-test experimental group (learning by using the model of learning cycle 5E) was higher than the control group (learning without using the model of learning cycle 5E). Gaining of students learning outcomes with classical mastery of 100% can not be separated from worksheet validation results. Getting very valid category because the worksheets have qualification on didactic, construction, and technical requirements and they are suitable for the learning cycle 5E model and critical thinking skills components. The three components (didactic, construction, and technical requirements) help students to understand the concept of learning for sub-topics of environmental pollution and achieve their learning outcomes mastery.

Students' achievement test were analyzed further to determine the mastery of learning indicators. Data in Table 3 shows that the highest percentage of indicator mastery was 100%. It was reached for the first, second and fifth indicators ("interpreting the results of observations about the water conditions in Kenjeran coastal environment, explaining the causes of water pollution in Kenjeran coastal environments, and formulating the scientific problem of the impact of the location of water pollution on the survival of Kenjeran coastal macroinvertebrates".). The lowest percentage of indicators was 58% for the last indicator. The indicator is "designing coastal environmental conservation activities to prevent/overcome the effects of water pollution".

Indicator of interpreting the observation result and formulating the scientific problem got a percentage of 100%. Students can interpret the results of observations about the water condition on Kenjeran coastal environments because the images of liquid waste contained in coastal environments are able to inform students about the conditions in the Kenjeran coastal environment. Furthermore,

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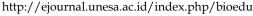
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students can achieve indicator of formulating the problem of the impact of the location of water pollution on the survival of Kenjeran coastal macroinvertebrates because articles and images on this worksheet and the limited trial activities can facilitate students in formulating the problem. Indicator of explaining the impact of water pollution on macroinvertebrate diversity in Kenjeran coastal environment also got a percentage of 100% because students were assessed has been able to explain the impact of water pollution after learning by using worksheets 1. Based on these percentages, it can be said that the worksheet of learning cycle 5E on water pollution sub-topic be able for training students to explain the impact of water pollution based on the phenomenon found in Kenjerancoastal environments.

Based on Table 3 about learning indicators mastery of water pollution sub-topic, it was found that the lowest percentage of indicator mastery was 58% indicator of "designing coastal environmental conservation activities to prevent/overcome the effects of water pollution". Based on the students answer of learning outcomes tests, the indicator category was unmastery. It can be said that the students have not been able to reach the level of cognitive C6 (create). Cognitive level of C6 are included in the high cognitive level. Kuswana (2012) defines that cognitive level of 'creating' is putting parts togetherness into an idea, all things are interconnected in order to make a good result. Students must involve their high order thinking skills to access this indicator.

Based on data about the mastery of learning indicators of soil pollution sub-topic in Table 4, the indicator mastery percentage was 100% for the indicator of "interpreting the results of observations about the condition of the soil pollution in the Kenjeran coastal environment, describing the effects of soil pollution on plant growth, creating solutions to prevent/overcome the effects of soil pollution, taking measurements of plant growth on soils with different levels of pollution, and evaluating the effect and cause of soil pollution". While the lowest percentage was 80% for the indicators of explaining the causes of soil pollution in the Kenjeran coastal environment". Indicators of "explaining causes of pollution" of water pollution subtopic also got a low percentage of 78%. Indicators of "explaining the cause of the

soil pollution" got the lowest percentage because students have not been able to explain about the potential pollutants (waste) that can lead to water and soil pollution in the Kenjeran coastal environment, affect plant growth and the diversity of macroinvertebrates. Students have been able to identify the cause of pollution is a waste, but some students are still wrong in writing the reason behind it.

Test achievement also can determine the indicators achievement of students' critical thinking skills. Critical thinking skills trained to students consist of interpretation, inference, analysis, and evaluation. Data of critical thinking skills indicator achievement in Table 5 shows that the average indicator achievement of critical thinking skills in the sub-topic of water pollution was 93% and the sub-topic of soil pollution was 97%. The data shows that the worksheets of learning cycle 5E used in the learning activities are capable to train students' critical thinking skills. The statement is also supported by the results of the worksheet validation component about critical thinking skills that consist of the skills of interpretation, analysis, inference, and evaluation which get an average score of 4 with very valid category. Research of Murdhiah*et al.* (2014) also showed that the increasing of students' critical thinking skills which include skills to analyze, synthesize, and evaluate were 15.7% after learning using learning cycle 5E.

Worksheet effectiveness criterion were determined from the results of student's response after learning activities using the developed worksheets in this study. Average of students positive responses to the worksheets water pollution and soil pollution sub-topic were 99% with very effective category. The lowest percentage was 93% for the aspect of time allocation and the worksheet appearance at the sub-topic of water pollution, also the type and size of letters and stage exploration activities at the sub-topic of soil pollution. While the highest percentage of positive responses was 100%.

Based on the lowest percentage of student positive responses gained, it can be known that the student worksheets still has several weaknesses. They were the time allocation that was insufficient, the worksheet appearance was less attractive and unclear. The first weakness of water pollution worksheet was about time allocation. The time

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spent during the lesson using Worksheet 1 was not suitable with the allocation of time written in the worksheet. The second weakness in the worksheet developed, according to one of the students was the worksheet appearance was less attractive. The worksheet appearance was one of the things that needs high attention because it related to student interest to learning. Another worksheet weakness were the type and size of the letters used in Worksheet 2 that were difficult to read. The type and size of letters were two aspects that were included in the worksheet creating requirements. Therefore, in the worksheet former must pay attention to the legibility of letters. The last worksheet weakness according to one of the student opinion was the exploration phase that did not give opportunity to the students to be more active in collecting information on learning materials. Exploration phase was a stage of collecting the data. Activities of soil pollution sub-topic in exploration phase were measuring plant growth and recapitulating the results of measurements in the table recapitulation. Plant growth measurement activities were carried out in the classroom. It is different when it is compared to the activity of students in the first meeting (water pollution sub-topic) that was conducted at the Kenjeran coast. The organized learning activities that were done in an open space will make students more active because they were not limited by the walls of the classroom.

Worksheet effectiveness criteria were determined in this study based on the learning outcomes and students positive responses. Therefore, the average percentage of learning outcomes mastery was $\geq 61\%$, learning indicators mastery was $\geq 61\%$, achievement indicators of students' critical thinking skills was $\geq 70\%$, and the students' positive responses was $\geq 61\%$. In this case, the worksheets were effective based on the effectiveness criteria.

SUGGESTIONS

Suggestions that can be conveyed relates to this research about worksheets suitability and time management. Using learning cycle worksheets needs high attention to the suitability between characteristics of worksheets, topics of learning, and learning activities. A good time management also required in this case.

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