

## DEVELOPING ISSUE-BASED TEACHING MATERIALS TO IMPROVE STUDENT LEARNING OUTCOMES IN FRESHWATER BIOLOGY COURSE

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### ABSTRACT

*One of Freshwater Biology course problems is that the students were unable to understand the environmental phenomena around them. The aim of this study was to develop issue-based teaching materials in Freshwater Biology course to improve the students' understanding about the environmental phenomena through their learning outcomes. This research and development used three phases of the 4D model developed by Thiagarajan, namely define, design, and development. The development results were validated by content and media experts. The design used for a pilot test, which was conducted among 20 students, was one group pretest-posttest design; meanwhile, the data analysis technique used was the independent t-test. It can be concluded that the teaching materials developed was valid with the average validation score as high as 79.83%. In addition, there was a significant improvement (sig. 0.000) of student learning outcomes after attending the course which implementing the issue-based teaching materials developed. Thus, the implementation of issue-based teaching materials is recommended in Freshwater Biology course due to its potential in improving students' learning outcomes.*

**Keywords:** *Biology, issue-based materials, learning outcomes*

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### INTRODUCTION

Biology is one science subject which often considers have various abstract concepts for students (Çimer, 2012; Etobro & Fabinu, 2017; Ogunkola & Samuel, 2011; Topçu & Şahin-Pekmez, 2009). The assumption will more perceive by students if the learning process relies solely on textbooks. In fact, the object of biological studies is various environmental phenomena and organisms that exist around the student. Students will engage to learn if the source of learning is a phenomenon or issue in their environment (Brickell, Hedberg, Ferry, & Harper, 2001; Elder, 2015; Hill, 1998; Permana, Suwono, & Listyorini, 2016), which is familiar with them. By developing teaching material based on phenomenon or issue in students' environment, will encourage them to explore biological concepts.

The utilization of relevant learning resources will be achieving systematic learning to design effective learning. According to the Ministry of National Education, teaching materials play an important role in the learning process (Bahri,

Syamsuri, & Mahanal, 2016) and can optimize the learning outcome (Susilana & Riyana, 2009). Regarding to that situation, the quality of learning will increase when the learning component can be optimally empowered, by making improvements and updates on the learning materials.

Improvement of learning material can be arranged using a phenomenon or issue (Nuangchalerm, 2009; Nuangchalerm & Kwuanthong, 2017). In this type of learning that combines the symptoms that occur in the environment with learning content, students' science literacy can increase (Nuangchalerm, 2009; Presley et al., 2013). Problems in student environmental have a prominent linking to the biological concept, such as ecology, conservation, and extinction issue (Presley et al., 2013). Therefore, the development of learning material based on issues is a good alternative in biology learning.

Freshwater Biology course is one of the specialization courses in Biology Education of Indonesia University of Education. The scope of Freshwater Biology includes freshwater

zation, freshwater quality and its relationship (physical, chemical and biological factors), and freshwater biota (autotroph and heterotroph) in static water (called **lentic**) and flowing water (called **lotic**). Based on the preliminary research, there was an absence of specific teaching materials to discuss the bio-indicators plankton in some freshwater ecosystem (e.g. lake, pond), especially in West Java area. Student only did a critical analysis of articles, rather than explore the issues around their environment. This condition tends students to less aware of the potential problem or issue of their area.

Various research and development have been conducted by previous researchers to improve the process of biology lectures (Fauzi, 2017; Miharja, Syamsuri, & Saptasari, 2015; Widiensyah, Indriwati, Munzil, & Fauzi, 2018). However, the research and development that conducted on Fresh Water biology course is still hard to find. In addition, until now, the development of issue-based teaching materials is still rare to find in Indonesia. Therefore the development of issue-based teaching materials in Freshwater Biology course needs to be established. Moreover, according to Hunaepi, Kurnia, and Firdaus (2014), the common difficulties confronted in ecological learning are the lack of students' ability to examine and understand phenomena and issue in nature using ecological science. Therefore, the researchers chose the right location as the enrichment of teaching materials on Freshwater Biology course that is Situ Bagendit Lake in Garut, West Java Province, Indonesia.

## METHOD

This study actually was divided into two steps; first step was a preliminary study to determine the quality of freshwater in Situ Bagendit Lake; the second was development of issue-based teaching materials to improve students' learning outcome in Freshwater Biology course. However, this paper is more focus on reporting the second step. The first step was conducted in Situ Bagendit Lake, whereas the second step was conducted in the Faculty of Mathematics and Education Natural Sciences, Indonesia University of Education. The study begins with a preliminary study (step 1) about the quality of freshwaters in Situ Bagendit Lake based on bio-indicator using

plankton. Then, the result of the preliminary study was used as a material for planning the preparation of developing teaching materials.

The development research (step 2) only consists of 3 phases of 4D Thiagarajan's model. The stages in this study, namely (1) define phase, including the analysis of lecture unit, materials, indicators, as well as the formulation of learning objectives; (2) the design phase, including the selection of the format, and the preparation of the initial design (product draft); (3) development phase, including the validation of product draft by the experts, then revised the draft, and conduct a pilot test.

In a pilot test, the design used in this stage was one group pretest post-test design. The measured parameter was learning outcomes, i.e. students' concept understanding and problem solving skills. Problem-solving skills consist of five aspects including formulating problems, stating hypotheses, testing hypotheses, describing conclusions and applying conclusions.

The students would get a pretest to measure their learning outcome before the implementation of teaching materials. After the implementation of teaching materials, students get a post-test to determine the improvement of student learning outcomes. Then, the data were analyzed using the normalized gain (N-gain) and the independent t-test. The study was conducted in July until September 2017 with the subjects were students who take Freshwater Biology courses. The sampling technique used was purposive sampling.

## RESULTS AND DISCUSSION

### Definition Phase

#### *Observation results in Situ Bagendit Lake*

Observation of water quality in Situ Bagendit Lake conducted first before developed into teaching materials. Three areas of Situ Bagendit Lake were measured as the observation station; inlet, middle, and outlet. The measurements of physical and chemical factors, includes temperature, turbidity, pH, depth, Dissolved Oxygen (DO), free carbon dioxide, and Biochemical Oxygen Demand (BOD). The observation result presented in Table 1 (physical-chemical factors of freshwater in Situ Bagendit Lake) and Table 2 (freshwater quality based on plankton as bio-indicators in Situ Bagendit Lake).

**Table 1.** The measurement result of physical-chemical freshwater condition in Situ Bagendit Lake

No.	Parameters	Quality standart	Station		
			Inlet	Middle	Outlet
1	Temperature (°C)	28-30	26.51	25.44	25.18
2	Turbidity (cm)	-	18.71	27.76	29.31
3	Depth (cm)	-	142	155	174
4	pH	6-9	3.26	3.79	6.5
5	DO (mg/l)	> 4	3.81	4.23	6.76
6	CO <sub>2</sub> (mg/l)		8.18	10.2	4.84
7	BOD(mg/l)	3	3.11	3.03	2.02

(Source: Government regulation of The Republic of Indonesia Number 82 year 2001 on water quality management and water pollution control, 2001).

**Table 2.** Water quality in Situ Bagendit Lake based on plankton as bio-indicators

Stasiun	Situ Bagendit pollution rate			Water quality
	Type composition	Index of diversity	The level of pollution	
Inlet	Low	Low	Medium	Poor
Middle	Medium	Medium	Medium	Poor
Outlet	Medium	Medium	Low	Moderately good

The turbidity value of Situ Bagendit Lake ranged from 18.71-23.31 cm. The lowest brightness was in the inlet area (18.71 cm), whereas the brightest area was an outlet area (29.31 cm). The turbidity of water bodies is influenced by the water clarity. The more turbid waters showed the higher concentration of total suspended solids. Turbidity can be caused by the presence of abiotic materials such as sediment and pollution waste, or the high concentrations of biota such as phytoplankton (Feng, Hu, Chen, Tian, & Chen, 2012; Johan, 2011; Monica Z. Bruckner, 2018). Based on the data, the water in Situ Bagendit Lake was clear and penetration of light entering is high. This is supported also by the value of depth range from 142-174 cm.

Value the potential of Hydrogen (pH) at each area in Situ Bagendit Lake ranged from 3.26 to 6.5. Based on the data obtained, the pH value in Situ Bagendit Lake waters is at the lowest allowable range. This is supported by the opinions of Johan (2011) who states the degree of acidity (pH) of water is one of the chemical properties of water affecting the growth of plants and aquatic animals and could use as a guide to examine the quality of water environment as a living environment.

Dissolved oxygen in Situ Bagendit Lake waters ranged from 4.23 to 6.76 mg/L. The high oxygen dissolved in the outlet compared to other stations related to the low temperature of these waters. This statement is accordance with Johan (2011) who informed dissolved oxygen in waters can come from the air and from the movement of water, the largest source of

dissolved oxygen in the waters comes from the process of photosynthesis of water plants. The water-soluble oxygen levels that can still be tolerated by aquatic organisms especially phytoplankton are not less than 5 mg/l.

The free carbon dioxide value in Situ Bagendit Lake waters ranged from 4.84-10.12 ppm. The highest free CO<sub>2</sub> was found in the inlet, the middle ranged from 8.18 to 0.12 ppm, and the lowest was in the outlet (4.48 ppm). The high content of CO<sub>2</sub> in the waters can lead to disruption of marine life. Table 2 describes the quality of Situ Bagendit Lake waters was poor to moderately good. The inlet and the middle part were the stations with medium pollution level, besides the outlet was moderate. Medium levels of contamination in the inlet and middle portions show poor water quality.

#### *Analysis of material developed for issue-based teaching materials*

The material developed for issue-based teaching material was the use of plankton as bio-indicator which refer to the Achievement of Study Program (ASP) that is: students are able to utilize the expertise in the field of biology with the aim of solving problems in the community adaptively (LO 3), mastering the concept, principles, theories, and laws of biological science to solve scientifically (LO 6), and capable of developing biological science through research so as to contribute to problem solving in society (LO 7). While the learning achievement was the student is able to utilize plankton as bio-indicator to solve the freshwater ecological problem or issue.

The learning achievement related to general skill is to make decisions appropriately to solve the problem related to freshwater ecosystem based on the analysis of information and data. In more detail, the analysis results are presented in Table 3. Based on Table 3, the teaching

materials consist of 4 sub-materials that are, 1) aquatic physics factors and measurement methods; 2) plankton diversity; 3) the role of plankton as bioindicator; 4) the linkage between water quality and plankton community.

**Table 3.** Identification of the findings in the field as material for the utilization of plankton as bio-indicator

No.	Field facts	LOs	Objectives
1	Temperature (25,18- 26,51 °C) brightness (18,71-23,31 cm) Depth (142 cm-174 cm) pH (3,26-6,5) DO (4,23-6,76 mg/l) CO <sub>2</sub> (4,84-10,12 ppm) BOD (2,02-3,11ppm)	3,6	a) Students can explain the various physical chemical factors that affect the life of the plankton community in Situ Bagendit Lake b) Students are able to perform methods of measuring and analyzing data
2	Phytoplankton species were found from five classes ( <i>Bacillariophyceae</i> , <i>Cyanophyceae</i> , <i>Chlorophyceae</i> , <i>Euglenophyceae</i> , and <i>Xanthophyceae</i> ) for a total of 173 individuals. Zooplankton found as many as 5 classes ( <i>Rotifera</i> , <i>Protozoa</i> , <i>Cladocera</i> , <i>Copepoda</i> and <i>Rotatoria</i> ) with a total of 199 individuals.	3,6	Students can explain the diversity of plankton in Situ Bagendit Lake
3	Plankton diversity index ranges from 1.22 to 2.49. The value of plankton dominance index in Situ Bagendit ranged from 0.1 to 0.23. In Situ Bagendit water, there was a total abundance of phytoplankton in the range of 15.471-25,554 cells/l, while total zooplankton abundance was 20.864-33,273sel / l.	3,6	Students can explain the diversity of plankton in Situ Bagendit Lake
4	Based on the parameters of species composition and the diversity of inlet type and the middle part was found <i>Oscillatoria</i> sp. and <i>Anabaena</i> sp which is kind of phytoplankton. In the inlet and middle area were found <i>Branchionus</i> sp.	3,6,7	Students can explain the role of plankton as a bioindicator of water quality
5	Inlet area was in medium pollution level and poor water quality. The middle area was medium pollution levels and poor water quality. The outlet area was in level of mild contamination with water quality is quite good.	3,6,7	Students are able to analyze the linkages between the quality of freshwater waters and the plankton community

### Planning phase

This teaching material consists of three parts, namely introduction, content, and cover. The introduction contains the title page, the preface, the table of contents, the instruction manual, the concept map and the learning objectives. The content consists of four sub-subjects, namely the plankton community in freshwater, physical and chemical factors that affect the life of the plankton in the water, plankton as a bioindicator of water quality, and relationship with the plankton community as well as equipped with problem columns.

The cover section contains a summary of questions, evaluations, answer keys, and

bibliography. The results of the design of the issue-based teaching materials include the cover, instructions on the use of teaching materials, table of contents, concept maps, materials, summaries, tests, answer keys, feedback, and bibliography (Prabowo, Nurmiyati, & Maridi, 2016). The design of teaching materials has been adapted to the curriculum and material concepts that have been established at the definition stage.

### Development phase

#### *Results of feasibility the teaching materials*

The teaching materials were validated by the validator include aspects of feasibility,

appearance, and language. This is similar to the research undertaken by Miharja et al., (2015) who developed the teaching materials judged on the content feasibility aspect, appearance and language.

Assessment of feasibility of issue-based teaching materials on plankton as bio-indicator materials using a modified textbook assessment instrument. Recapitulation of validation issue-based teaching materials by validators is presented in Table 4.

Based on Table 4., it can be seen that the score obtained from a material expert was 35 with an average score as high as 4.37 and the percentage was 87%. This value is included in the “valid/without revision” category. The teaching materials were validated by the validator include aspects of feasibility, appearance, and language. The score from the second validator as high as 63 with an average of 4.5 and the percentage was 84%.

**Table 4.** Results materials assessment by validator

No.	Validator	Component	Acquisition scores	Average Score***	%	Criteria
1	Content expert	Content	35*	4.37	87.5	Valid/without revision
2	Learning media expert 1	(feasibility, appearance, and language)	63**	4.50	84.0	Valid/without revision
3	Learning media expert 2	(feasibility, appearance, and language)	51**	3.64	68.0	Valid/without revision
Average Overall				4.17	79.83	Valid/without revision

Note: \*maximum score = 40; \*\*maximum score = 75;\*\*\* Score Range ≥ 1.00 - 5.00

The score obtained from the third validator was 51 with an average of 3.64 and percentage score was 68%. The second and third validator values are included in the “valid/without revision” category. The overall average score from three validators as high as 4.17 with the category valid/without revision (79,83%). Thus, it can be conclude that the teaching materials appropriate with the ASP, so each indicator is precise and measurable.

*Results of student responses to teaching materials*

The student responses are consisting of four aspects covering the content, appearance, language, and utility. The responses are presented in Table 5.

**Table 5.** Summary of student’s responses on issue based teaching materials

No.	Aspects	Average Score (%)	Category
1	Content	74.13	Good
2	Appearance	81.08	Very good
3	Language	82.60	Very good
4	Utility	84.60	Very good
Average		80.64	Very good

Based on Table 5., the average score responses from 20 students in content was 74.13%, the appearance was 81.08%, language was 82.6%, and the utility was 84.6%, with an average score as high as 80,64%. This score is included in “good” category, so the teaching material that has been developed is no need to be revised.

*Influence of issue-based teaching material on student learning outcomes*

The pilot test to examine the effect of issue-based teaching material on students’ learning outcomes conducted with as many as 20 students of the Indonesia University of Education, majoring in Biology Education. The process of testing conducted through direct learning activities as listed in the Events Unit Class (EUC) that has been designed. The pilot test results indicate an increase in learning outcomes after the implementation of issue-based teaching materials in learning, presented in Table 6.

**Table 6.** The average of pretest, posttest, and N-gain of students

Pretest	Posttest	N-Gain
60.00	86.00	0.64

Based on Table 6, the average students' learning outcomes score before the implementation of issue-based teaching material was 60.00 and after the implementation was 86.00, whereas N-gain that was obtained as high as 0.64. From the result, students' learning outcomes have improved and based on N-gain, the improvement was in the medium category.

The data were analyzed using the independent t-test. The result of the test is presented in Table 7. After that, based on the result of the independent t-test that can be seen in Table 7, t value that was obtained as high as 18.606 with p-value = 0.000. Therefore the null hypothesis was rejected and it can be concluded

the student's learning outcomes after issue-based teaching material implementation was higher than the students' learning outcomes before teaching material implementation. This is in accordance with opinion from Erwanto & Santos (2016) who said through problem-based learning (issue-based learning is one of problem-based learning variant), student is conditioned to be actively involved in understanding the problems presented, exploring facts and planning for completion, discussing group work, independent learning by doing guesswork, testing answers and summarizing the work, presenting the work, and reviewing the work.

**Table 7.** The result of independent t-test on the data of students' learning outcomes

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval				
				Lower	Upper			
Pretest-posttest	-26.00	6.249	1.397	-28.925	-23.075	-18.606	19	0.000

The result of this study is in accordance with Aji, Hudha, and Rismawati (2017) who informed that teaching materials can bridge, even combine experiences and learners' knowledge, simple teaching materials can be formulated as anything that can facilitate the participants educated in an effort to obtain some information, knowledge, experience, and skills in teaching and learning process. This research is also supported by Miharja (2015) that informed the students were easy to understand the material by using problem-based teaching materials because of increasing students' interest through the "Problem Column" which is inserted, so the students feel not bored with the material presented.

The problem-solving skills data that were obtained in this study can be seen in Table 8.

All aspects of problem solving skills have been improving due to the implementation of teaching material that has been developed in this study. During pretest, the categories of student's problem-solving skills in each skill were categorized as good. After the learning process, those aspects have increased to be "good" and "very good" category. This is supported by Diani (2015) that informed the issue-based instruction model is a constructivist-based learning model that accommodates learners' involvement in authentic learning and problem-solving. This result is similar to the results of the study of Anista, Ibrohim, and Suwono (2016) that reported there was an increase in students' critical thinking ability and problem-solving.

**Table 8.** Percentage of problem-solving skills

No.	Aspect PSS	Pretest	Category	Posttest	Category
1	Formulating problems	50.80	Enough	81.40	Good
2	Creating hypotheses	51.90	Enough	81.10	Very good
3	Testing hypotheses	54.00	Enough	80.00	Good
4	Formulating conclusions	58.09	Enough	82.45	Very good
5	Implementing conclusions	45.00	Enough	79.10	Very good
	Average	52.12		80.81	

In the 21st-century, one of the roles of biology learning is to empower students' thinking skills (Magsino, 2014; Mcfarlane,

2013), communication skills (Buku, Mite, Fauzi, Widiensyah, & Anugerah, 2015; Huang et al., 2010; Talat & Chaudhry, 2014), and

metacognitive skills (Fauzi, 2013; Ramadani, Fauzi, Sukmawati, & Corebima, 2015; Tanner, 2012). However, these goals will not be achieved if students have difficulty understanding the concepts they are learning. Not only understand the concepts, the students but also hopefully store their concepts in long-term memory, so they have a good retention on those concepts (Sukmawati, Ramadani, Fauzi, & Corebima, 2015). Thus, the improving learning outcomes are one goal that should not be forgotten by educators until today (Fauzi, 2013; Husamah & Pantiwati, 2014; Ramadani et al., 2015). Therefore, one way to optimize the learning process is by improving students' learning outcomes.

Based on the result from this study, the implementation of issue-based teaching materials has been proven could improve students' learning outcomes. This teaching material is the product of the research and development process. Research and development is one kind of research that often conducted by biology educators as the solution to solve some problem in the learning process. Various information can be the basis of the development process, such as various research results in the biology field, based on local wisdom, as well as from environmental conditions and community activity (Setyawan, Rohman, & Sutomo, 2015). Due to this research have many advantages for improving educational quality, this kind of study is still recommended to be conducted by the researcher in Indonesia.

However, besides studying chemical and biological factors in aquatic environment and utilization of plankton as bio-indicator, the study object of Fresh Water course is various water biotas which size bigger than plankton. In this study, the teaching materials were developed based on observational data of biological and chemical condition in Situ Bagendit Lake and the diversity of plankton in that location. Various biotas, such as macroinvertebrates (Nuha et al., 2015; Sukoco et al., 2015; Wijayanti et al., 2015), various algae and plants (Maznah, Omar, Pinang, Biologi, & Biologi, 2010), to fish (Naigaga et al., 2011) are actually also the water biota that is often found and also become the bio-indicator of aquatic environment. Therefore, the development of teaching materials that discusses other biota conditions is also recommended for further research.

## CONCLUSION

Issue-based teaching materials have been developed. Based on validation result by content expert and media expert, the teaching material was valid and can implement without revision. The validation results are in line with the student's response. After that, the implementation of the teaching material on student could improve students' learning outcome, both in the aspect of mastery the concepts and problem-solving skills. However, the use of issue-based teaching materials takes a long time. Therefore, it is necessary to study the time planning at the beginning of the semester before the learning begins so that the implementation process can running well.

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