Bioedukasi
Jurnal Biologi dan Pembelajarannya
Vol. 22 No 3, October 2024, page 346-355
e-ISSN: 2580-0094; p-ISSN:1693-3931
DOI: 10.19184/bioedu.v22i3.49276
jurnal.unej.ac.id/index.php/BIOED

Development of Electronic Module Based Microalgae and Testing Water Quality in Environmental Change Material to Improve Environmental Attitudes for High School Students

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Article Info
Article history:
Accepted June 25, 2024
Revised August 21, 2024
Accepted September 30, 2024

Keywords: (AZ)
Electronic Module
Environmental Attitudes
Problem Based Learning

ABSTRACT
One of the global problems that often occurs in society is environmental pollution, one of which is water pollution. The impact of water pollution is in the form of ecosystem damage and decreased water quality. One of nature's efforts to prevent environmental pollution in waters is by having bioindicators in waters, one of which is microalgae. However, if the community is less sensitive to environmental sustainability, environmental pollution will continue to occur. Therefore, public awareness is needed to protect the environment, one way is to foster an attitude of environmental concern among high school students by creating teaching materials related to the environment. To make it easier for students to understand and use the teaching materials, teaching materials were made in the form of PBL-based electronic modules that integrate materials related to microalgae and water quality to improve the environmental concern of class X high school students in a valid, practical and effective manner. The subjects used in this study were four classes of class X students of SMAN 12 Makassar. The instrument used in this study was an environmental concern attitude questionnaire that had been validated by experts. The results of this study can be categorized as valid, practical and effective because the validity results obtained 100% from the material expert validator, 92.2% from media and teaching materials experts, and 89.3 from biology education practitioners. While for the practicality test, there are 3 categories, namely, for individual tests the results were 86.58%, small group tests of 87.42%, and field tests of 87.44%. The effectiveness test is divided into 5 tests, namely, normality test, homogeneity test, N gain test, T test and ANCOVA test, where all tests obtained the results of the electronic module effectively used as teaching materials for class X of high school. This shows that the electronic module has an influence on the environmental care attitude of high school students in class X.

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1. INTRODUCTION

The environment is a factor that directly influences the survival of humans and the organisms in them (Singh et al., 2019) . However, it is very unfortunate that over time, many cases of environmental pollution have occurred in various places. Lack of human awareness of the environment is the main factor in cases of environmental pollution. (Kaiser & Lange, 2021) . Environmental pollution does not only occur on land and air but also occurs in the aquatic environment (Peter et al. 2021). Water environmental pollution is often a problem in several regions in Indonesia (Xiao et al., 2021) . Experts say that pollutants in reservoirs can make a full contribution to the extinction of microorganisms in these waters (Halang et al., 2021) . The impact of water pollution is in the form of damage to aquatic ecosystems, extinction of organisms and microorganisms, and decreased water quality in these waters. These waters are considered less effective for local communities to use to meet their daily needs (Yan et al., 2020) .

Clean water quality is very important for people, especially those living around water environments, (Sueb & Damayanti, 2021) . According to Wang & Zhang (2020) , around 80% of the water supply used by society is obtained from water, especially fresh water environments such as rivers, lakes and reservoirs for drinking,

cooking, washing and so on. According to Zhang et al (2020) , there are differences in water quality in urban and rural areas. Water in urban areas has lower water quality than in rural areas. This happens because people in urban areas tend to have more activities than those in rural areas. Apart from that, in urban areas it is not uncommon to find many company buildings standing near bodies of water which sometimes dump their waste into these waters. One of nature's efforts to prevent environmental pollution in waters is by having bioindicators in the water (Howladar et al., 2021) .

Bioindicators can be plants, animals, plankton and others (Rani-Borges et al., 2021) . One of the living creatures most commonly found in freshwater waters is microalgae (Y. Xiao et al., 2020). Microalgae are considered one of the main producers in freshwater ecosystems (Chakraborty et al., 2020) . In general, microalgae function as effective bioindicators for assessing water quality (Peter et al., 2021) . Microalgae can also be an indicator of water quality in aquatic environments (Aldieri et al., 2020) . However, no matter how many bioindicators there are in the waters, if local communities are less sensitive to environmental sustainability, environmental pollution will still occur. Therefore, public awareness is needed to protect the environment (Soares et al., 2019).

One effort that can be made is to foster an environmentally friendly attitude among the community, one of which is among students by implementing water environmental issues in learning at school, one of which is by making teaching materials. One of the teaching materials that is considered efficient is a PBL-based electronic module in biology subjects, especially environmental change material KD 3.11 and 4.11 for class X SMA. This material can be used as a reference for developing students' environmental attitudes. The electronic module contains several environmental problems that occur around students, one of which is pollution of the aquatic environment. So that students can find out about environmental pollution around them and also know what the impacts of environmental pollution are. It is hoped that this will make students aware that around them there are environmental problems that are quite crucial and need to be resolved (Pikoli et al., 2019).

Electronic modules are said to be interactive because they are equipped with learning materials, photos and videos, apart from that there are several evaluation questions which aim to determine students' ability to understand the material being taught (Rashid et al., 2019). Teachers in developing teaching materials should adapt them to the learning model and the material to be taught, this aims to make it easier for students to understand the material presented by the teacher. It is also easier for teachers to teach because the teaching materials used are in accordance with the syntax of the learning model used. However, it is very unfortunate that there are still many teachers who do not use electronic modules as teaching materials (Hariyati & Putro, 2019) . Electronic modules are still rarely used in these schools, even though one of the advantages of electronic modules is that they make it easier for students to use them because they are practical and can be used anytime and anywhere (Anjar et al. 2020) . The learning model that is considered suitable for application to Environmental Change material is the problem-based learning model or commonly called the Problem Based Learning (PBL) model (Menrisal et al. 2019) . According to Winaya, the use of electronic modules based on the PBL learning model able to increase student motivation and learning outcomes because it can optimize students' scientific thinking processes in finding solutions to problems given by the teacher.

This research was conducted at SMAN 12 Makassar, because according to direct observations made by researchers, the location of the school is very close to one of the water environments that has a high level of pollution, namely Tunggu Pampang Reservoir. According to the results of research conducted (Nur & Hasyim, 2020) which concluded that various community activities around the reservoir plus the existence of a rubbish dump located 1 km from the reservoir were the main causes of pollution of this reservoir. Therefore, there needs to be a solution to provide understanding to the community to better protect the environment around the reservoir, so that local people can still use the reservoir water safely without polluting the reservoir. Based on the results of interviews conducted by researchers with two biology subject teachers at SMAN 12 Makassar, the results showed that environmental attitudes had never been measured in class. According to both of them, basically environmental change material is very suitable for encouraging students to be more aware of environmental problems that occur, because environmental change material is related to everyday life. Teachers need teaching materials that contain environmental problems that occur around students. Teaching materials that are considered efficient and can be used to integrate environmental knowledge are using learning modules. Because according to them the teaching materials they currently use only refer to textbooks and PPT so they are considered less effective because there are still many students who do not understand the material taught by the teacher. Students need supporting tools to optimize their understanding. These teaching materials can make it easier for students to learn online because electronic-based teaching materials are interactive (Ballesteros et al., 2021). Electronic modules are said to be interactive because they are equipped with learning materials, photos and videos, apart from that there are several evaluation questions which aim to determine students' ability to understand the material being taught (Pham, 2019). It is also easier for teachers to teach because the teaching materials used are in accordance with the syntax of the learning model used (Hariyani et al., 2021) . The aim of this research is to develop a product in the form of an electronic module based on Problem Based Learning with integrated Microalgae material and water quality to improve the environmental attitudes of class X SMA students in a valid, practical and effective manner.

2. RESEARCH METHODS

This research uses the Lee and Owens development model with quantitative methods. This study uses the Lee and Owens development model. The development model proposed by Lee & Owens consists of 4 stages of development, namely: 1) multimedia need assessment and analysis, 2) multimedia instructional design, 3) multimedia development and implementation, and 4) multimedia evaluation. This development research basically aims to produce a product that is useful for its users. The final result of this development research is a product that can be used as one of the teaching materials for high school students in grade X. The product produced is an electronic module on environmental change material based on PBL. This research was located at SMAN 12 Makassar which is located on Jl. Moha Lasuloro No. 57, Antang, Kec. Manggala, Makassar City, South Sulawesi. Before sampling, the overall report card scores of Class X as many as 6 classes were tested for normality and homogeneity first. The instruments used in this study were media expert validator instruments, material expert validator instruments, biology education expert validator instruments, environmental attitude questionnaire instruments sourced from (Milfont & Duckitt, 2010).

The product trials in this study were divided into several stages, namely one-on-one trials, small group trials, and field trials. One-on-one trials were conducted on 3 students of class XI MIPA who had taken the biology of environmental change subject. Small group trials were conducted on 9 students of class XI MIPA who had taken the biology of environmental change subject, this test was conducted to see whether the module was suitable for use or still needed to be revised. While the field trial was conducted on 26 students of class X SMA who were studying environmental change material. The field test was conducted on students of class X SMA consisting of 4 classes divided into 2 experimental classes and 2 control classes. The experimental class is a class that uses e-module products in its learning activities, while the control class is a class that uses teaching materials from teachers, namely textbooks and power point. The aim is to compare which teaching materials are more effective to use in learning and to determine the level of effectiveness of the electronic module for use by students. In addition, a syntax implementation test was also carried out which was assessed by the observer. Meanwhile, for the effectiveness of the electronic module, researchers conducted an effectiveness test which was then analyzed using the normality test (Kolmogorov-Sminorv), Homogeneity Test, T-Sample Test, N-Gain Test, and ANCOVA Test.

3. RESULTS AND DISCUSSION

The product in this research adopts the Lee and Owens development model. This electronic module was developed based on an analysis of the needs of teachers and students as well as the environmental conditions around the students. This e-module development was designed using Canva Pro, because Canva has attractive images, illustrations and animations. Next, the e-module prototype is converted into Portable Document Format (PDF) then uploaded to the FlipBuilder software or application and turns it into an attractive and interactive format that can be accessed via various devices. The e-modules created can be published in various formats, such as HTML, EXE, ZIP, and mobile formats such as APK. The composition of the e-module products developed: cover, foreword, concept map, instructions for using the e-module, introduction, material on the human reproductive system, worksheets with PBL stages, practice questions, glossary and bibliography. E-modules can be accessed online or offline using Android smartphones and laptops. Provides flexibility for students to study anywhere and anytime according to their convenience. E-module developed to help students understand environmental change material. The environmental pollution electronic module used is shown in Figure 1.

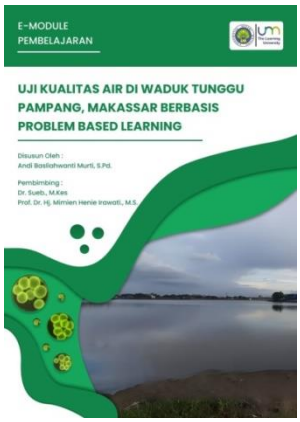

Figure 1. E-module display

Furthermore, the product that has been developed is then validated by material experts, media experts and biology education practitioners.

a. Material Expert Validation Results

Validation results are used to assess the validity of the material in the electronic module. The validation results are listed in the table below.

Table 1. Material Expert Validation Results

No	Indicator	Percentage %	Category
1.	Relevance	100	Very Valid
2.	Accuracy	100	Very Valid
3.	Serving Equipment	100	Very Valid
4.	Systematic Presentation	100	Very Valid
Average		100	Very Valid

Based on Table 1 on the indicators of relevance, accuracy of content, completeness of presentation and systematics, the average data obtained is 100% for all indicators, while the validity of data obtained from material experts is 100% for all indicators so it can be concluded that the electronic module is developed has categories. very valid. Validity is measured in the context of this research to evaluate the extent to which the E-module is accurate, appropriate, and appropriate for use in educational environments. These results show that the E-module has gone through careful evaluation and can be used as an effective learning resource (Yang et al., 2021). Therefore, it can be concluded that this E-module is declared very valid and ready to be used in the learning process.

b. Media and Teaching Material Expert Validation Results

Validation results are used to assess the validity of media and teaching materials. The validation results are listed in the table below.

Table 2. Validation Results of Media and Teaching Material Experts

Criteria	Percentage (%)	Category
Self-Instruction	4.67	Very Valid
Stand-alone	4.67	Very Valid
Adaptive	4.5	Very Valid
Easy to use	5	Very Valid
Graphics	4.25	Very Valid
Average		4.61
Percentage of Media and Teaching Material Expert Validation Results		92.2 %

Based on Table 2, in the media and teaching materials expert validation questionnaire, there are five criteria, namely self-instruction, stand-alone, adaptive, user friendly, and graphic. These five electronic module criteria obtained an average validation result of 4.61 and a percentage result of 92.2% by the media expert validator. The validation results can be categorized as very valid. So, the results of media expert validation as a whole show that electronic modules are suitable for use as student teaching materials. This is in accordance with research conducted by (Syamsussabri et al., 2019) . Based on the eligibility criteria, this aspect of the E-module can also provide good benefits by using electronic modules that are easy to understand and effective in learning. One of the module components is learning activities. A good module not only contains a collection of material, but also contains learning activities that accommodate active processes. Learning activities must be contextual to the student's environment.

c. Biology Education Practitioner Validation Results

Validation of biology education practitioners was carried out by biology subject teachers at SMAN 12 Makassar who taught in class X SMA. The assessment results can be seen in the table below.

Table 3. Biology Education Practitioner Validation Results

Criteria	Percentage (%)	Category
Software engineering	5	Very Valid
Presentation Components	4.5	Very Valid
Average	4.75	
Percentage of Biology Education Practitioner Validation Results	8.93%	

Based on Table 3, in the validation questionnaire of biology education practitioners, there are two criteria, namely software engineering and presentation components. Both criteria obtained an average value of 4.75 and a validation result percentage of 89.3% by the validator of biology education practitioners, namely biology teachers at SMAN 12 Makassar. The validation results can be categorized as valid. The overall validation results indicate that the electronic module is suitable for use as teaching materials for teachers to teach environmental change material.

d. Results of Validation of the Environmental Attitude Questionnaire

The results of the validity of the environmental attitude questionnaire which have been validated by experts can be seen in the table below.

Table 4. Validation Results of the Environmental Attitude Questionnaire

Rated aspect	Percentage (%)	Category
Material	100	Very Valid
Construction	100	Very Valid
Language	100	Very Valid
Systematic Study	100	Very Valid
Mark	100	

Based on Table 4, on the indicators of material, construction, language and systematic presentation, the average data obtained is 100% for all indicators, while the validity of data obtained from material experts is 100% for all indicators, so it can be concluded that the environmental attitude questionnaire developed has very valid category. After validation by experts, the researchers carried out a series of trials, namely one-on-one trials, small group tests, and field tests. The analysis results of the three trials can be seen in the table below.

Table 5. Product Trial Analysis Results

NO	Trials	Subject Value	Aspect			Practicality Score
			Eastern Usage	Effectiveness	Profit	
1	*One-on-one trials*	3	86.38	86.67	87.70	86.58
2	*Small group*	9	87.62	85.56	89.09	87.42
3	*Field test*	26	88.13	85.38	88.81	87.44

The development model described by describes three stages of practicality testing carried out in stages. In the first stage (one on one trial), practicality tests were carried out on 3 individual students. The results of the comments and suggestions given by students became the basis for researchers to revise the products developed. These revisions were made to ensure the product meets student needs and input. Second stage (small group), practicality test in small groups involving 9 students. The researchers used the criticism and suggestions from these 9 students to further improve the product being developed. Apart from that, this stage also serves to test the product on a slightly larger scale before proceeding to the next stage. The third stage (field test) is a practical test on a wider scale, namely field testing. At this stage, products that have been revised and improved based on input from the previous stage are tested on all class X students who are studying environmental change material or are in the experimental class. Thus, this practicality testing stage helps ensure that the product being developed is appropriate to student needs and is effectively used in a broader learning context. The results of the field practice test of the PBL E-module on environmental change material that was developed show that the E-module is included in the practicum category. This level of practicality is in accordance with the learning methods and models used in the learning process. The learning activities arranged in the E-module are designed so that they can be used by students independently, and this allows students to be actively involved in the learning process (Khoironi et al., 2019). In other words, this E-module has been proven to be practical for use in a learning environment, in accordance with the learning methods and models used. The practicality of the product in assessment development research provides great benefits both for the application and for students because it is designed systematically, especially for electronic module material (Acuña-Alonso et al., 2021). The practicality test is used to determine participants' responses to the teaching materials developed in terms of the appearance of the teaching materials, presentation of the teaching materials and their use (Herrera et al., 2021).

The next stage for researchers to carry out implementation is by testing the effectiveness of the product. Analysis of the electronic Problem Based Learning learning module which is integrated with microalgae material and water quality testing for classes. The following is a description of the effectiveness of the module on environmental attitudes.

1) Environmental Attitudes

The normality test on environmental attitude variables was analyzed using the Kolmogorov-Sminorv normality test. The following is a table of normality test results on environmental attitude variables.

Table 6. Kolmogorov-Smirnov Normality Test on Environmental Attitudes

Environmental Attitudes	Kolmogorov-Smirnov [a]		
	Statistics	df	signature.
Pretest_Control	,105	70	,055
Posttest_Control	,102	70	,067
Pretest_Experiment	,101	70	,071
Posttest_Experiment	,077	70	,200 *

Table 7. Homogeneity Test of Environmental Attitudes

Environmental Attitudes	Levene Statistics	df1	df2	signature.
Based on Average	3,603	1	138	,060
Based on Median	3,671	1	138	,057
Based on Median and with adjusted df	3,671	1	129,198	,058
Based on trimmed mean	3,590	1	138	,060

Based on the data output from the analysis of the normality test and homogeneity test, a value of sig>0.05 was obtained in the normality test, so the decision was that the data was normally distributed. Decision making in the homogeneity test is if Sig. Based on Mean > 0.05, the data is declared homogeneous. Data from homogeneity test analysis shows a significance value of 0.587 > 0.05 so it is declared homogeneous. Next, to determine the effectiveness of the experimental class and control class, an N-Gain test was carried out. The following are the results of N-Gain data analysis using the formula in Table 4.9.

Table 8. Results of Analysis of the N-Gain Value Test for Environmental Attitudes

No	Class	Score N- Gain	Criteria
1	Test	0.57	Effective enough
2	Control	0.30	Low-medium

To test the effectiveness of the E-module in measuring environmental knowledge, the N-Gain test can be used. This test was carried out to determine the increase in students' environmental knowledge after being given treatment. The data needed is the score (pretest and posttest). The results of the N-Gain test analysis mean the experimental class value is 0.57 according to the classification, namely being in the criteria of being quite effective. Meanwhile, for the control class it was 0.30, which according to its classification was in the low-medium criteria. The use of e-modules is quite effective when used in learning activities and is able to increase students' environmental knowledge. Meanwhile, learning activities without using e-modules have a low to medium classification. Using e-modules is more effective than without using e-modules.

Table 9. Paired Sample Test of Environmental Attitudes

Paired Sample Test								
Environmental Attitudes	Pair Differences					Q	df	signature. (2-tail)
	Means	Std. Deviation	Std. Meaning of Error	95% Confidence Interval of the Difference				
				Lower	On			
Postest_Control - Postest_Experiment	-,29257	2.59707	,31041	-,91182	,32668	-,943	69	,349

Based on the paired T test, it is known that the p value (2-tailed) is 0.349 > 0.05, which means there is no significant difference between the pretest and posttest. This shows that there is no significant influence on the differences in treatment given to both the control and experimental classes.

Table 10. ANCOVA Test Analysis Results for Environmental Attitudes

Source	Type III Sum of Squares	df	Means Square	F	signature.	Partial Eta Squared
Corrected Model	3,191 [a]	2	1,595	,190	,827	,003
Intercept	3228.409	1	3228.409	384,005	,000	,737
Prates	,195	1	,195	,023	,879	,000
Treatment	3,014	1	3,014	,358	,550	,003
Error	1151,788	137	8,407			
Total	880468,599	140				
Corrected Amount	1154.979	139				

The results of the analysis show that there is a real influence on environmental attitude scores, between classes that use electronic modules and those that do not use electronic modules. The results of the table above in the corrected model show a significant number of 0.003, which means Ho is rejected because the significance is smaller than 0.05, which means it can be concluded that there is an influence on students' environmental attitudes towards classes that use electronic modules. This is supported by research that classes that use the ecosystem module have better environmental insight and environmental attitudes than classes that do not use the module (Sueb et al., 2021) . Research conducted by (Zafar et al., 2021) shows that the role of online-based media has a positive influence on a person's attitudes and responsibilities towards their environment (Zafar et al., 2021) . Several schools in the world are trying to improve environmental attitudes in their students by maximizing environmental curricula and increasing environmental knowledge (Qian et al., 2021) because this not only has a positive impact on schools but also better attitudes towards the environment (Robina-Ramírez & Medina - Merodio, 2019) .

4. CONCLUSION

The development of an electronic module based on Problem Based Learning which integrates microalgae and water quality testing in environmental change material to improve the environmental attitudes of high school students in this development research has been valid and very practical to use after being tested by expert validators. The development of an electronic module based on Problem Based Learning which integrates microalgae and water quality testing in environmental change material in this development research has been effective in improving environmental attitudes towards the environment in class X SMA. This was proven after testing at SMAN 12 Makassar.

5. ACKNOWLEDGEMENT

The author would like to thank the lecturers who were willing to become media and teaching material expert validators as well as material expert validators in this research. The author also would like to thank the students and biology teachers at SMAN 12 Makassar who were willing to be subjects in this research. research. Thank you also to the lecturers who participated and directed the author in writing this article.

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