Environmental Chemistry Modules Development to Enhance Students' Creative Thinking Abilities in Heavy Metal Water Pollution Materials

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ABSTRACT

Development of teaching material based on laboratory research is one way that can be done to improve students' creative thinking abilities in meeting the challenges of 21st century learning. The aims of this study were to determine the feasibility of the developed environmental chemistry modules, to improve of students' thinking abilities and determine the students' responses to the use of modules in environmental chemistry lectures. Module development by R and D methods 4D model, namely Define, Design, Develop and Disseminate. Module quality is determined by expert validation test. Based on the results of expert validation, the module developed obtained 90.91% percentage of eligibility with a very good category. Based on the N-Gain value obtained, an increase in students' creative thinking abilities on the aspect of flexibility was 0.47, and the aspect of elaboration was 0.64 with medium category. The student responses to the use of modules in learning environmental chemistry obtained a percentage of 83.82% with very good category.

Keywords: R and D 4D models; Module; creative thinking.

INTRODUCTION

Chemistry is a knowledge obtained and developed based on experimental results. In the process of learning chemistry involves skills and reasoning, because learning chemistry is closely related to natural phenomena and has a role in everyday life and the development of Science and Technology. Environmental chemistry is one part of chemistry which is a compulsory course for students of the Chemistry Education Program Faculty of Teacher Training and Education University of Bengkulu. Based on the results of interviews with lecturers of environmental chemistry courses, it is known that one of the materials that is difficult for students to understand is heavy metal water pollution. This material demands the ability to understand heavy metal analysis and the results of research about heavy metal analysis in the environmental water samples. Efforts to increase student creativity are needed to be able to understand this problem by orienting on improving students' creative thinking abilities (Agustina and Novita, 2012). the improvements of creative thinking abilities is one of the demands of 21st century learning. The development of teaching materials based on laboratory research is one way that can be used to improve the creative thinking abilities (Sener et al., 2015).

Teaching material is an important part of the learning process because teaching material is a learning resource that contains learning materials and messages, which can be utilized for the benefit of learning to achieve learning objectives (Mulyasa, 2006). One of the teaching materials that can be developed is a module. The module is a complete unit that stands alone and consists of a series of learning activities arranged to help students learn independently in achieving goals

that are specifically formulated and clear. Modules from the results of research in the laboratory and field can be used as a learning resource that is expected to improve students' creative thinking abilities in the challenges of 21st century learning. The use of modules in learning from several previous studies has shown that the use of modules can improve the students' creative thinking abilities (Suryadi, 2018; Festiana, 2014), improve critical thinking skills (Wahyunarti, 2018), develop science process skills, thinking skills and scientific literacy abilities (Wahyono et al., 2014). The use of environmental chemistry modules that contain water pollution by heavy metals in environmental chemistry courses at the University of Bengkulu has not been found.

Based on the description, researchers are interested to developing environmental chemistry modules based on laboratory research to improve students' creative thinking abilities in the material of water pollution by heavy metals.

METHODS

Time and Place of Research

This research was conducted in March to October 2019 at the chemistry education students University of Bengkulu in environmental chemistry courses.

The type of research is a development research with the method of Research and Development (R and D) 4-D models, namely Define, Design, Develop and Disseminate

Define

In the define stage, an initial analysis is carried out to obtain the information needed in the research process. Initial analysis included syllabus analysis, student analysis, module needs analysis, interviews with lecturers in environmental chemistry courses. Retrieval of laboratory research data about the analysis of heavy metals in waters for module development materials is also carried out at this stage. At this stage, information and needs related to research tools were also collected, such as validation instruments, creative thinking instruments and student response instruments.

Design

At the design stage, module design is carried out. The module was developed based on the results of laboratory research on the analysis of heavy metals in waters. Module material development refers to the basic competencies and indicators to be achieved. Modules are designed to help students improve their creative thinking abilities by containing creative thinking stimuli that are systematically and attractively packaged. At the design stage, a test instrument was also made to determine the students creative thinking abilities according to the development of the rubric of creative thinking on aspects of fluency, flexible thinking, and elaboration.

Develop

At this stage a feasibility test is carried out on the modules and research instruments that have been made. The feasibility test conducted is logical validity, which is an instrument that shows the conditions of meeting the validity requirements based on expert judgment consisting of at least 3 suitable experts (Arikunto, 2009). The results of the feasibility test serve as a reference for revising or improving teaching materials and test instruments. At this stage also carried out a small-scale test on students who have passed environmental chemistry courses to determine the validity, reliability, level of difficulty and distinguishing features of the items.

Disseminate

The disseminate of environmental chemistry modules is carried out to determine the effect of the use of modules on students' creative thinking abilities. The test was conducted on chemistry education students in the 5th semester in the environmental chemistry course in the subject of water pollution by heavy metals. The test conducted was One group pretest-posttest. The effect of the use of modules on students' creative thinking abilities is seen from the results of the

pretest and posttest on aspects of fluency, flexible thinking, and elaboration.

RESULT AND DISCUSSION

Define

Based on the results of preliminary analysis such as syllabus analysis, student analysis, interviews with lecturers supporting environmental chemistry courses it is known that in environmental chemistry lectures required the development of teaching materials that can help students learn independently to meet the challenges of 21st century learning. Teaching materials that can be developed from laboratory research regarding water pollution by heavy metals is a module. The modules developed are used to improve students' creative thinking abilities.

Design

Product design is a follow up of the results of the analysis of the needs of environmental chemistry teaching materials. Module material development refers to mapping competency standards in accordance with basic competencies and indicators to be achieved. The design modules designed are shown in table 1.

Table 1. Module design

Module Section	Module Contents
Introduction	Cover Foreword Table of contents List of Figures
Content Section	Background Competency standards Learning objectives Lesson plan Material description Summary Stimulus list think creatively
Closing Section	Evaluation Follow-up Hope References Glossary

Develop

Validation test results from the assessment of 3 experts are shown in Table 2. The module assessment results are said to be feasible or valid if obtaining a feasibility result > 75% (Akbar, 2013). Based on table 2 it can be concluded that the environmental chemistry module developed is declared valid / feasible as teaching material that can be implemented in learning environmental chemistry.

Table 2. Hasil uji validasi modul

Assessment Aspects	Assessment Result	Eligibility Category
Content eligibility aspects	89.70%	Valid/feasible
Aspect of presentation eligibility	90.67%	Valid/feasible
Aspects of language assessment	93.33%	Valid/feasible
Overall assessment	90.91%	Valid/feasible

The results of the validation of the questions based on expert judgment are shown in Table 3.

Table 3. Validation test results

Q Question Number	Validation Results			Sum	%	Eligibility category
	V1	V2	V3			
1	5	3	5	13	86.67	Very Valid
2	4	3	5	12	80	Valid
3	5	5	4	14	93.33	Very Valid
4	5	4	5	14	93.33	Very Valid
5	5	4	5	14	93.33	Very Valid

Based on table 3 obtained the results of the validation test questions by expert judgment. Questions number 1, 3, 4 and 5 get results in the very valid category, while question number 2 gets results in the valid category. These results state that the questions made are feasible to be implemented as a form of test for the use of the developed module teaching materials.

Small-scale tests are conducted on students who have passed environmental chemistry

courses. The purpose of this trial is to determine the level of validity of test items, reliability, level of difficulty, and different power. The results of small-scale trials can be seen in the table below.

Table 4. The results of the validity test items, reliability, level of difficulty and different power

Question Number	%	Correlation	Sign. Correlation
1	66.67	0.584	Significant
2	83.33	0.702	Significant
3	66.67	0.682	Significant
4	80.00	0.738	Very Significant
5	66.67	0.594	Significant
Mean =12.20	Standard deviation =2.94	Reliability Test = 0.88	Number of Subjects = 10

Based on the table 4, it can be observed that questions number 1-5 are declared valid with significant criteria for numbers 1, 2, 3 and 5 while questions number 4 with very significant criteria. The power of distinguishing questions in the category both for questions number 1, 3 and 5 while for questions number 2 and 4 in the category is very good. Difficulty level of questions number 1-5 are in the medium category and test questions have very good reliability (high) in the amount of 0.88.

Disseminate

The distribution was carried out at the chemistry education students University of Bengkulu in the 5th semester with 24 students. The implementation of this deployment aims to determine the effect of the use of environmental chemistry modules developed on students' creative thinking abilities. Based on the One group pretest-posttest test conducted obtained the results of the distribution of pretest and posttest values are shown in Figure 2 and 3.

Based on Figure 1 it is known that the results of the pretest on the aspect of flexibility as many values appear at intervals of 20-27 were 13 students. In the aspect of elaboration, the most grades appear in the range of 60-67 as many as 12 students. The results obtained indicate that the aspects of flexible thinking are low with an average of 33.33. In this aspect of flexibility, students are required to be able to change their perspective or approach with similar results, and this ability has not yet appeared in the student's initial test so that the ability of apek flexibility is still very low. In the aspect of elaboration having a slightly better data distribution, although the value in this aspect is also still in the low category with an average of 54.17. Overall pretest results are still relatively low, meaning that action is needed to stimulate students' creative thinking abilities. The use of modules that have been developed are expected to help stimulate students' creative thinking abilities.

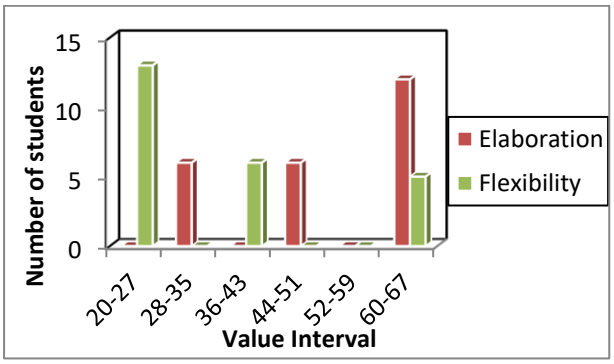

Figure 1. Distribution of creative thinking at the pretest

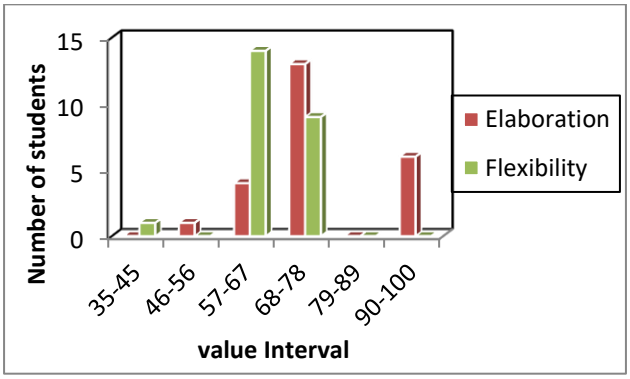

Figure 2. Distribution of creative thinking at the posttest

Based on Figure 2 it is known that the results of the posttest on the aspect of flexibility as many values appear at intervals of 57-67 as many as 14 students and on the aspect of elaboration the most grades appear in the range of 68-78 as many as 13 students. The posttest data distribution results obtained show that students' creative thinking abilities are generally good in the aspect of elaboration and in the aspect of flexibility. The results obtained indicate an increase after the implementation of learning

using module teaching materials developed. This means that the stimulus of creative thinking ability contained in the module can help students improve their creative thinking abilities.

The improvement of students' creative thinking ability in the pretest and posttest is contained in Figure 3 below:

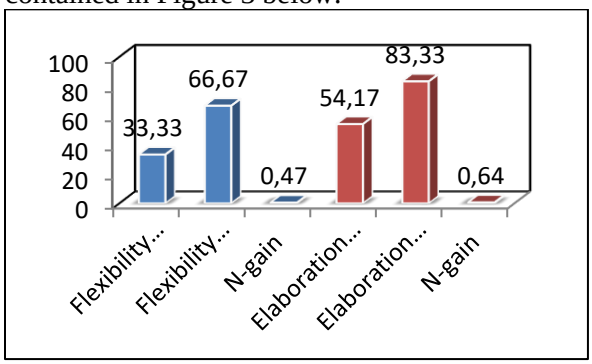

Figure 3. Increasing students' creative thinking abilities

Based on picture 3 can be seen an increase in the creative thinking abilities. Increased creative thinking abilities is expressed in the form of N-Gain values. Gain Normality Test (N-gain) is a test that can be used to provide a general description of an increase in learning outcome scores between before and after the application of a particular method or treatment in research. Based on the results of increasing students' creative thinking abilities, it is known that the best improvement occurs in the aspect of elaboration with an N-Gain value of 0.64. This means that the stimulus contained in the module can effectively assist students in enriching, detailing and expanding an idea. In the aspect of flexibility, there is an increase in the value of N-Gain 0.47. This result also belongs to the medium category, meaning that the stimulus in the module can help students change their perspective / approach with similar results to the given problem. In general, the N-Gain value obtained is in the medium category. The value of N-Gain in the range of values is $0.30 \leq$ N-Gain ≤ 0.70 in the medium category (Hake dan Reece, 1999).

Student responses to learning using module teaching materials are determined based on the questionnaire response. The questionnaire used was a closed questionnaire, a questionnaire that was available with question items with a predetermined score range. Students only need to determine the response to each question item by checking the choice in the range of scores with predetermined criteria. The use of this questionnaire aims to determine the response and response of students to the use of module teaching materials in the learning of environmental chemistry of water pollution material by heavy metals. The results obtained are contained in the following table.

Table 5. Student response results

Assessment Aspects	Percentage	Response Category
Student responses to the use of module teaching materials	83.82%	Very good

Based on table 5 it can be observed the results of the questionnaire assessment analysis by 24 students involved in the learning process. Student responses to the use of module teaching materials in the study of environmental chemistry of water pollution material by heavy metals were obtained at a percentage of 83.82% with a very good category. The results obtained indicate that students' positive responses to the use of module teaching materials in learning environmental chemistry. Students gain a pleasant learning experience and can help in understanding the chemistry of the environment in the material of water pollution by heavy metals and are able to stimulate students' creative thinking abilities to be better. The creative thinking stimulus contained in the module can help students improve their creative thinking abilities. In addition, students also considered that the module teaching materials used had very good criteria and were worthy of being used as good learning resources in developing creative thinking abilities for students.

The hypothesis test conducted is the Paired-Samples T Test which aims to find out whether there are differences in the average of two samples (two groups) that are paired or related. Paired samples come from the same subject, each variable is taken when the situation and circumstances differ according to the treatment to be carried out in the research process. In this study

a hypothesis test was conducted to determine the effect of the use of the environmental chemistry module "Digital Image as an Alternative Method of Quantitative Heavy Metal Analysis" on improving students' creative thinking abilities. Paired-Samples T Test is part of the parametric statistical analysis. Therefore, as a basic rule in parametric statistical analysis the main requirement is that research data must be normally distributed. Based on the results of the normality test with the Kolmogorov-Smirnov One-Sample Test analysis, the Pretest value obtained an Asymp. sig value (2-tailed) = 0.100. This value ≥ α (0.05) concluded that the pretest data were normally distributed. In the posttest value obtained Asymp. sig value (2-tailed) = 0.200. This value is ≥ α (0.05) so it can be concluded that the posttest data is normally distributed. Based on the results of the Paired Samples Hypothesis T Test, the Sig (2-tailed) = 0,000 was obtained, this value <α (0.05), then H0 was rejected and Ha was accepted. Therefore, there is a difference in the value of the pretest and posttest after the treatment using the module.

CONCLUSION

Based on the results of expert validation, the module developed obtained 90.91% eligibility results with very good category. The use of modules can improve students' creative thinking abilities in the aspect of elaboration from an average pretest value of 54.17 up at posttest to 83.33 with an N-Gain value of 0.64 and in the aspect of flexibility from an average pretest value of 33.33 rising at posttest becomes 66.67 with an N-Gain value of 0.47. The increase in creative thinking is in the medium category. Student responses to the use of module teaching materials in the study of environmental chemistry of water pollution material by heavy metals obtained 83.54% with very good category.

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