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Feasibility of STEM-based basic chemistry teaching materials to improve students' science literature in wetland context

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Feasibility of STEM-based basic chemistry teaching materials to improve students' science literature in wetland context

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Abstract. Development research has been carried out to produce teaching materials for basic chemistry learning materials based on STEM in a wetland context to improve scientific literacy that is valid, practical, and effective. This type of research is Research and Development (R & R&D) with a 4D development model modified into 3D (define, design, and develop). The trial of the developed teaching materials was carried out in a class in the first Basic Chemistry course consisting of 28 students. Data collection techniques used validation sheets, readability questionnaires, response questionnaires, observation sheets, and scientific literacy tests. Data analysis used descriptive analysis. The results showed that the developed teaching materials had met the following criteria: (1) Valid; judging from the value of the feasibility aspects of content, presentation, language, and media, each of which obtained very valid criteria. (2) Practical; reviewed from the results of the readability of teaching materials in individual and small group tests, the criteria are practical and very practical. Students' responses to teaching materials have very practical criteria, and observations of the ability of teachers to use teaching materials and manage their respective classes get very good criteria. (3) Effective, seen from the results of the N-gain scientific literacy showing a high increase. With the results of this development, it can be said that the STEM-based teaching materials for basic chemistry learning to improve scientific literacy in the context of wetlands are suitable as teaching materials.

1. Introduction

The country of Indonesia has entered the 21st century, marked by the increasing demand for high-quality human resources. Besides being required to master the knowledge to be taught, a prospective teacher is also required to have a set of knowledge and technical teaching skills.

Based on research results from the Program for International Student Assessment (PISA), it shows that the scientific literacy ability of Indonesian students is generally below the average compared to the international average score [1]. Therefore, for prospective teacher students, it is crucial to have high scientific literacy skills so that later they will improve students' scientific literacy skills.

The selection of appropriate models and approaches in learning can improve scientific literacy skills and student learning outcomes. The model and approach chosen is a project-based learning model with a STEM approach. The project-based learning model is innovative, encouraging students collaboratively to research and create projects that apply their knowledge of discovering new things, proficient in the use of technology, and able to solve real-world problems [2]. The STEM approach combines art with STEM subjects to increase student engagement, creativity, innovation, problem-solving skills, and other cognitive benefits [3].

The use of learning teaching materials used for direct student involvement will be interesting and increase the success of a learning process, especially the influence of technological developments. Teaching materials are often developed in the form of e-modules or electronic modules. One of the applications made is flipbook-based, where it looks like a digital book that looks interesting and more motivated.

Objects that are used as problems in each learning material can be sourced from the environment around students. One of them stems from the issue of the wetland context, which is a large area of land owned by South Kalimantan [4]. One part of the branch of chemistry that can directly contact the wetland environment is the sub-material of learning basic chemistry, namely acids and bases, and colloids. Based on this explanation, researchers are interested in developing teaching materials for basic chemistry learning based on a project-based learning model with a STEM approach to improving scientific literacy and student learning outcomes in the context of wetlands.

2. Method

This Research and Development (R&D) uses a model 4D development of 3D modification, namely define, design, and development [5]. The research procedure can be seen in Figure 1 below.

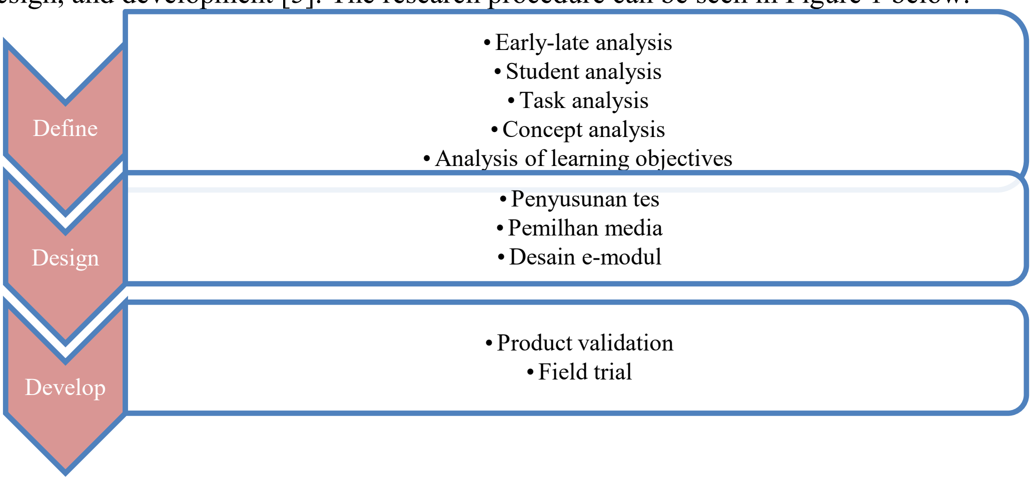

Figure 1 A Model 4D Development of 3D Modification

The dissemination stage was not carried out because the research time was close to the end of the even semester of the 2020/2021 academic year, so there was insufficient time. The research was carried out at the Chemical Education Study Program FKIP ULM Banjarmasin for second-semester students of class A2 for the academic year 2020/2021 for individual and small group trials and semester two students of class A1 for the academic year 2020/2021 for limited trials.

Data collection techniques are carried out through non-test instruments, including validation questionnaires, readability questionnaires, student response questionnaires, observation sheets on the ability of lecturers to use teaching materials and manage classes. Then, the test instruments in the form of objective questions and essays to measure students' scientific literacy skills were given before and after treatment.

Data analysis used descriptive analysis. Determination of the percentage value (P) in the validity and effectiveness test using the following formula.

$$Percentage\ value\ (P) = \frac{Total\ score\ given}{Overall\ score}\ x\ 100\%$$

The results obtained for the validity test are interpreted in Table 1 with the following criteria.

Table 1 Criteria for the validity of teaching materials [6]

No	Percentage value	Validity criteria	Information
1	85.01 – 100.00	Very valid	No need to revise
2	70.01 – 85.00	Valid	No need to revise
3	50.01 – 70.00	Less valid	Minor revision
4	1.00 – 50.00	Invalid	Major revision

The average score obtained for the practicality test is interpreted in Table 2 below.

Table 2 Criteria for the practicality of teaching materials [7]

No	Average score $\bar{x}$	Criteria
1	$\bar{x}$ > 3.25 – 4.00	Very practical
2	$\bar{x}$ > 2.50 – 3.25	Practical
3	$\bar{x}$ > 1.75 – 2.50	Less practical
4	$\bar{x}$ > 1.00 – 1.75	Not practical

The results obtained for the effectiveness test regarding scientific literacy skills are interpreted in Table 3 below.

Table 3 Criteria for scientific literacy ability [8]

No	Percentage value	Criteria
1	86.00 – 100.00	Very high
2	72.00 – 85.00	High
3	58.00 – 71.00	Medium
4	44.00 – 57.00	Low
5	0.00 – 43.00	Very low

3. Results and Discussion

Teaching materials developed using 3D model stages are presented as follows.

3.1 Define

3.1.1 Early-late analysis

The final preliminary analysis was carried out through field studies and literature studies aimed to discover the fundamental problems students face in learning related to acid-base and colloidal materials. It found out the difficulty of students understanding the material due to the lack of attractive teaching materials available.

3.1.2 Student analysis

Student analysis includes an analysis of students' academic ability and motivation, which aims to examine the characteristics of students in line with the design to be developed, such as students having the ability to do their projects and having adequate facilities to use smartphones devices.

3.1.3 Task analysis

Task analysis aims to thoroughly examine what tasks students will carry out through the developed teaching materials. Task analysis includes lessons that train students' scientific literacy skills in a wetland context.

3.1.4 Concept analysis

Concept analysis aims to identify concepts and determine the content of the teaching materials that are developed and then presented in a concept map.

3.1.5 Analysis of learning objectives

Analysis of learning objectives is made by adjusting existing tasks and concepts and then connecting them with the behavior of the subject to be achieved, namely increasing students' scientific literacy.

3.2 Design

3.2.1 Test preparation

The preparation of the test is the stage of preparing essay questions for scientific literacy instruments.

3.2.2 Media preparation
The media used as a medium for making teaching materials is a flipbook, where previously, the initial file form of teaching materials was in pdf form. Then converted into the form of a digital book with the addition of an attractive display and symbols.
3.2.3 Formatting
The choice of format includes selecting material content, strategies, learning methods, and learning models in the teaching materials.
3.2.4 Preliminary design
This stage is the first design carried out to design the developed e-module.

3.3 Develop
3.3.1 Product validation by experts
The validity test aims to determine the level of product validity, which is measured based on the assessment of the validator consisting of 3 lecturers of Chemistry Education FKIP ULM Banjarmasin as material experts and one education practitioner FKIP ULM Banjarmasin as media experts. The results of the assessment of the validators are shown in Figure 2 below.

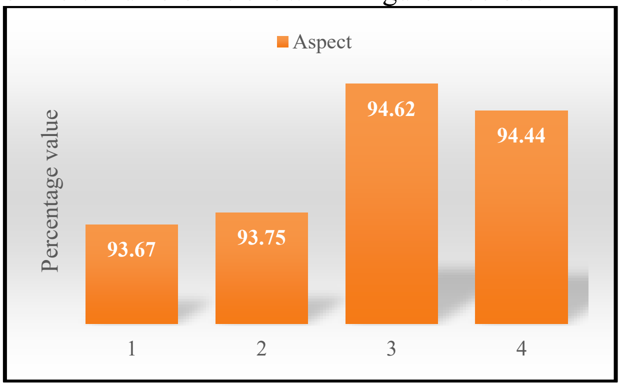

Figure 2 The results of the validation test of the feasibility of teaching materials

Based on Figure 2, it is known that the percentage scores for all aspects of the feasibility of teaching materials get high scores with very valid criteria. The content aspect gets a percentage value of 93.67% because the teaching materials have presented appropriate and accurate material content and have other supporters to clarify the material. The material content is proven to be up-to-date. The presentation aspect gets a percentage value of 93.75% because the teaching materials have been prepared with good presentation techniques and other supports. The form of learning encourages students to be interactive and participative, and teaching materials are arranged according to the rules, consisting of an introduction, content, and cover. The language aspect obtained a percentage value of 94.62% because the teaching materials had been presented in a language that was straightforward, communicative, dialogical, interactive, in accordance with the intellectual development and social, emotional level of students, coherent and integrated, as well as the consistent use of terms, symbols or icons. The media aspect gets a percentage value of 94.44% because the teaching materials have presented an attractive appearance and content and are in accordance with the characteristics of teaching material.

3.3.2 Product validation by experts
Field trials include individual, small group, and limited trials. Individual and small group trials were conducted to determine the practicality of teaching materials in terms of the readability questionnaire of teaching materials. The average score of the readability questionnaire for individual and small group trials is shown in Figure 3 below.

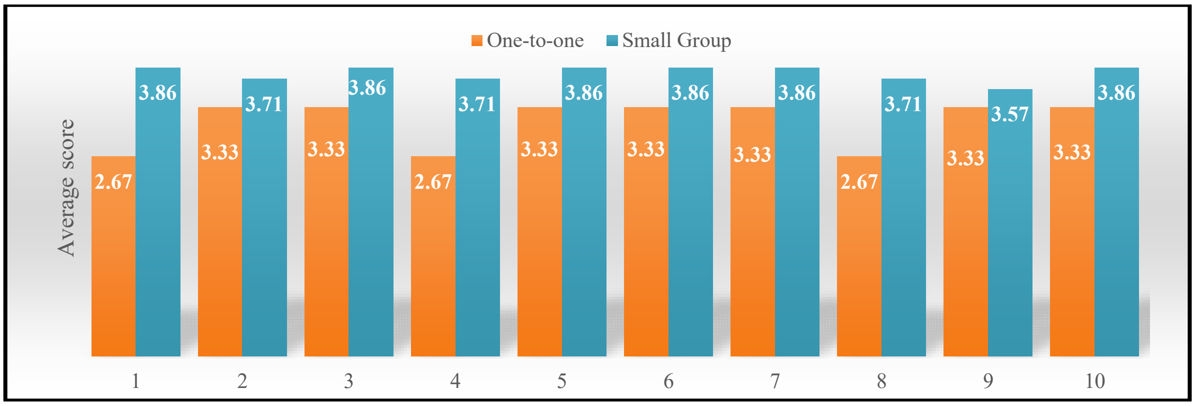

Figure 3 Average score of the readability questionnaire of the one-to-one and small group

Based on Figure 3, it is known that almost all readability statements obtained an average score in very practical criteria in individual trials although statement 1 (cover design), statement 4 (display color combinations), and statement 8 (ease of understanding the material) obtained practical criteria. Therefore, before being retested in the small group trial, revisions were made by changing the cover design, changing color combinations for display, and adding videos to clarify the material's content. Hence, in the small group trial, all the readability statements obtained an average score in very practical criteria. Choosing a harmonious and attractive color combination can provide a special attraction for students, and another purpose of this visual display is to facilitate the delivery of messages [9]. Then, the role of video in learning is a medium for demonstrating several material concepts, helping stimulate student curiosity about the chemical material to be studied and increasing student interest in learning.

The assessment of the readability of teaching materials is based on several things, such as the number of clear and not blurry images found to clarify the material's content. As revealed by Amir [10], that with the help of pictures helps facilitate the learning process and the achievement of learning objectives. Writing sentences in teaching materials are easy to understand because there is no misinterpretation due to wrong writing. Arizona [11] revealed that if there are spelling errors and improper use of punctuation in writing, then the meaning of the writing can be different from the intent or purpose, causing sentences to be challenging to understand. Teaching materials contain quiz time and formative tests that are easy for students to understand and answer to increase their understanding and motivation to learn. Puryati [12] stated that when students can answer practice questions, a sense of satisfaction will arise and make them more successful in their studies.

Limited trials were conducted to determine the practicality and effectiveness of teaching materials. The practicality of teaching materials is viewed from student response questionnaires and observation sheets on lecturers' ability to use teaching materials and manage classes. Meanwhile, the effectiveness of teaching materials is viewed from the scientific literacy ability of students. The average score for student responses is shown in Figure 4 below.

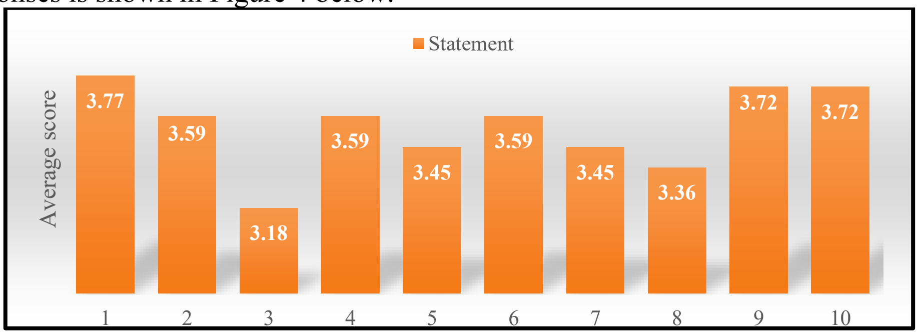

Figure 4 Average student response scores

Based on Figure 4, it is known that almost all statements obtained an average score in very practical criteria, except for statement 3 regarding the ease of solving acid-base and colloid problems which got practical criteria. The use of teaching materials can increase students' willingness to take part in learning. Zaharah & Susilowati [13] stated that learning using electronic modules could improve student learning motivation. The preparation of teaching materials using communicative language makes it easier for students to understand the material's content. The teaching materials themselves have implemented a project-based learning model syntax with a STEM approach not to cause students to feel bored during learning. As revealed by Rozikin., Lesmono., & Bachtiar [14], it is stated that through the application of the project-based learning model, it has a significant influence on interest in learning. One of which is marked by students' attitude being more concentrated and attentive when participating in learning because they feel they have a vital role in learning, especially related to doing projects with a STEM approach.

The use of teaching materials encourages students to learn independently. As stated by Setiyadi., Ismail., & Gani [15], teaching materials have self-instruction properties characterized by the presence of several command sentences that are easy to understand. There are practice questions, a summary of the material, and the contents of learning materials packaged in small units, making it easier to study thoroughly. The use of these teaching materials makes students happy to learn acid-base and colloid materials included in basic chemistry because they discuss the interrelationships of everyday life in the context of a wetland. As stated by Yildiz & Baltaci [16], contextual learning is more interesting for students because it has a connection to the experiences they have experienced.

The teacher's ability to use teaching materials is seen from the assessment of 3 observers based on three indicators: instructions for teaching materials, their contents, and ease of use. The average score for each indicator of the ability of teachers to use teaching materials is shown in Figure 5 below.

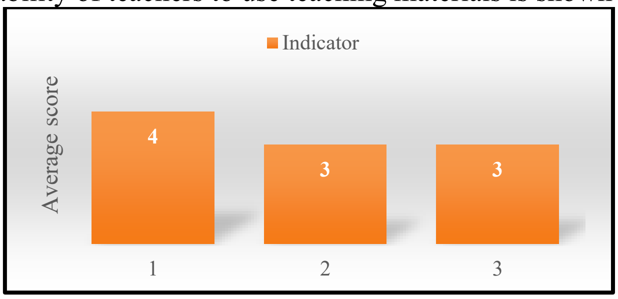

Figure 5 Average score indicator of the ability of lecturers to use teaching materials

Based on Figure 5, it is known that the indicator indicators obtain very practical criteria. Examples of use accompany instructions delivered by the teacher. Providing optimal direction and guidance from the teacher will make students use their potential in participating in the lecture process [17]. Content indicators and ease of use obtain practical criteria. The teacher shares the link for teaching materials through the WhatsApp group, then conveys the critical points of the subject matter in the teaching material so that later students can independently learn more about the material's content. As Johanes [18] stated, the lecturer is to act as a facilitator so that there is no need to intervene too deeply and does not take away the students' right to learn in the true sense.

The ability of the lecturer to manage the class is seen from the assessment of 3 observers based on four dimensions, namely introduction, core, closing, and time allocation. The average score obtained from the statement of the ability of the teacher to manage the class is shown in Figure 6 below.

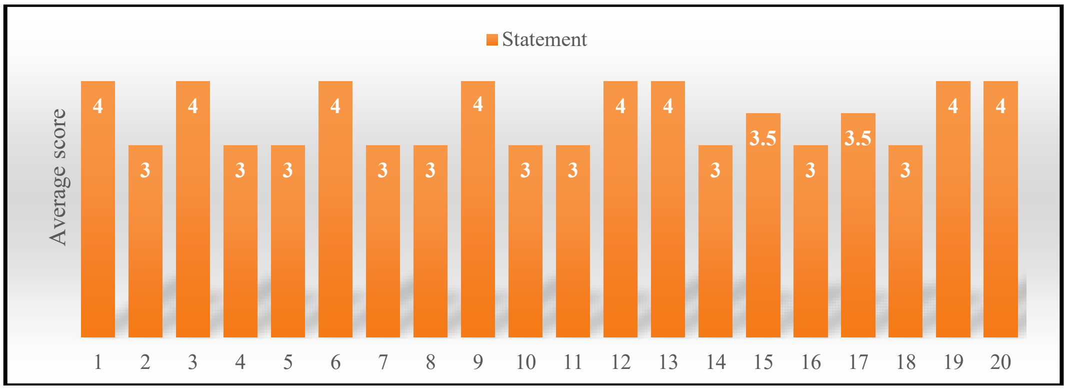

Figure 6 Average score of the statement of the ability of the teacher to manage the class

Based on Figure 6, it is known that the preliminary dimensions in statement 1 obtain very practical criteria. Before entering the core of learning, the teacher instructs the students to open the teaching materials that have been distributed. The core dimensions in statements 2 to 18 have very practical criteria. In this dimension, the stage of running the syntax of the project-based learning model with the STEM approach. According to Hendra., Arsa., & Krisnawati [19], the project-based learning model is meaningful learning that brings students to an impressive learning experience.

Moreover, the experience was obtained from problems in the context of wetlands. The closing dimension in statement 19 has very practical criteria. In this dimension, the learning process is closed with students making conclusions. According to Rahmawaty., Nurhayati., & Arsyad [20], learning with self-discovery of concepts and meaning can better understand concepts and student retention at the end of learning. The dimension of time allocation in statement 20 obtains very practical criteria. The time allocation is carried out in accordance with the RPP that has been made. Yatmini [21] revealed that RPP is an absolute requirement for the implementation of a conducive learning process.

The effectiveness of teaching materials in students' scientific literacy ability is seen from the N-gain obtained. The results of the N-gain of students' scientific literacy abilities are shown in Figure 7 below.

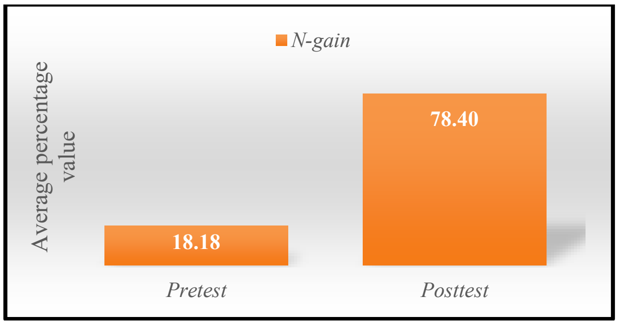

Figure 7 Average percentage of pretest and posttest scores of students' scientific literacy skills

Based on Figure 7, it is known that the average posttest result is higher than the pretest; this is because the posttest has used teaching materials based on a project-based learning model with a STEM approach during learning. As revealed by Khotimah., Suhirman., & Raehanah [22], using the project-based learning model can improve students' scientific literacy skills. It is also supported by the research results of Rusyati., Permanasari., & Ardianto [23] that through learning with the STEM approach, students can train students' scientific literacy skills. The application of the project-based learning model prepares students to solve problems through the stages of searching, analyzing, and synthesizing results that will be conveyed to other students. As revealed by Wulandari [24], through the application of the project-based learning model, students will explore, assess, interpret, and synthesize to produce various forms of learning outcomes. The application of the STEM approach trains students to build their knowledge in the scientific method. As revealed by Munawar., Roshayanti., & Sugiyanti [25], the STEM approach is seen as an approach that can encourage students to develop curiosity so that they can build knowledge by exploring, observing, discovering, and investigating how something happened. Through the implementation of this student-centered learning pattern, they can increase their learning activities [26].

4. Conclusion

Based on the results of discussion, it can be concluded that basic chemistry learning teaching materials for acid-base and colloid materials based on STEM integrated project-based learning models to improve scientific literacy in the context of developed wetlands are feasible because of: (a) Obtaining very valid criteria for use in learning with a score of 93.67% (very valid) in the aspect of content validity; 93.75% (very valid) on the aspect of the validity of the presentation; 94.62% (very valid) on the aspect of language validity; and 94.44% (very valid) on the media validity aspect; (b) Obtaining practical criteria because the average score on the individual test is 3.20 (practical), small group test is 3.68 (very practical), student response questionnaires are 3.54 (very practical), lecturers' ability observation sheets use e -module is 3.33 (very practical), and the observation sheet on the ability of e-module to manage class is 3.45 (very practical); (c) Obtaining effective criteria can contribute to a high increase in student scientific literacy results in the limited trial class, as seen from the N-gain value between pretest and posttest, namely 0.75 and 0.79, respectively.

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