Development of e-modules colloid materials based on PjBL-STEM to improve scientific literature and student learning outcomes of wetlands context

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Abstract. Development research has been carried out that aims to produce an e-module, a valid, practical, and effective STEAM-PjBL approach on colloidal material. This type of research is Research and Development (R&D) with a 4D development model modified into 3D (define, design, development). The e-module trial was carried out in the School Chemistry 2 class, which consisted of 22 students. Data collection techniques used validation sheets, readability questionnaires, response questionnaires, observation sheets, scientific literacy tests, and learning outcomes tests. Data analysis used descriptive analysis. The study results indicate that the developed e-module has met the following criteria: (1) Validity, judging from the value of the module feasibility aspects, has very valid criteria. (2) Practicality, seen from the readability results of e-modules on individual and small group tests obtaining practical and very practical criteria, student responses to e-modules obtained very practical criteria, as well as observations of lecturers' ability to use e-modules and manage their respective classes. -each obtained very practical criteria. (3) Effectiveness, seen from the results of the N-gain scientific literacy and knowledge learning outcomes, each of which shows an increase in height and the criteria for learning outcomes of attitudes and skills to obtain good and very skilled criteria.

1. Introduction
The state of Indonesia has entered the 21st century, characterized by the increasing demand for human resources (HR) that have high quality. Therefore, for a prospective teacher, in addition to being required to master the scientific to be taught, it is also necessary to have a set of knowledge and technical skills.

Based on the results of research from the Programme for International Student Assessment (PISA) show that the scientific literacy skills of Indonesian learners, in general, are below average when compared to the average international score [1]. Therefore, for prospective teacher students, it is essential to have high scientific literacy skills to be later able to improve the scientific literacy skills of learners.

The selection of models and approaches to informal learning can train scientific literacy skills and student learning outcomes. The model and approach chosen is the project-based learning model with the STEAM approach (STEAM-PjBL Approach). The project-based learning model is innovative, encouraging students collaboratively to research and create projects that apply their knowledge from discovering new things, proficient in the use of technology, and able to solve a real-world problem [2]. In addition, combining art with STEM subjects with the STEAM approach can enhance student engagement, creativity, innovation, problem-solving skills, and other cognitive benefits [3].
The use of teaching materials in the form of exciting modules can increase the success of a learning process, especially the influence of technological developments. Modules are often developed in the form of e-modules (electronic modules). One application of e-module creation is flipbook-based, where it looks like a digital book that looks more attractive.

Objects that are used as problems in every learning material can be sourced from the environment around students. One of them is sourced from the context of wetlands, which is a large land owned by South Kalimantan [4]. For example, one part of the branch of chemistry that can directly contact the wetland environment is the sub-material of the Chemistry School 2 course, colloidal. Based on these exposures, researchers are interested in researching the development of the e-module STEAM-PJBL approach in a wetland context on colloid materials to improve scientific literacy and student learning outcomes.

2. Methods
Research and Development (R&D) uses a 4D development model modified into 3D, namely define, design, and development [5]. The dissemination stage is not carried out because the research is done close to the end of the even semester of the 2020/2021 school year, so it does not have enough time. The research was conducted at the Chemical Education Study Program of FKIP ULM Banjarmasin in the 2nd semester of class A2 of the 2020/2021 school year for individual trials and small group trials, as well as students of semester 2 of class A1 of the 2020/2021 school year for limited trials.

Data collection techniques used non-test instruments that include validation questionnaires, readability questionnaires, student response questionnaires, observation sheets of lecturers' abilities using e-modules and managing classes, and observation sheets to measure student attitude learning outcomes and skills. Then, test instruments in the form of essay problems to measure the ability of scientific literacy and multiple-choice questions to measure the learning outcomes of student knowledge given before and after treatment. Data analysis used descriptive analysis—determination of percentage value (P) in the validity and effectiveness test using the following formula.

\[ \text{Percentage value (P)} = \frac{\text{The total score given}}{\text{Total overall score}} \times 100\% \]

The percentage of values obtained for the validated test is interpreted with Table 1. the following criteria [6].

| Percentage value (P) | Validated criteria | Information          |
|----------------------|--------------------|----------------------|
| 85,01 - 100,00       | Very valid         | No need to revise    |
| 70,01 - 85,00        | Valid              | No need to revise    |
| 50,01 - 70,00        | Less valid         | Minor revisions      |
| 01,00 - 50,00        | Invalid            | Major revisions      |

The average score obtained for the practicality test is interpreted in Table 2. The following criteria [7].

| Average score (x)    | Criteria          |
|----------------------|-------------------|
| \( x > 3,25 \) - 4,00 | Very practical    |
| \( x > 2,50 \) - 3,25 | Practical         |
| \( x > 1,75 \) - 2,50 | Less practical    |
| \( 1,00 \) - 1,75     | Impractical       |

The percentage of scores obtained for the effectiveness test is reviewed from the ability of scientific literacy to be interpreted with Table 3. the following criteria [8].
Table 3. Criteria for scientific literacy skills

| Percentage value (P) | Criteria   |
|----------------------|------------|
| 86.00 - 100.00       | Very high  |
| 72.00 - 85.00        | Tall       |
| 58.00 - 71.00        | Keep       |
| 44.00 - 57.00        | Low        |
| 0.00 - 43.00         | Very low   |

The percentage of values obtained for the effectiveness test is reviewed from the learning outcomes of knowledge interpreted with Table 4, the following criteria [9].

Table 4. Criteria for learning knowledge results

| Percentage value (P) | Criteria |
|----------------------|----------|
| P ≥ 80.00            | A        |
| 77.00 - P < 80.00    | A-       |
| 75.00 - P < 77.00    | B+       |
| 70.00 - P < 75.00    | B        |
| 67.00 - P < 70.00    | B-       |
| 67.00 - P < 67.00    | C+       |
| 60.00 - P < 64.00    | C        |
| 50.00 - P < 60.00    | C-       |
| 40.00 – P < 50.00    | D        |
| 0.00 – P < 40.00     | E        |

The percentage of scores obtained for the effectiveness test is reviewed from the results of attitude learning interpreted with Table 5 [10].

Table 5. Criteria for attitude learning outcomes

| Percentage value (P) | Criteria      |
|----------------------|---------------|
| P > 81.25 – 100.00   | Very good     |
| P > 62.50 - 81.25    | Good          |
| P > 43.75 - 62.50    | Pretty good   |
| 25.00 – 43.75        | Less good     |

The percentage of scores obtained for the effectiveness test is reviewed from the learning outcomes of the skill interpreted with Table 6, the following criteria [10].

Table 6. Skills learning outcome criteria

| Percentage value (P) | Criteria      |
|----------------------|---------------|
| P > 81.25 – 100.00   | Very skilled  |
| P > 62.50 - 81.25    | Skilled       |
| P > 43.75 - 62.50    | Quite skilled |
| 25.00 – 43.75        | Less skilled  |

3. Research and Discussion Results

Colloidal material e-modules that have been developed using 3D model stages are presented as follows:

3.1. Defining Stage (Define)

Activities at the stage of definition that is done there are several, namely can be described as follows: (a) Early analysis. The final initial research is done through field studies and literature studies that aim to find out the fundamental problems students face in learning related to colloidal materials, such as the difficulty of understanding the material because of the lack of exciting teaching materials. (b) Student analysis. Student analysis includes the analysis of academic ability and motivation of students who aim to study the characteristics of students by design to be developed such as students can create their projects and have adequate facilities to use smartphone devices. (c) Task analysis. Task analysis aims to thoroughly review what tasks students will undertake through developed e-modules. Task analysis
includes tasks that train scientific literacy skills and student learning outcomes in the context of wetlands. (d) **Concept analysis.** Concept analysis aims to identify concepts and determine the material's content in e-modules developed to be presented in the concept map. (e) **Analysis of learning objectives.** Analysis of learning objectives is made by adjusting existing tasks and concepts then linking to the behaviour of the subject to be achieved, namely improving scientific literacy and student learning outcomes.

### 3.2. Planning Stage (Design)
Activities at the stage of design that is done there are several, namely can be described as follows: (a) **Preparation of tests.** The test preparation is the stage for preparing the essay problem for instrument scientific literacy and the multiple-choice question for learning instruments; (b) **Media drafting.** The media used to make e-modules is a flipbook, where the initial file form of the e-module was pdf. Then converted into the form of a digital book with additional interesting views and symbols; (c) **Formatting.** Format selection includes selecting material content, selection of strategies, learning methods, and learning models contained in e-modules; (d) **Initial design.** This stage is the first design to be done to design e-modules developed.

### 3.3. Development Stage (Develop)
Activities at the stage of development are carried out there are several, namely can be described as follows:

#### 3.3.1 Validation of the product by an expert
The validity test aims to determine the level of product validity measured based on validator assessment consisting of 4 lecturers of Chemical Education FKIP ULM Banjarmasin as material experts and one lecturer of Educational Technology FKIP ULM Banjarmasin as a media expert. The results of the validator's assessment are shown in Figure 1.

![E-module eligibility validation results](image)

**Figure 1.** E-module eligibility validation results

Based on Figure 1, it is known that the e-module obtained a category worth using without any revision from the validators. Aspects of the content of the e-module have presented the content of the material appropriately and accurately, have other supporters to clarify the material, and the content of the material proved to be final. In the aspect of the presentation that has been arranged with good presentation techniques and equipped with various other supporters, the form of learning encourages students to be interactive and participative, and e-modules are arranged according to the rules that consist of preliminary content and closing sections.

Aspects of language have been presented with straightforward, communicative, dialogical, interactive vocabulary, following the student's intellectual development and social-emotional level and the consistent use of terms, symbols, or icons. The media aspect has presented an attractive look and content and has been by the characteristics of an e-module.

Field trials. Field trials include individual, small group, and limited trials. Individual and small group trials are conducted to determine the practicality of e-modules reviewed from the e-module readability questionnaire. The average score of individual and small group trial readability scores is shown in Figure 2.
Based on Figure 2, it is known that the individual test obtained an average overall score of 3.20 in practical criteria, and the small group test obtained an overall score average of 3.68 in efficient criteria. In individual trials, its suggestions with the cover's design, the colour combination of look, and the material content. Therefore, before being retested in small group trials, revisions were made by changing the cover's design, color combinations for the display, and adding videos to clarify the material's content. Choosing a harmonious and exciting color combination can give students its appeal, as well as another purpose of this visual display is to facilitate the delivery of messages [11]. Then, video in learning is a medium to demonstrate some material concepts, help stimulate students’ curiosity about the chemicals to be studied and increase students’ interest in learning [12].

The assessment readability of the e-module is based on several things, such as the number of clear and non-blurry images to clarify the content. As revealed by Amir [13], the help of images helps facilitate the learning process while achieving learning goals. Writing sentences in e-modules is easy to understand because there is no discovery of misinterpretation due to miswriting. Arizona [14] states that if there are spelling errors and improper use of punctuation in writing, then the meaning of the writing can be different from its purpose or purpose, causing the sentence to be challenging to understand. The e-module contains quiz time and formative tests that are easy for students to understand and answer to improve their understanding and learning motivation. Puryati [15] expressed that when students can answer the problem, there will be a sense of satisfaction and make them more successful in learning.

Limited trials are conducted to determine the practicality and effectiveness of e-modules. The practicality of e-modules is reviewed from student response questionnaires, observation sheets of lecturers' abilities using e-modules, and managing classes. Meanwhile, the effectiveness of e-modules is examined from the ability of scientific literacy and student learning outcomes. The average student response score is shown in Figure 3.
the application of project-based learning models has a significant influence on learning interests, one of which is characterized by the attitude of students more concentration and attention when following learning because they feel they have a significant role in learning, primarily related to the task of doing projects with the STEAM approach.

The use of e-modules encourages students to study independently. As revealed by Setiyadi, Ismail, & Gani [18], that e-modules have self-instruction properties characterized by the inclusion of several command sentences that are easy to understand, and there are training questions, there are summaries of materials and contain the contents of learning materials packaged in small units, making it easier to learn thoroughly. These e-modules make students happy to study colloidal materials because it discusses the interrelationships of wetland-textured daily life. Yildiz & Baltaci [19] revealed that contextual learning is more attractive to students because it has a connection from the experiences they have experienced.

The ability of lecturers to use e-modules is seen from the assessment of 3 observers based on three indicators, namely e-module instructions, e-module content, and ease of use of e-modules. The average score of each indicator of a lecturer's ability to use e-modules is indicated in Figure 4.

![Figure 4](image)

**Figure 4.** Average indicator score of lecturer's ability using e-modules

Based on Figure 4, it is known that the ability of lecturers using e-modules obtains very practical criteria that show these abilities are done very well. Examples of the use of e-modules accompany instructions submitted by lecturers. Providing optimal direction and guidance from lecturers will make students make the best use of their potential in following the lecture process [20].

The content indicator and ease of use of the e-module acquire practical criteria. Lecturers share e-module links through the Whataspp group, then convey the essential points of the subject matter in the e-module so that students can independently learn more about the content of the material. As Johannes [21] expressed, lecturers act as facilitators, so there is no need to intervene too deeply and do not take away students' right to study in the true sense.

The ability of lecturers to manage classes is seen from the assessment of 3 observers based on four dimensions, namely introduction, core, closing, and time allocation. The average score of the acquisition from the statement of the lecturer's ability to manage the class is shown in Figure 5.

![Figure 5](image)

**Figure 5.** Average statement scores of lecturer's ability to manage classes

Based on Figure 5, it is known that the ability of lecturers to manage classes obtains very practical criteria and shows that ability is done very well. In the preliminary dimension, before entering the core
of learning, lecturers instruct students to open e-modules that have been shared. The core dimension is the stage of running the syntactic of the project-based learning model with the STEAM approach. According to Hendra, Arsa, & Krisnawati [22], the project-based learning model is meaningful learning that brings students an impressive learning experience. Moreover, the experience is obtained from the problem of wetland texture. In the closing dimension, the student concludes. According to Rahmatawy, Nurhayati, & Arsyad [23], learning by discovering itself concepts and meaningful can result in a good understanding of concepts and retention of students at the end of learning. Finally, the allocation of time is carried out following the RPP that has been made. Yatmini [24] expressed that RPP is an absolute requirement for implementing a conducive learning process.

The effectiveness of e-modules is reviewed from the scientific literacy skills of students judging from the N-gain obtained. The results of N-gain of students' scientific literacy skills are shown in Figure 6.

**Figure 6.** Value percentage of students' pretest and posttest grades of scientific literacy skills

Based on Figure 6, N-gain is obtained by 0.75 and shows an increase in the percentage of the value obtained from pretest to high posttest. Thus, according to Khotimah, Suhirman, & Raehanah [25], that through the application of project-based learning models can improve students' scientific literacy skills and also supported by the results of Rusyati, Permanasari, & Ardianto [26], that through learning with STEM approach can train students' scientific literacy skills.

The application of the project-based learning model trains students to solve problems through the stages of the search, analysis, and synthesis of results that will be delivered to other students. Wulandari [27] expressed that through the application of project-based learning models, students will explore, assess, interpret, and synthesize to produce various forms of learning outcomes. The application of the steam approach trains students to build their *knowledge scientifically*. As revealed by Munawar, Roshayanti, & Sugiyanti [28], the steam approach is seen as an approach that encourages students to develop curiosity and ask questions so that students can build knowledge around their world by exploring, observing, discovering, and investigating how things happen. Through the implementation of student-centred learning patterns, they can increase their learning activities [29].

Effectiveness on the learning outcomes of student knowledge is seen from the N-gain obtained. The results of N-gain student knowledge learning results are shown in Figure 7.

**Figure 7.** Value percentage of pretest and posttest grades of student knowledge learning outcomes

Based on Figure 6, N-gain obtained by 0.79 shows an increase in the percentage of the value obtained from pretest to high posttest. Thus, based on the results of Ma'sumah & Mitarlis's [30] research, that
through learning that applies the project-based learning model with STEM approaches successfully affects student learning outcomes by showing an increase from pretest to posttest.

Project assignments presented from the project-based learning model provide opportunities for students to learn from hands-on experience. Through project-based learning, students have a better mastery of concepts and make students more active as learning centres. In contrast, lecturers as facilitators, so that with the functional role of students cause the learning results obtained also increase [31][32].

Effectiveness to student attitude learning outcomes is measured during the learning process at two meetings consisting of curiosity, responsibility, and cooperation. The percentage of student attitude learning outcomes is shown in Figure 8.

![Figure 8](image)

**Figure 8.** The average percentage value of each aspect of attitude learning outcomes

Based on Figure 8, it is known that students show a good attitude during learning using e-modules. Furthermore, students are given group tasks to create projects related to the wetland environment with lecturers as facilitators who, without directly telling students how to create the project, so that students’ attitude of curiosity, responsibility, and cooperation is trained independently.

According to the results of Setiono's research, Dadi & Yuliawati [33], the application of project-based learning models successfully increases students' curiosity in learning because this attitude of interest is a character that students must master to be able to learn independently. The project-based learning model is also able to improve student responsibility attitudes [34]. According to Rahayu, Puspita, & Puspitaningsih [35], the students’ emergence of a cooperative attitude makes it easier for them to socialize and foster an open and accessible perspective to accept differences.

Effectiveness to the learning outcome of student skills was measured at the 2nd meeting related to the results of the water purification project. The percentage of student skills learning outcomes is shown in Figure 9.

![Figure 9](image)

**Figure 9.** The average percentage of grades from each aspect of learning skills results

Based on Figure 9, students show highly skilled abilities in project creation and percentage of results. According to Rati, Kusmaryanti, & Rediani [36], the application of project-based learning models gives students the flexibility to find solutions and problem solving from various sources. From the reference sources established to make students carry out a targeted and integrated project work process.

4. Conclusion
Based on the results of research and discussion can be concluded that the e-module colloidal material based on STEAM-PJBL approach to improving scientific literacy and learning outcomes in the context of wetlands developed: (a) Obtaining a very valid criterion for use in learning with a score of 93.67% (very valid) on the validity aspect of the content; 93.75% (very valid) on the validity aspect of presentation; 94.62% (very valid) on the validity aspect of language; and 94.44% (very valid) on the aspect of media validity; (b) Obtaining practical criteria because of the average score on individual tests of 3.20 (practical), small group tests of 3.68 (very practical), student response questionnaires of 3.54 (very valid) on the validity aspect of media validity; (c) Obtaining effective criteria can contribute to significant improvements from the results of scientific literacy and student knowledge learning outcomes in limited trial classes seen from the N-gain value between pretest and posttest is 0.75 and 0.79, consecutively. Then, the results of learning attitudes obtained a score of 78.59 with good criteria, and the learning skills result obtained a value of 93.18 with very skilled criteria.

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