Development of Knowledge Building Environment (KBE) - based colloidal system learning materials to develop student's environmental literacy: An environmental analysis

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Abstract. This study aims to develop a knowledge building environment (KBE)-based colloidal system learning material to develop students’ environmental literacy. To realize this, the problem questions raised in this study are: "1) What are the product characteristics of colloidal system teaching materials based on knowledge building environment to develop student environmental literacy which is developed with the 4STMD method? 2) What is the understanding aspect of colloidal system teaching materials based on knowledge building environment to develop student environmental literacy which is developed with the 4STMD method? and 3) How is the feasibility of colloidal system teaching materials based on knowledge building environment to develop student environmental literacy which is developed with the 4STMD method? The research method used is Development Research (DR) with a book development model using 4STMD. The results of the study show: 1) Characteristics of teaching materials developed are very in accordance with the following criteria: curriculum, scientific correctness, containing KBE values and environmental literacy, equipped with concept maps, structured and systematic; 2) Understanding of teaching materials by students is high (88.21%); and 3) The feasibility of teaching materials amounting to 96.81% (very feasible) fulfilling the criteria for the assessment of lesson text books based on BSNP standards means that they are worthy of use.

1. Introduction

Chemistry is a subject that is inseparable from the environment. The environment can be developed through the ability to think inductive and deductive analysis in solving problems related to natural events, both quantitatively and qualitatively. Chemistry is not just a collection of facts and principles but more than that, Chemistry also contains ways to obtain these facts and principles and their attitudes [1]. But not only with facts and principles, it also requires understanding through both the theory and application processes in real life so that a meaningful Chemistry learning strategy is needed for students [2].

Chemical learning especially in colloidal system material will be very meaningful if it is based on the development of environmental knowledge because it will provide a more valuable experience for students especially now that environmental issues have become world problems such as environmental damage due to industrial waste, due to disasters, and so on. The learning strategy applied by the teacher will greatly influence the development of students' environmental literacy [3].
One of the strategies that can be developed by teachers to develop environmental literacy in this colloidal system material is to develop teaching materials. Teaching materials in the context of learning is one component that must exist, because teaching materials are a component that must be studied, examined, studied, and made into material that will be mastered by students as well as can provide guidance to learn it. Without teaching materials, learning will not produce anything.

Teaching materials are external factors of students that can strengthen internal motivation to learn. Teaching materials that are fully designed in the sense that they have adequate learning resources, complete with interesting content and illustrations will affect the learning atmosphere. The learning process that occurs in students becomes more optimal and will stimulate students to use teaching materials as learning material or as learning resources. Therefore, in supporting the achievement of the optimal Teaching and Learning Process (PBM) teaching material is an important object. Teaching material is also a component that must receive special attention, because there are still many teaching materials both in terms of breadth and depth that are not yet in accordance with the level of student development so that it is not easy for students to understand [4].

On the other hand, in Chemistry subjects especially Colloidal System material is still considered a difficult material by most students [5]. The concepts of Colloidal System Chemistry by most students are considered quite difficult to understand. These difficulties are caused by the nature of the Colloidal System concepts which have high levels of abstractness and complexity. Besides that, the concepts that must be understood by these students are quite a bit while there is little time available. According to Mahardika [6] to help overcome the problem of students' difficulties needed teaching materials that can help students in understanding teaching materials and the benefits can be directly felt. Therefore, in addition to learning strategies, to help overcome the problem of student difficulties also needed teaching materials that can help students in understanding chemical concepts. Another thing that needs to be considered is the design of the teaching material both the presentation model and the content design because it is very important to increase learning motivation and make it easier for students to understand the concepts presented. Based on the results of a study conducted by Suminar [7] found 45.7% of students had learning difficulties because of difficulties in understanding teaching materials in books and vice versa were very motivated to learn subject matter if the material was displayed in the form of images, graphics, illusions, etc. not only said.

The direction of the design of the next teaching material is about the content because this is very important with regard to the content of the skills you want to be taught in addition to understanding mere concepts. Because chemistry as one of the subjects can be used as a very good medium in training various abilities of students, namely observing, analyzing, hypothesizing, predicting, assembling, measuring and drawing conclusions. These abilities will have an impact on the development of self-potential, intellectual development and attitudes of students. This is in accordance with the nature of science demands, namely science as a process, product, and attitude. In this case one of the suitable skills to be included in the design of instructional material content is environmental literacy skills because these environmental literacy skills not only encourage understanding of concepts but also train other abilities namely the ability to use environmental knowledge, identify questions, and draw conclusions based on facts order to understand the universe and changes made to nature through human activities [8].

2. Method
This study uses the design of Development Research. The term Development Research or DR refers to a variety of research approaches related to design and development [9]. Development research is defined as a systematic assessment of Design, Development, and Evaluation of learning processes and products that must meet the criteria of validity, practicality and effectiveness [10]. The procedure of this study consists of three stages, namely: Design, Development, and Evaluation, more clearly as follows:


2.1. Design
The Design Stage begins with conducting a literature review of chemical concepts where students often experience difficulties when studying it. The colloid system is difficult material because some topics are abstract. But on the other hand, the material of the colloidal system is very important for students to master because it is very useful in its application in everyday life. Next, conduct a preliminary study in the form of curriculum assessment and indicator setting.

2.2. Development
At the manufacturing stage, the procedure used is the procedure for developing teaching materials. At this stage, the method chosen to develop teaching materials is the four steps teaching material development method, also known as 4STMD, which is a method developed by Anwar [4]. There are four stages of development, namely selection, structuring, characterization, and didactic reduction.

2.3. Evaluation
The evaluation phase consists of a test of understanding and feasibility. After the didactic reduction stage is done by reducing the difficulty level of the text of the teaching material, a comprehension / readability test is conducted. Readability test at the evaluation stage is the same as the characterization in 4STMD, namely students are asked to determine the main idea and the level of difficulty in each text. While the feasibility test is in the form of a feasibility instrument for teaching materials adapted from BSNP which is filled and given perceptions by high school chemistry teachers. The flow of research on teaching materials is shown in Figure 1.

The location of this study was conducted in one of the State High Schools in Garut Regency with participants involving the school, namely chemistry teacher and class XI students. The instruments used in this study include several types of instruments, namely:

| No | Research Question                                                                 | Instrument                                      | Data Generated                                      |
|----|-----------------------------------------------------------------------------------|-------------------------------------------------|-----------------------------------------------------|
| 1  | What are the product characteristics of colloidal system teaching materials based on knowledge building environment to develop student environmental literacy which is developed with the 4STMD method? | Review sheet selection stage                    | 1. Indicators according to KD                        |
|    |                                                                                  |                                                 | 2. Label the concept according to the indicator      |
|    |                                                                                  |                                                 | 3. Description of the concept label                  |
|    |                                                                                  |                                                 | 4. Description of KBE-based environmental literacy developed |
| 2  |                                                                                  | Review sheet for structuring stage              | 1. Concept map                                     |
|    |                                                                                  |                                                 | 2. Macro structure                                  |
|    |                                                                                  |                                                 | 3. Multiple representations                         |
| 3  |                                                                                  | Review sheet characterization stage             | 1. Score the right main idea                        |
|    |                                                                                  |                                                 | 2. Characterization of difficult concepts            |
| 4  |                                                                                  | Review sheet of didactic reduction stage        | Difficult concept reduction                         |

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Table 1. Research instrument.
Table 1. Cont.

| 2 | What is the understanding aspect of colloidal system teaching materials based on knowledge building environment to develop student environmental literacy which is developed with the 4STMD method? and Learning material comprehension test sheet | The main idea scores answered correctly |
|---|-------------------------------------------------------------------------------------------------|---------------------------------------|
| 3 | How is the feasibility of colloidal system teaching materials based on knowledge building environment to develop student environmental literacy which is developed with the 4STMD method? The research method used is Development Research (DR) with a book development model Learning material validity test sheets are reviewed from: | 1. Worthy or not feasible 2. Advice from the teacher |
| | • Aspects of eligibility • Language aspects • Presentation aspects • aspects of graphics • KBE aspect • Aspects of environmental literacy teaching materials on colloidal system material |

The data analysis technique in this study consisted of:

2.3.1. Characterization data analysis. Characterization data analysis was carried out on each text in the teaching material. The characteristic test sheet of teaching materials is filled by high school students of Class XI. Characterization analysis is carried out with the following steps: 1) Calculating the correct main idea answers for each student by determining the score of the main idea of the student's answer containing the correct answer (1) and the main idea of the student's answer that does not contain keywords (0), 2) Calculating the percentage score for determining text categories based on ideas. The results of data analysis at this characterization stage are used for didactic reduction stages. Concepts that include difficult categories are analyzed whether including complex, complicated, or abstract concepts. Reduction in concepts is difficult to do in the eight ways described by Anwar [4].

2.3.2. Analysis of readability test data. To measure the level of readability of instructional materials the results of the development are used in the test of overlapping (close test). In the test of the colloid chemistry teaching material overlapping randomly used word slides are used because the character of the colloid teaching material is a combination of the presentation of concepts through the format of verbal (text), mathematical, image, and graphic representation.

2.3.3. Analysis of feasibility data on teaching materials. Assessment of the feasibility of teaching materials by the teacher in terms of content, material presentation, language, and graphics. Data analysis in the form of a questionnaire was conducted by calculating the number of teachers who answered Yes and No. Obtaining data is accumulated in each item according to draft material conformity assessment.
Data analysis is done by calculating the number of teachers who answered Yes and No. Score 1 to answer Yes and score 0 to answer No.

3. Results and discussion
Based on the research conducted, the following results were obtained:

3.1. Characteristics of teaching materials developed with the 4STMD method
Based on the stages of development of colloidal system teaching materials using the 4STMD method that has gone through expert review and correction processes and subsequently improved to achieve several things, namely: suitability of curriculum achievement, truth of concepts, planting of values (KBE and Environmental Literacy), concept mapping and the structure and systematics of teaching materials. Table 2 presents the recapitulation of the results of the assessment of the characteristics of the colloidal system teaching materials. Expert assessment is intended to show whether the teaching materials developed have been in accordance with these criteria. Participants who assessed the suitability of the characteristics of the colloidal system teaching materials were two Chemistry Department lecturers in the UPI graduate school environment and nine high school chemistry teachers in Garut Regency. The recapitulation results are shown in table 2.

The full research flow is shown in Figure 1 as follows.

![Flow of research](image-url)
Table 2. Recapitulation of the results of the assessment of the characteristics of teaching materials.

| No | Assessment criteria                          | Percentage (%) |
|----|---------------------------------------------|----------------|
| 1  | Curriculum                                  | 100            |
| 2  | Truth concept                               | 100            |
| 3  | Value of Knowledge Building Environment     | 100            |
| 4  | Environmental Literacy Value                | 100            |
| 5  | Concept maps                                | 100            |
| 6  | Structure and Systematics                   | 100            |
|    | **Average percentage**                      | **100**        |

Overall the percentage of assessment characteristics of this colloidal system teaching material is 100%, meaning that the teaching material developed has been in accordance with the characteristics of the teaching material to be achieved.

3.2. Understanding of developed teaching materials that contain KBE and environmental literacy

The content of KBE in teaching materials is seen through the results of validation at the selection stage. The results of understanding tests of teaching materials regarding KBE values are presented in table 3.

Table 3. Test results of KBE value in teaching materials.

| No | Indicator of KBE Value | Yes | No |
|----|------------------------|-----|----|
| 1  | Attentiveness          | 9   | 2  |
| 2  | Careless               | 10  | 1  |
| 3  | Curiosity              | 10  | 1  |
| 4  | Critical               | 8   | 3  |
| 5  | Respect for environment| 11  | 0  |
| 6  | Respect for health     | 11  | 0  |
| 7  | Wisdom                 | 9   | 2  |
|    | **Percentage (%)**     | **88.31** | **11.69** |

Based on the results of the evaluation for the KBE value at the validation stage, it was found that the teaching material contained KBE values. Teaching materials contain attentiveness, careless, curiosity, critical (respect for environment), respect for health, and wisdom or wisdom [11]. with the percentage of answering yes as much as 88.31% (very much) means that the value of KBE is very much contained in teaching materials.

The content of environmental literacy in teaching materials is seen from material content testing by experts and teachers who base on the existence of 6 things as stated by Endrogan, et al. [12], namely: ecological knowledge, knowledge of environmental issues, socio-political knowledge, cognitive skills, affective, and environmentally responsible behavior. Based on the results of the test of the environmental literacy content the results are shown as shown.

Table 4. Test results for the value of environmental literacy in teaching materials.

| No | Indicator of the Value of Environmental Literacy | Yes | No |
|----|-----------------------------------------------|-----|----|
| 1  | Ecological knowledge                          | 11  | 0  |
| 2  | Knowledge of environmental issues             | 11  | 0  |
| 3  | Socio-political knowledge                     | 11  | 0  |
| 4  | Cognitive skills                              | 11  | 0  |
The percentage of the value of the content of environmental literacy material in teaching materials is 100%, this means that all participants believe without doubt that in this teaching material there is a charge of environmental literacy.

Understanding of teaching materials is done by writing the main text ideas and the level of difficulty of the text (easy or difficult) on the teaching material. Understanding tests were conducted to determine the level of readability of the text in teaching materials after going through the stages of 4STMD. This understanding test is carried out on students who are different from students who become participants in the text characteristic test.

The thing that distinguishes between characteristic test and understanding test is data analysis. In the test of data analysis calculation characteristics only until the percentage of the level of difficulty and suitability of the main ideas per text, but in the percentage comprehension test averaged back to see the students' understanding of teaching materials. Teaching materials whose percentage of understanding is more than 57% included in the high category (or independent category). The results of the understanding of the colloidal system teaching materials based on students' ability to write the main text ideas and determine the level of difficulty of the text are shown in table 5.

Table 5. Recapitulation of the results of the understanding test of teaching materials.

| No | Tekt | Percentage (%) |
|----|------|----------------|
| 1  | Tekt 1-10 | 90 |
| 2  | Tekt 11-20 | 100 |
| 3  | Tekt 21-30 | 80 |
| 4  | Tekt 31-40 | 80 |
| 5  | Tekt 41-50 | 90 |
| 6  | Tekt 51-60 | 90 |
| 7  | Tekt 61-68 | 87.5 |

Average percentage 88.21

Table 5 shows that text 1-68 or teaching material has a percentage of comprehension on average more than 57% which is 88.21% with high category (independent) meaning teaching materials have characteristics that can teach students independently (self-instructional), teaching materials have ability explains as clearly as possible all the material contained in it, and teaching materials made in a format that is simple and not too complex so students can learn teaching materials developed independently.

3.3. Feasibility of teaching materials developed

The feasibility test of teaching materials aims to determine the feasibility of teaching materials which include the feasibility of content, the feasibility of presentation, the feasibility of language, and the appropriateness of graphics. Participants in the feasibility test of this teaching material are education experts, chemists, and high school chemistry teachers. The feasibility test of teaching materials is carried out by giving the instrument the feasibility questionnaire of teaching materials to twelve participants (2 lecturers and 9 teachers). The feasibility test instrument used is based on a guide from the BSNP (Education National Standards Agency) regarding the assessment of textbooks for primary and secondary education. Analysis of feasibility data is done by counting the number of respondents who answered yes. Score 1 for answers yes and 0 for answers no. The results of data analysis at this stage are the percentage of feasibility of teaching materials in each component of feasibility shown by tables 6, 7, 8, and 9, as follows:
Table 6. Results of the feasibility test for the content of teaching materials.

| No | Item Sub-component | Aspects of Assessment | Assessment Indicator | Score | Gain |
|----|--------------------|-----------------------|----------------------|-------|------|
| 1  | Material coverage  | a. Conformity between the material elaborated with KI and KD | 11 | |
|    |                    | b. Conformity between the introduction of concepts and interactions between concepts presented in teaching materials with KI and KD | 9 | |
| 2  | Material accuracy  | a. Accuracy of facts in accordance with reality and efficiency to improve students' understanding | 11 | |
|    |                    | b. The presentation of concepts does not cause many interpretations and is in accordance with the prevailing definitions | 9 | |
|    |                    | c. Theories are presented in accordance with the prevailing theory | 11 | |
|    |                    | d. Truth principles or laws are listed in the book | 11 | |
| 3  | Update             | a. The material presented is up to date and in accordance with the development of science | 11 | |
|    |                    | b. Linkages of features include presentation of descriptions, examples, exercises that are relevant and interesting and reflect events or conditions that are up to date | 11 | |
|    |                    | c. Reasonable references, namely references that are relevant, valid, and up to date | 11 | |
| 4  | Curiosity          | a. Information provided on teaching materials can lead to student curiosity | 10 | |
| 5  | Life skills        | a. Develop personal skills (i.e. presenting exercises, examples, which motivate students to recognize strengths and weaknesses and develop themselves as good individuals) | 9 | |
|    |                    | b. Develop social skills (i.e. presenting exercises, examples, which motivate students to communicate, interact, and cooperate with others) | 9 | |
|    |                    | c. Develop academic skills (i.e. presenting exercises, examples that motivate students to find and explore information, solve problems, and make decisions) | 9 | |
| 6  | Contextual insight | a. Presenting concrete examples from the local / national / international environment | 11 | |
|    |                    | b. Appreciation of science pioneers | 11 | |

Table 4 shows that teaching materials have a percentage of eligibility in the content aspect of 93.33% with a very feasible category, meaning that teaching materials have met the assessment of textbooks based on BSNP standards.
Table 7. Test results for the language feasibility of teaching materials.

| No | Item Sub-component | Aspects of Assessment | Assessment Indicator | Score Gain |
|----|--------------------|-----------------------|----------------------|------------|
| 1  | Conformity with student development | a. Conformity with student development (language used both to explain concepts and illustrations and to provide concrete and abstract examples) | 11 |
|    |                    | b. Conformity with students' social emotional development (language used in accordance with the level of maturity of students) | 11 |
| 2  | Communicative      | a. Teaching materials are presented in languages that are interesting and common in communication | 11 |
|    |                    | b. Suitability of the illustration with the substance of the message to be delivered | 11 |
| 3  | Dialogical and interactive | a. The ability to motivate students to respond to messages (the language used fosters joy when students read it and encourages to read the book) | 11 |
|    |                    | b. Creating interactive communication (students seem to communicate with the author) | 11 |
| 4  | Straightforward     | a. The accuracy of the sentence structure (the sentences represented represent the contents of the message delivered and follow the correct sentence order) | 11 |
|    |                    | b. Stiffness of the term (conformity with agreed technical terms of science) | 11 |
| 5  | Coherence and clutter of thought | a. Integrity of meaning in the chapter / sub chapter / paragraph / sentence | 11 |
|    |                    | b. Participation between chapters / sub chapters / paragraphs / sentences | 11 |
| 6  | Language suitability | a. Accuracy of grammar | 11 |
|    |                    | b. Spelling accuracy | 11 |
| 7  | Use of terms and symbols | a. Consistency in the use of terms | 11 |
|    | symbols / symbols   | b. Consistency of using symbols | 11 |
|    | Percentage (%)      | 100                  |                      |

Table 7 shows that teaching materials have a percentage of the feasibility of aspects of the language of 100% with a very decent category, meaning that teaching materials have met the assessment of textbooks based on BSNP standards.
**Table 8.** Test results for the feasibility of presenting teaching materials.

| No | Item Sub-component Aspects of Assessment | Assessment Indicator                                                                 | Score Gain |
|----|------------------------------------------|-------------------------------------------------------------------------------------|------------|
| 1  | Presentation technique                    | a. The systematic consistency of the presentation in the sequential chapter includes introduction, content, and closing | 11         |
|    |                                          | b. Logical presentation (presentation according to the flow of thinking both general to specific or special to the public) | 11         |
|    |                                          | c. Collusion of concepts (presentation of material from easy to difficult, from concrete to abstract, from simple to complex, and from what is known to unknown). | 11         |
|    |                                          | d. Submission of material between sub-chapters with other sub-chapters, sub-sections with paragraphs | 11         |
|    |                                          | c. Having relevance                                                                 |            |
| 2  | Material accuracy                         | a. Suitability or accuracy of illustrations with material                             | 11         |
|    |                                          | b. Presentation of text, tables, pictures and attachments accompanied by references taken |            |
|    |                                          | c. Tables, pictures and attachments are numbered and titled                          |            |
|    |                                          | d. The accuracy of numbering and naming tables, images, and attachments.              |            |
|    |                                          | e. Advanced organizer at the beginning of the chapter                                 |            |
|    |                                          | f. Introduction (description of the contents of the book and how to use it at the beginning of the chapter) |            |
|    |                                          | Bibliography                                                                         |            |
| 3  | Presentation                              | a. Involvement of students                                                            | 10         |
|    |                                          | b. Student-centered                                                                   | 8          |
|    |                                          | c. Presents feedback for self-evaluation                                              | 9          |
|    |                                          | d. Conformity with the characteristics of subjects                                   | 9          |

**Percentage (%)** 93.94

Table 8 shows that teaching materials have a percentage of feasibility in the material presentation aspect of 93.94% with a very feasible category, meaning that teaching materials have met the assessment of textbooks based on BSNP standards.
Table 9. Feasibility test results for graphic teaching materials.

| No | Assessment Indicator                                                                 | Score Gain |
|----|---------------------------------------------------------------------------------------|------------|
| 1  | The font size in the title of the teaching material is proportional to the teaching material | 11         |
| 2  | The color of the title and text in the teaching material contrast with the background color | 11         |
| 3  | The cover image shows the contents of the material or content of the teaching material | 11         |
| 4  | Placement of layout elements (title, subtitles, text, images, captions, page numbers) proportionally | 11         |
| 5  | Combined image combination                                                             | 11         |
| 6  | The use of letter variations is not excessive                                         | 11         |
| 7  | The font size used is proportional                                                     | 11         |
|    | **Percentage (%)**                                                                    | **100**    |

Table 9 shows that the teaching material has a percentage of feasibility on the feasibility aspect of the graph of 100% with a very feasible category, meaning that the teaching material meets the assessment of the textbook based on the BSNP standard.

The recapitulation of the results of the feasibility test of teaching materials is shown in table 10, as follows:

Table 10. Recapitulation of the results of the feasibility test of teaching materials.

| No | Assessment criteria | Percentage (%) |
|----|---------------------|----------------|
| 1  | Content             | 93.33          |
| 2  | Language            | 100            |
| 3  | Presentation        | 93.94          |
| 4  | Graphics            | 100            |
|    | **Average percentage** | **96.81**    |

Overall the feasibility of this teaching material is 96.81% with a very decent category. This means that teaching materials have met the assessment of lesson textbooks based on BSNP standards and are feasible for use by students.

4. Conclusion
Based on the results of the research and discussion it can be concluded as follows:

4.1. Characteristics of teaching materials
Colloid system material is developed using the 4STMD method, then it has been adjusted to the following criteria:

- Teaching materials developed in accordance with the national curriculum that refers to KD. 3.15 colloidal system material.
- Teaching materials developed in accordance with the truth of science.
- Teaching materials instill KBE values and environmental literacy.
- Teaching materials are equipped with concept maps that are in accordance with the concept of concept mapping
- Teaching materials are developed in accordance with the structure and systematics of teaching materials.
4.2. Understanding of teaching materials
The test results for the content of KBE values in teaching materials were obtained at 88.31% and values containing Environmental Literacy were 100%. This shows that teaching materials contain these values very well. Furthermore, the results of students’ comprehension test on the colloidal system teaching materials containing KBE values and environmental literacy and developed using the 4STMD method had an average percentage of understanding of 88.21% with high categories (independent). This means that teaching materials that have been developed have the characteristics of being able to teach students independently.

4.3. Feasibility of teaching materials
The results of the feasibility test for the colloidal system developed have an overall feasibility percentage of 96.81% with a viable sagat category. This means that teaching materials that have been developed have met the assessment of textbooks based on BSNP standards and are suitable for use by students.

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