The impact of the last stage of 4S TMD in chemistry books using knowledge building environment

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Abstract. This research is a follow-up study which aims to describe how to develop a chemistry book in hydrocarbon materials based on KBE with the 4S TMD model. The 4S TMD model consists of four stages, namely selection, structuring, characterization, and didactic reduction. This research will focus on the stage of characterization and didactic reduction. The Knowledge Building Environment (KBE) is a theory used to build values and knowledge in the environment to improve the quality of teaching materials. The values to be developed include attentiveness, caring, curiosity, critical, moderation, respect for the environment, respect for health, and wisdom. The research uses design, development, and evaluation research methods. In this article, we will discuss how the chemistry book is in the didactic characterization and reduction stages. The characterization stage finds difficult concepts that need to be reduced. Didactic reduction stage to reduce difficult concepts to be concrete and simple. The didactic reduction method is to return to the qualitative stage; neglect; use of explanations in the form of pictures, symbols, sketches, and experiments; use of analogy; use of historical development levels; generalization; particularization; and ignoring different concept statements.

1. Introduction
Knowledge building environment (KBE) contains values that can build knowledge through the environment related to teaching materials [1]. Environmental learning methods that involve students in various experiences such as direct learning, dialogue through discussion, and reflection can foster environmental awareness [2]. Teaching materials that contain KBE values still need to be developed by using appropriate teaching material development methods [3]. Research that has been carried out is conducted by So, Seah, and Heng (2010) found that collaborative KBE can affect student achievement [4]. Based on the results of the study, it was stated that chemistry teaching materials were easier to understand by students than textbooks in high schools [5]. Processes reduce the difficulty of chemical materials in a variety of ways, namely by improving their abstractness and complexity[1], [6]–[9]. Learning also requires teachers and students to communicate interactively using technologies such as information and communication...
technology [10]. The use of this media depends on the structure of the learning material and the type of communication required. Technology is often used by computers with the internet, cellphones using applications, video, telephone, and fax. In the modern era, technology is increasingly developing along with the use of the internet on computers and cell phones so that we can easily implement various applications. In addition, there is also research on knowledge building environments that has been researched previously with a study entitled the development of chemical teaching materials on redox reaction materials based on knowledge building environment (KBE) [11]. There is also research on knowledge building environment which is conducted under the title research on the development of chemical teaching materials on hydrocarbon materials to develop KBE [12], [13].

One of the teaching materials development methods, namely the 4STMD method, consists of four stages, namely selection, structure, characterization, and didactic reduction. In the 4STMD stage, the teaching materials are processed and prepared by paying attention to the arrangement and focusing on the characteristics of the teaching materials so that they are ready to be studied by students independently. 4STMD was chosen as a method of processing teaching materials because 4STMD would produce teaching materials that were in accordance with the cognitive development of students [14]–[17] [18]. The characterization stage is the stage carried out to identify difficult concepts using characterization instruments for teaching materials. One of the problems of learning chemistry that students face in understanding chemistry is that students have difficulty understanding the material being taught [22]–[24]. Reduction means a reduction in the difficulty level of teaching materials. The term "Didactic Reduction" comes from the German "Didaktische Reduction" which consists of the word Reduction which means reduction and Didactic means the science of teaching. The didactic reduction process is an effort to reduce the level of difficulty both in abstractness and complexity of a teaching material so that it becomes easier, simpler, more concrete and simpler teaching material. Teaching materials that have been reduced didactic are expected to be easier to understand by students [14]–[16], [29], [30].

Based on this description, the authors feel the need to discuss how to develop teaching materials on hydrocarbons using the 4STMD method to develop a knowledge building environment. However, a more detailed discussion will discuss the last two stages of 4STMD, namely characteristics and didactic reduction, how the effect of the last stage in 4STMD in chemistry learning using KBE. The purpose of this descriptive study is to make descriptions, systematic descriptions and describe the effects of the last stage in 4STMD, namely characterization and didactic reduction in chemistry books using a knowledge building environment.

2. Methods

This research uses descriptive quantitative methods. The subject of the research was the comprehension test on 40 students of class XI SMA Negeri 5 Talang Ubi and the feasibility test on 5 chemistry teachers consisting of teachers of SMA Negeri 5 Talang Ubi and teachers of SMA Negeri 14 Palembang. The students were tested for understanding to find out their ability of the teaching materials being developed. The teacher is given an instrument in the form of a feasibility test for teaching materials that have been developed previously. The results of this study are the basis for us in developing hydrocarbon chemistry books using the 4STMD method with a knowledge building environment that can be used in chemistry learning in high school.

The Four Step Teaching Material (4STMD) teaching material development method was developed by Sjaeful Anwar [19]–[21]. In this study, a characterization instrument was used to find out which concepts were categorized as difficult to understand by students, which would then be specifically fixed on each concept. Concepts that are categorized as difficult will be reduced to concepts that are categorized as easy by arranging the grid through the didactic reduction stage, namely: (1) the use of explanations with pictures, symbols, sketches, and experiments; (2) use of analogy; (3) generalization; and (4) particularization. This
method consists of 4 stages, namely selection, structuring, characterization and didactic reduction. The focus of this research discusses the impact of the last stage of 4S TMD in chemistry books using a knowledge building environment so that the focus of the discussion are characterization and didactic reduction.

3. Results and Discussion

3.1 Four Step Teaching Material (4S TMD)

Characterization Stage. Characterization of teaching materials is needed so that difficult teaching materials can be processed (packaged) specifically according to the characteristics of each concept. Characterization is needed so that difficult teaching materials can be processed specifically according to students' views, whether the concept is difficult or easy to understand. With the characterization of teaching materials, it is hoped that the teacher can choose the appropriate learning strategy, because each learning material has different characteristics [13], [25]–[28].

![Figure 1. Characterization Stage](image)

**Figure 1.** Characterization Stage

**Characterization Results**

The score shows that there are 10 paragraphs that are categorized as difficult and need to be reduced didactically. From the results of the data analysis, several things happened, namely: 1) During the characterization stage there were still paragraphs explaining the concepts in less detail or abstractly; 2) There are still paragraphs that are not accompanied by pictures to help students understand the text so that it does not motivate students to read the paragraphs; 3) There is still a long paragraph.

![Figure 2. Initial Characterization Results.](image)
Figure 3. Suitability of Main Ideas on Characterization and Comprehension Test in Difficult Text.

The value indicates that the paragraph that needs to be reduced already has a high understanding value. Comprehension is the ability to understand the text or reading which can be proven by the ability to retell or determine the main idea of the text and reading that has been read. In this study, the level of understanding of students when using the teaching materials developed. The level of understanding is measured by the suitability of the main ideas made by students in each text.

The Didactic Reduction Stage. If narrowly didactic reduction can be interpreted as a simplification process. The meaning of didactic reduction (Didaktische Reduction) in a broad sense is defined as reducing the level of difficulty of a teaching material both qualitatively and quantitatively. Reducing the level of difficulty in teaching materials is expected that the material can be more easily understood by certain levels of students. Didactic reduction is not just an additional stage in the learning process but is a necessity that every teacher needs to do [12], [17], [31]. Difficult material with didactic reduction will be made easy to learn and understand [21].

In the didactic reduction stage, the paragraphs of teaching materials which have difficult categories are carried out based on the characterization stage test. Concepts categorized as difficult can be simplified by means of a reduction grid, along with decreasing the level of difficulty by returning to the qualitative stage; neglect; use of explanations in the form of pictures; symbols, sketches and experiments; use of analogy; use of historical development levels; generalization; particularization; and ignoring different concept statements. Reduction really needs to be used to simplify scientific terms in everyday life. Scientific terms that are often used and are often called the misconception of the word "heat" which means temperature, the word "substance" is commonly used for objects and so on. Scientific terms can still be reduced didactically as long as they do not lead to misconceptions [19], [20], [26].

Figure 4. The Didactic Reduction Stage.
Figure 5. Results of Feasibility of Hydrocarbon Materials for Developing KBE.

The value shows that the hydrocarbon teaching materials for developing KBE are categorized as feasible. So that the chemistry teaching materials of hydrocarbon materials to develop the Knowledge Building Environment are suitable for use by teachers and students in the learning process.

3.2 Knowledge Building Environment (KBE)

Knowledge building environment (KBE) is a presentation of chemical phenomena related to everyday life, so that students can be found in their living environment, so that students are able to present material that is suitable for everyday life. According to Zhao and Chan, the knowledge building environment is used to determine the dynamics of collective knowledge formation and individual learning in the context of high school education [25].

Students are expected to be able to connect the value of knowledge building through the KBE environment with the phenomena that occur in the environment or daily life with chemical materials as a
whole. Students can have and display the value of KBE, namely: attentiveness, careness, curiosity, critical, moderation, respect for environment, respect for health and wisdom.

Table 1. Examples of KBE materials presented in teaching materials.

| Indicator | Teaching materials | The value of KBE |
|-----------|--------------------|------------------|
| 3.1.6 Describe the structure of alkenes | **1. Alkenes**

**Figure 7.** Teflon cooking utensils containing tetrafluoro ethene (Source: https://greenlivingideas.com/2012/06/13/how-toxic-is-teflon/)

**Do you have any cooking utensils in the form of Teflon?** Yes, Teflon is often used by mothers to cook in the kitchen.

Teflon is a cooking tool that contains tetrafluoro ethene, one of which is an alkene compound.

**Surely you've seen plastic, right!** Because plastic is still often used in everyday life. **Did you know, plastic contains polyethene.**

Polyethylene is a polymer of ethene (ethylene), that is polyethylene is a long chain arrangement of ethene (ethylene)!

| 1. Alkenes | **Figure 8.** Plastic contains polyethylene (Source: https://id.wikipedia.org/wiki/Poliethylena) |

The environment allows a more meaningful learning process because students are exposed to the actual conditions. Studying chemistry by using natural phenomena is more beneficial for students and experiences friendly with nature are more likely to prepare positive feelings for students towards learning chemistry. So that chemistry teaching materials to develop a Knowledge Building Environment are suitable for use by teachers and students in the learning process.

4. Implications
The last stages in 4S TMD are characterization and didactic reduction. The developed chemistry book can only explore the basic competencies and chemical concepts contained in the 2013 curriculum. The chemistry books on hydrocarbon materials that have been developed can be used as a reference for finding reading sources in chemistry subjects.

5. Conclusion
The feasibility of chemical teaching materials has been categorized as very feasible and meets the feasibility aspect of teaching materials with the percentage of eligibility in the content eligibility component reaching 87.5% (very feasible); linguistic reach 92.86% (very feasible); serving reached 87.5% (very feasible); the graphic reached 80.54% (feasible) and the KBE component reached 87.5% (very feasible). So that the chemistry teaching materials of hydrocarbon materials to develop the Knowledge Building Environment are suitable for use by teachers and students in the learning process. The comprehension of chemistry teaching
materials was categorized as high and find the aspect of understanding, with an average result of learning material comprehension of 89.47%. So that this chemistry teaching material can help students improve conceptual understanding of hydrocarbon material. It is proven that the chemical teaching materials of hydrocarbon materials prepared using the 4S TMD method have the potential to develop the value of Knowledge Building Environment. Based on the description above, it can be concluded that the two last stages in 4S TMD, namely characterization and didactic reduction, are very influential in the success of developing teaching materials that contain Knowledge Building Environment values that are very easy to understand for students and reduce abstract concepts that can create multiple understandings for learners.

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References
[1] Scardamalia M and Bereiter C 2003 Sage Publications
[2] Kiarie S M 2016 Int. J. Environ. Sci. Educ. 11 12 5736–5761
[3] Oktasari C, Priscylio G and Rachman F A 2019 8 3 300–311
[4] So H-J, Seah L H and Toh-Heng H L 2010 Comput. Educ. 54 2 479–490
[5] Dukerich L 2015 J. Chem. Educ. 92 8 1315–1319
[6] Aisah I, Anwar S and Sumarna O 2020 J. Phys. 1469
[7] Robinson T J, Fischer L, Wiley D and Hilton J 2014 Educ. Res. 43 7 341–351
[8] Birisci S and Metin M 2010 Asia-Pacific Forum Sci. Learn. Teach. 11 1 1–16
[9] Lei C and Chan C K K 2018 J. Comput. Educ. 126 153–169
[10] Fibrianto S, Supriatna A, Hendayana S and Oktasari C 2019 Proc. ICES 2019 Educ. No Boundaries as a Chall. Soc. 5.0 63–66
[11] Andrianto Y 2017 2nd Int. Semin. Chem. Educ. 12–13
[12] Oktasari C, Anwar S, Priscylio G, Wahyuni W S, Agustina N R and Lestari O 2020 J. Phys. 1567
[13] Oktasari C, Anwar S, Priscylio G, Agustina N R, Lestari O and Wahyuni W S 2020 J. Phys. 1469
[14] Lestari O, Anwar S, Priscylio G, Agustina G, Wahyuni W S and Oktasari C 2020 J. Phys. 1567
[15] Agustina N R, Anwar S, Priscylio G, Lestari O, Oktasari C and Wahyuni W S 2020 J. Phys. 1567
[16] Salmawati, Anwar S and Priscylio G 2019 ACM Proceeding Int. Conf.
[17] Priscylio G, Anwar S and Salmawati 2019 ACM Proceeding Int. Conf.
[18] Munawwarah M, Anwar S and Sunarya Y 2017 J. Phys.
[19] Syamsuri B S, Anwar S and Sumarna O 2017 J. Phys. 895
[20] Munawwarah M, Anwar S and Sunarya Y 2017 J. Phys. 895
[21] Arifin and Anwar S 2016 J. Pendidik. Fis. Indones. 12 1 8–18
[22] Nyachwaya J M and Gillaspie M 2015 Chem. Educ. Res. Pract. 17 1 58–71
[23] Bierema A M.-K, Schwartz R S and Gill S A 2017 J. Res. Sci. Teach
[24] Ferreira C, Baptista M and Arroio A 2013 J. Balt. Sci. Educ. 12 4 509–524
[25] Hendri S and Anwar S 2019 J. Educ. Sci. Technol. 5 2 130–139
[26] Rahman D F, Chandra D T and Anwar S 2019 J. Phys. 1157
[27] Lestari O, Anwar S, Priscylio G, Wahyuni W S, Oktasari C and Agustina N R 2020 J. Phys. 1469
[28] Agustina N R, Anwar S, Priscylio G, Oktasari C, Wahyuni W S and Lestari O 2020 J. Phys. 1469
[29] Syamsuri B S, Anwar S and Sumarna O 2017 Int. Conf. Math. Sci. Educ.
[30] Hidayah D N, Kaniawati I and Anwar S 2019 Sci. Technol. Eng. Math. Learn. 626–635
[31] Wahyuni W S, Anwar S, Priscylio G, Lestari O, Agustina N R and Oktasari C 2019 1st Int. Sem. STEMEIF 225–238