How to develop student creativity through teaching materials of hydrocarbon SETS-based?

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Abstract. This study aims to produce teaching materials of hydrocarbon SETS-based to develop student creativity through 4S TMD method. This article is the important part of the development of teaching materials that includes the selection and structuration steps. In the selection step, developing of indicators, explaining the concept of hydrocarbon using standardized textbooks sources, and developing student creativity and SETS aspects that can be integrated into hydrocarbon materials. Furthermore, in the structuration step, organizing concepts and materials into concept maps, macro structures, and multiple representations. The result of the two steps in the important part of this study produced a draft of SETS-based teaching material. Evaluation of the draft of teaching material has done by expert lecturers in the field of chemical education. The results show that the teaching material developed have been in conformity with the curriculum, scientifically correct, student creativity and SETS aspect is compatible with the subject matters, and concept maps, macro structures, multiple representations developed have been valid.

1. Introduction
Based on preliminary studies, it has been found that the circulating chemistry materials, especially on hydrocarbon matter, have not been fully in accordance with the curriculum requirements and are not scientifically correct. The breadth and depth of the material presented are not fully in accordance with the curriculum requirements and the material presented is also not entirely correct scientifically [1]. Though teaching materials is one of the main components in the learning process. Because in the process of teaching and learning there is a transformation of science (teaching materials) from the teacher to the students, from the transformation the students gain learning experience [2].

Teaching materials serve as guidelines for teachers who will direct all their activities in the learning process, as well as a substance of competence that should be taught to students, guidelines for students who will direct all activities in the learning process, as well as a substance of competence that should be studied, and learning achievement evaluation instrument [3].

Furthermore, hydrocarbon material was also identified difficult for students. There are various misconceptions on hydrocarbon matter, such as the concept of carbon atomic uniqueness, the concept of bond between atoms, and the concept of a closed chain [4]. Therefore, the authors feel the need to develop teaching materials on hydrocarbon material. The development of teaching materials was done using the Four Steps Teaching Material Development (4S TMD) method because of the clear and detailed developmental steps [2].

The development of SETS-based teaching materials (Science, Environment, Technology, and Society) engage students to try to relate the scientific aspect to the appropriate aspects of the environment, technology, and society as a form of integrated interconnection [5]. Therefore, through the
SETS approach, it is expected to provide students with awareness of the various benefits of science they are learning, bringing students closer to real-life, so that students can solve problems that arise in daily life.

The development of teaching materials with the SETS approach can help develop students' creativity significantly [6] [7]. And creativity development is one of the important competencies as part of life skills that became one of the goals of national education [8]. Therefore, the purpose of this research is to produce teaching materials of hydrocarbon SETS-based to develop student creativity through 4S TMD method.

2. Experimental Method
The study design used is the developmental research with the stages of the procedure, namely design, development, and evaluation [9]. In the design stage, a study of the teaching materials that has been circulated, especially on hydrocarbon material. Development stage of teaching materials is done by 4S TMD method. The 4S TMD method consists of four developmental steps, namely selection, structuration, characterization, and didactic reduction [2]. This article is the important part of the development of teaching materials consisting of the steps of selection and structuration. The selection step begins with the development of hydrocarbon material indicators, further explaining the hydrocarbon concept using standardized textbook sources, and developing aspects of creativity and SETS that can be integrated into teaching material of hydrocarbon. At the step of the structuration is done the development of concept maps, macro structures, and multiple representations of hydrocarbon material. The selection and structuration steps produced a draft of SETS-based hydrocarbon teaching material. At each step of this study conducted evaluation by expert lecturers.

3. Result and Discussion

3.1. Selection Step
The selection step consists of three main sections. The first part is the development of indicators. Development of indicators should be in accordance with curriculum requirements [3]. The teaching materials developed on hydrocarbons, consisting of KD 3.1 and 4.1. KD 3.1 contains the main concept of hydrocarbon material, while KD 4.1 is practicum. Subsequently identified concept labels related to indicators that have been developed. The development of indicators and concept labels can be seen in Table 1.

<table>
<thead>
<tr>
<th>KD</th>
<th>Indicators</th>
<th>Concept labels</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Analyzing the structure and properties of hydrocarbon compounds based on understanding the uniqueness of carbon atoms and the classification of their compounds</td>
<td>1. Explaining the uniqueness of carbon atoms</td>
<td>1. The uniqueness of carbon atoms</td>
</tr>
<tr>
<td></td>
<td>2. Analyzing the type of C atom based on the number of C atoms bound to the chain of carbon atoms (primary, secondary, tertiary, and quaternary C atoms)</td>
<td>2. Primary, secondary, tertiary, and quaternary C atoms</td>
</tr>
<tr>
<td></td>
<td>3. Classifying hydrocarbon compounds based on structures and bonding saturation</td>
<td>3. Hydrocarbon</td>
</tr>
<tr>
<td></td>
<td>4. Summarizing the general formula of alkanes, alkenes and alkyynes based on the analysis of structural formulas and molecular formulas</td>
<td>4. Aliphatic, alicyclic, aromatic hydrocarbons</td>
</tr>
<tr>
<td></td>
<td>5. Naming the alkanes, alkenes and alkyynes according to the IUPAC rules</td>
<td>5. Saturated and unsaturated hydrocarbon compounds</td>
</tr>
<tr>
<td></td>
<td>6. The physical properties of alkanes, alkenes, and alkyynes</td>
<td>6. Alkanes, alkenes, and alkyynes</td>
</tr>
<tr>
<td></td>
<td>7. Isomers</td>
<td></td>
</tr>
</tbody>
</table>
6. Relating alkanes, alkenes, and alkynes with the regularity of their physical properties (boiling point and melting point)
7. Explaining the meaning of isomers
8. Determining the isomer of hydrocarbon compound
9. Distinguishing the type of alkane, alkene and alkynes reactions.
10. Describing the usefulness of hydrocarbon compounds in daily life

Table 1 shows 10 indicators developed from KD 3.1. To see the appropriateness of indicators developed with basic competencies, a review is done by expert lecturers. So that the teaching materials are developed in accordance with the requirements of the curriculum. Furthermore, the determination of concept labels in accordance with the indicators is done to find out the core concepts of hydrocarbons to be presented in the teaching materials.

The second part of the selection step is explaining the material from the concept labels that have been identified. The main source of material descriptions comes from standardized textbooks. Standardized textbooks are required as a definite reference that can guarantee the truth of the concepts described [2]. A total of 12 standardized textbooks are used as a reference in the development of this teaching material, namely Chemistry The Central Science by Brown, et.al, General Chemistry by Chang & Overby, Introduction to General Organic and Biochemistry by Hein, et.al, Fundamental of General Organic and Biological Chemistry by Holman, Chemistry Principles and Modern Applications by Petrucci, General Chemistry Principles and Modern Applications by Petrucci, et.al, Chemistry by Silberberg, Principles of General Chemistry by Silberberg, and Chemistry by Zumdahl & Zumdahl.

The third part of the selection step is to analyzing the values that can be integrated in the hydrocarbon teaching material. The values developed are religious, curiosity, reading, meticulous, environmental care, and creativity. Table 2 shows examples of values that can be integrated with hydrocarbon teaching material.

**Table 2.** Value linkage with hydrocarbon concepts.

<table>
<thead>
<tr>
<th>Concept description</th>
<th>Related value</th>
<th>Value linkage with concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>The perfect hydrocarbon combustion reaction will produce CO₂ and H₂O gases.</td>
<td>Environmental care and creativity</td>
<td>At the moment, plastic packaging is so widely used. So most household waste is plastic.</td>
</tr>
<tr>
<td>For example an ethene combustion reaction (monomer from plastic packaging materials):</td>
<td></td>
<td>This will cause a buildup of plastic waste. Plastics are hard to degrade in the soil.</td>
</tr>
<tr>
<td>2C₂H₄(g)+3O₂(g)→2CO₂(g)+2H₂O(g)</td>
<td></td>
<td>If in the waste arbitrarily to the ground can cause a decrease in soil fertility, but it</td>
</tr>
<tr>
<td></td>
<td></td>
<td>can also cause flooding. To avoid this, some people burn this plastic waste. Though</td>
</tr>
<tr>
<td></td>
<td></td>
<td>plastic waste which is a hydrocarbon compound if burned will produce CO₂ gas. This gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>can cause increased geothermal (global warming). Better align, if plastic waste is reused.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For example, make hand-crafted bags.</td>
</tr>
</tbody>
</table>

Table 2 shows the values of environmental care and creativity in the concept of hydrocarbon combustion reactions. This teaching material was developed with SETS based. The phenomenon presented in the teaching materials is made in such a way, that is the aspect of science with the environmental and technological aspects that are directly perceived by the society of the advantages and disadvantages. So
that learning can be closely related to the daily life of students. Because the best way to help students learn is to introduce it to real life situations [10].

Based on the review by the expert lecturer, the results of the development at the selection step indicate that the developed indicators have been in accordance with the curriculum requirements, the explanation of the hydrocarbon material scientifically correct, the creativity and the SETS aspects developed in accordance with the hydrocarbon material.

### 3.2. Structuration Step

At the step of structuration is generated concept maps, macro structures, and multiple representations. Concept maps provide an opportunity for students to think about the relationship between the terms of the science they are learning, helping students to be able to visualize the relationship between key concepts systematically, and reflect on students' understanding [11]. The concept maps are reviewed by expert lecturers and can be seen in Figure 1.

![Concept maps of hydrocarbons](image1)

**Figure 1.** Concept maps of hydrocarbons

![Macro structures of hydrocarbon](image2)

**Figure 2.** Macro structures of hydrocarbon

Figure 2 shows the macro structures of hydrocarbon. The hydrocarbon concepts are mapped into two dimensions, namely the dimensions of progression and elaboration. The progression dimension is a
vertical dimension that shows the macro concept. While the dimension of elaboration is a horizontal dimension that shows the micro concept. The prepared macro structure has passed the review and suggestion step of the expert lecturer. The macro structure shows the conceptual position in the building of the learning material structure [2]. In other words, the preparation of macro structures is needed as a guideline for the presentation of materials in teaching materials, so that the learning materials are developed systematically.

Multiple representation shows the practice of representing the same concept to students with different representation forms [12]. In understanding chemistry, students must be able to use three levels of representation i.e macro, submicro, and symbolic [13]. The macroscopic level refers to the nature of real and visible chemical phenomena or measurable properties. The submicroscopic level provides an explanation of the phenomena experienced by the senses at the particulate level (the level of atoms, ions, molecules). Symbolic level refers to the use of chemical symbols, formulas, equations, diagrams, and models to symbolize matter [14]. The results of the hydrocarbon concept selection are drawn into these three levels of representation. Multiple representations made have been through the reviews and suggestions of expert lecturers. Example of multiple representation on hydrocarbon matter can be seen in Table 3.

Table 3. Multiple representation of hydrocarbon.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Multiple Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Macroscopic</td>
</tr>
<tr>
<td>Alkanes</td>
<td>LPG is a propane or butane gas from liquefied natural gas. Propane or butane gas is a hydrocarbon compound that forms a single covalent bond between the carbon atoms (C-C) and belongs to the alkanes group.</td>
</tr>
<tr>
<td></td>
<td>Currently LPG (Liquefied Petroleum Gas) is widely used by the society, especially for gas stove fuel.</td>
</tr>
</tbody>
</table>

The result of the development of the structuration step shows that concept maps, macro structures and multiple representations developed are valid. The results of multiple representations are then organized into a draft of learning material accordance to the macro structure that has been compiled.

4. Conclusion
The development of SETS-based hydrocarbon teaching material has been done with the 4S TMD method, especially at the selection and structuration step. The results of the evaluation of the selection step indicate that the developed teaching material has been in accordance with the curriculum requirements, scientifically correct, the creativity and the SETS aspects developed in accordance with the hydrocarbon material. The result of the evaluation of the structuration step shows that concept maps, macro structures and multiple representations developed are valid. The results of the two steps in the important part of this study are the draft of SETS-based teaching materials.

5. Acknowledgments
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6. References


[8] Depdikbud 2003 Undang-Undang No. 20 Tahun 2003, tentang Sistem Pendidikan Nasional (Jakarta : Depdiknas)


