DEVELOPMENT OF TEACHING MATERIALS BASED ON SCIENCE PROCESS IN THE VOCATIONAL SCHOOL OF HYDROCARBON COMPOUNDS

Galuh Isna Permata*[1] dan Rusmini[2]

[1,2] Department of Chemistry Education, Faculty of Mathematics and Natural Sciences
Universitas Negeri Surabaya

**Corresponding author: galuhisnap59@gmail.com*

Abstract. *This study aims to determine the validity, practicality, and effectiveness of teaching materials based on science process skills in hydrocarbon compounds for vocational students. This type of research is development research using 4-D models proposed by Thiagarajan. The targets of this study were 34 students of class XI of SMK Negeri 5 Surabaya in semester 1. Data collection techniques using the questionnaire method, student observation methods, and test methods. The data obtained were analyzed using quantitative analysis methods. The results of the study can be concluded that declared valid with an average percentage value of 78.00%, very practical with an average percentage interpretation value of 95.15%, and declared effective with an average percentage interpretation value of 75.88%.*

Keywords: *teaching materials, science process skills, hydrocarbon.*

INTRODUCTION

Education is a human need whenever and wherever humans are [1]. The 2013 curriculum prepares students to be able to live as someone who is faithful, productive, creative, innovative and affective and able to contribute to society, nation, state and world civilization.

Chemistry is closely related to everyday life. However, we know that most chemical concepts are abstract [2]. This abstract nature makes chemistry tends to be a difficult subject for most students. To make it easier to understand the concept, teaching materials are needed that are relevant to the development of today's science [3]. Teaching materials are defined as something that contains learning messages, both of a special nature

as well as general and utilized for the benefit of learning [4]. Teaching materials are used when learning activities take place both for teachers and students to direct learning in the classroom so that later it is in accordance with the ultimate learning objectives [5].

Science process skills (KPS) a series that can help students master their scientific skills in the field of science, can strengthen their knowledge and understanding of scientific theories and concepts and then develop them, as well as instill a scientific attitude with noble values [6]. The concept discovery process involves the basic skills needed [7]. However, it also builds scientific concepts in the cognitive structure of students [8]. KPS stimulates students' learning curiosity and develops students' knowledge [9]. KPS also allows students to test various methods/methods of scientific inquiry to enrich scientific knowledge [10]. As a result, to develop continuous learning, students need to apply scientific skills intensively [11]. These skills are attainable with scientific experiments that can be carried out and improved through laboratory activities [12]. KPS requires more experience such as the ability to observe, collect data, interpret and make hypotheses [13]. If students are actively involved in various scientific investigations they are more confident in mastering KPS [14]. Of course this affects the ability of students to solve/overcome the problem.

Therefore, KPS is very important to implement because the development of science is getting faster and more advanced so students must be accustomed to developing knowledge, discovering new knowledge, and being able to find their own scientific concepts according to their abilities [15].

There are 4 underlying reasons that KPS needs to be implemented, namely: (1) The development of science and technology (IPTEK) is getting faster. (2) Students tend to understand complex and abstract concepts when accompanied by concrete examples. (3) Science and technology discoveries and developments are relative (not 100% absolute). (4) Concept development is accompanied by the development of attitudes and values contained in students [16].

Based on the results of pre-research conducted on 35 students at SMK Negeri 5 Surabaya on Friday, 11 October 2019, it was found that there were still students who had not completed their KPS. Evidenced by 68.57% of students did not know the concept of hydrocarbon compounds and 31.43% of students knew the concept of hydrocarbon compounds. In addition, the KPS of SMK students is still relatively low in the KPS component of observing, planning science research, recording data, analyzing experimental data, and making conclusions so that KPS of SMK students needs to be trained. As many as 48.57% of students were unable to formulate hypotheses; 51.43% of students can formulate hypotheses; 68.57% participants students cannot design experiments; 31.43% of students can design experiments; 57.15% of students could not analyze the experiment; 42.85% of students can analyze the experiment; 40% can make conclusions and 60% cannot make conclusions.

According to 54.29% of students, the teaching materials used in the learning process have never used teaching materials that contain KPS on hydrocarbon compound material. Hydrocarbons are the simplest organic compounds. Where this compound consists of hydrogen atoms and carbon atoms [17]. Hydrocarbon compounds are found in everyday life. For example the use of LPG gas when cooking, refueling gasoline at gas stations, and the fruit ripening process. In the 2013 Industrial Chemistry Vocational High School curriculum, hydrocarbon compounds are included in the adaptive subjects contained in KD 3.9 Analyzing the structure, properties of hydrocarbon compounds and the impact of burning hydrocarbon compounds on the environment and health and how to overcome them. In this KD, students are expected to be able to distinguish and know the properties of hydrocarbon compounds. In the material of hydrocarbon compounds students will be trained in science process skills. KPS is very important to implement because the development of science is getting faster and more advanced so students must be accustomed to developing knowledge, discovering new knowledge, and being able to find their own scientific concepts according to their abilities [15]. In this regard, relevant KPS-based teaching materials are needed for SMK students, especially SMK majoring in Industrial Chemistry to make it easier to understand chemical concepts.

KPS-based teaching materials can be used as a learning resource for vocational students in understanding the concept of hydrocarbon compounds and their application in everyday life. This teaching material guides students to understand the concept of hydrocarbon compounds as well as trains students' KPS.

METHOD

Research development using the 4-D model proposed by Thiagarajan. The research targets were 34 students of class XI at Industrial Chemistry Vocational High School. The research instruments used were validation sheets, response questionnaire sheets, activity sheets, and KPS test sheets as well study result test sheet.

Data collection techniques using the questionnaire method, student observation methods, and test methods. The validation sheet contains a rating scale from the validator on the quality of teaching materials.

Questionnaires are used to determine student responses. Observation is used to observe student activity. The test is used for KPS assessment and learning outcomes.

Research data were analyzed in a quantitative descriptive manner using a Likert scale.

Table 1. Likert Score Scale

Score	Category
1	Very bad
2	Bad
3	Less
4	Good
5	Very Good

The percentage of validity assessment data is calculated using the following formula:

$$P\ (\%) = \frac{Total\ score}{Criteria\ score}\ \text{x}\ 100\%$$

Then it will be interpreted in table 2.

Table 2. Score Interpretation Criteria

Percentage (%)	Criteria
0-20	Invalid
21-40	Less valid
41-60	Valid enough
61-80	Valid
81-100	Very valid

[18]

The percentage of validity is good if you get a percentage of ≥ 61%.

Student response questionnaire data was analyzed in a quantitative descriptive manner. Percentages are calculated on the Guttman scale.

Table 3. Guttman Score Scale

Statement	Score
No	1
Yes	0

The percentage of results in this calculation use the following formula:

$$P\ (\%) = \frac{\sum response\ every\ aspect}{\sum response\ of\ all\ students}\ x\ 100\%$$

Then it will be interpreted in table 4 so that the practicality of KPS-based teaching materials is known.

Table 4. Score Interpretation Criteria

Percentage (%)	Criteria
0-20	Not practical
21-40	Less practical
41-60	Practical enough
61-80	Practical
81-100	Very practical

[18]

The results of student activity data were analyzed descriptively quantitatively. Percentages are calculated using the Guttman scale which are then interpreted in table 4.

Student KPS test analysis is used to analyze KPS through pretest and posttest question sheets. The scoring value is calculated by a formula:

$$Value = \frac{total\ score}{criteria\ score}\ x\ 100$$

The data that has been obtained will then be interpreted in table 5 as follows:

Table 5. Score Interpretation Criteria

Percentage (%)	Criteria
0-20	Not effective
21-40	Less effective
41-60	Effective enough
61-80	Effective
81-100	Very effective

KPS test data analysis is used to determine the completeness of individual KPS test results. Individual completeness if it reaches ≥ 75%.

Then the KPS test scores were tested using the gain score to determine the increase before and after.

Learning achievement test sheets were analyzed descriptively quantitatively. Percentages are calculated by scoring values which are then interpreted in table 5. The learning result test sheet is used to determine the completeness of the classical learning outcomes. Classical completeness if you get a percentage of > 75%.

RESULT AND DISCUSSION

The teaching materials developed are development research using the 4-D model proposed by Thiagarajan. This model consists of 4 stages, namely define, design, develop and disseminate. But at the disseminate stage it was not carried out because it was only for testing the feasibility of teaching materials. This teaching material contains theory and material concepts of KPS-based hydrocarbon compounds through scientific phenomena raised in everyday life. Students are also required to think and master their scientific skills through KPS questions presented in teaching materials. Furthermore, the teaching materials were assessed by three chemists to find out whether they met the eligibility criteria or not. Eligibility criteria are assessed using 3 assessment points, namely assessments based on validity, practicality, and effectiveness so that teaching materials that are suitable for use will be obtained.

Fase Define (Definition)

The define stage is carried out to determine and define development requirements. There are five steps in this stage, namely end analysis, student analysis, concept analysis, task

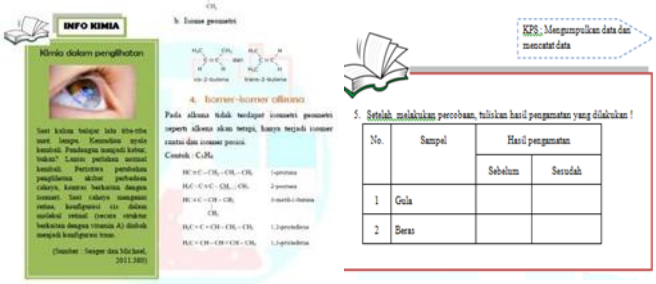
analysis, and learning objectives analysis. Front end analysis aims to identify and define the basic problems encountered in learning.

Student analysis is a study of the characteristics of students in accordance with the design of the development of teaching materials. Concept analysis, namely identifying the main concepts to be taught, arranging them in a hierarchical form, and detailing individual concepts into critical and irrelevant matters such as analyzing the concept of hydrocarbon compounds based on KPS. Task analysis is the task given to students in KPS-based teaching materials. Analysis of learning objectives aims to convert the results of task analysis and concept analysis into learning objectives in the classroom.

Fase Design (design)

The design stage is used to design teaching materials on KPS-based hydrocarbon compounds. There are two steps in this stage, namely the selection of teaching material formats and the initial design of teaching materials. The selection of formats for teaching materials pays attention to the suitability aspects of content, presentation, language, and graphics. This is in accordance with the requirements for preparing teaching materials which state that teaching materials contain the following criteria: cover title, preface, table of contents, instructions for using teaching materials, competency of teaching materials to be achieved and supporting information, tasks and steps as well as a list References [19]. The initial design of teaching materials begins with expert guidance regarding aspects of content, presentation, language, and graphics so that they are appropriate when used. The initial design of teaching materials can also be called draft I. The following is the initial design of KPS-based teaching materials:

Pigure 1. Cover Based Teaching Materials KPS



Pigure 2. Content Features in KPS-Based Teaching Materials

Pigure 3. Material on KPS-Based Teaching Materials

Fase Develop (Develop)

The development stage is carried out in order to produce valid teaching materials in accordance with the suggestions and comments of experts. There are four steps in this stage, namely review, revision, and validation, as well as testing of KPS-based teaching materials. The initial design of the teaching material which was draft I was reviewed by a chemist and asked to provide suggestions for improvement. The teaching materials were then revised according to the suggestions for improvement given. The result of the revision is called draft II. Draft II was then validated by chemists and given an assessment in accordance with the eligibility criteria in terms of content, presentation, language, and graphic suitability criteria. Teaching materials that have been validated, then tested on 34 class XI students of SMK Negeri 5 Surabaya in semester 1.

Eligibility Based on Validity, The validity of the teaching materials was carried out by three chemists. The results of the validation were analyzed in terms of suitability of content, presentation, language and graphic criteria. The validity results are shown in table 6.

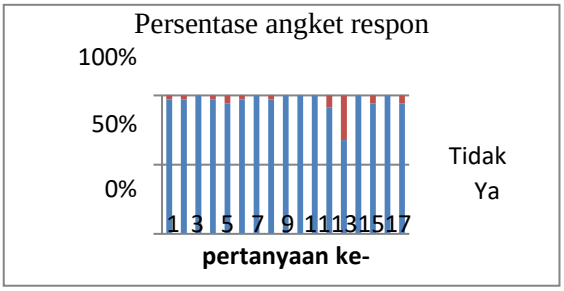
Table 6. Validation results

Eligibility criteria	Percentage (%)	Category
0-20	80,00	Valid
21-40	73,33	Valid
41-60	80,00	Valid
61-80	78,67	Valid
% Average	78,00	Valid

Based on the acquisition of validity values, teaching materials are said to be good/valid according to the Likert scale [19]. The assessment is carried out to see the content of teaching materials and their relevance which can improve KPS so that the teaching materials developed are declared valid [20]. The content criteria met the standard, namely 80.00% where the teaching materials developed were in accordance with the relevant materials and KPS components. All aspects of the presentation criteria obtain a percentage of 73.33% with appropriate criteria. This presentation criterion includes covers related to the contents of the teaching materials. Like the cover image, it must represent the contents of the teaching materials, the problems and phenomena raised in the teaching materials are in accordance with the subject matter being discussed in the teaching materials, namely the material of hydrocarbon compounds. All aspects of the language criteria obtain a percentage of 80.00% with appropriate criteria. This language criterion includes the use of good and correct language, sentences used in teaching materials do not contain double meanings so as to create effective sentences. All aspects of the graphical criteria obtained a percentage of 78.67% with the appropriate criteria. The graphical validation that was assessed was the suitability of the image illustrations with the content, the use of fonts that make it easier for readers, and attractive designs and good and colorful print quality.

Practicality Of Teaching Materials

The practicality of teaching materials is carried out using the questionnaire method given by students as research subjects and methods of observing student activities. The results of the response questionnaire are presented in Figure 4.



Pigure 4. Student Response Questionnaire Results

Based on the results of the response questionnaire obtained, the average percentage of all criteria is 96.16%. This response questionnaire consists of 17 questions that contain aspects of content criteria, presentation criteria, and language criteria as well as graphical criteria. The content criteria contained 7 questions, namely question number 4 materials in KPS-based teaching materials are easy to understand 97.06%; question number 8 KPS-based teaching materials make it easier to learn 97.06% hydrocarbon material; question number 9 determines the purpose of the experiment 100.00%; question number 10 KPS-based teaching materials guide students to write hypotheses 100.00%; question number 11 KPS-based teaching materials guide students to design a research 100.00%; question number 12 KPS-based teaching materials guide students to record observational data in tabular form 91.18%; question number 13 students have difficulty analyzing data 67.68%; question number 14 KPS-based teaching materials guide students to formulate 100.00% conclusions. There are 2 questions in the presentation criteria, namely question number 5, the presentation of KPS-based teaching materials according to the example problems of 94.18%; question number 7 presentation of practice questions helps students to understand the material of 100% hydrocarbon compounds. The language criteria contained 3 questions, namely question number 6 the terms of KPS-based teaching materials were easy to understand 97.6%; question number 16 letters and sentences in teaching materials clear and easy to understand 100.00%; question number 17 the language used is easy to understand 94.18%. Graphically there are 4 questions, namely question number 1 KPS-based teaching materials attract 97.06%; question number 2 the appearance of KPS-based teaching materials is

interesting and fun 97.06%;question number 3 the appearance of KPS-based teaching materials aroused students' motivation to learn 91.17%; question number 15 KPS-based teaching materials make the learning atmosphere fun 94.11%. This is in line with the research of Sholiha, A (2015), namely compliance with the content criteria of 99%. Serving 97%. Language 96%. Graphics 90.5% [21]. The response results support the application of the PPP approach because it is able to provide motivation in exploring knowledge, generate interest in learning and improve KPS. KPS is formed only through an iterative process [22].

The second practicality is reviewed from the results of observations of students' activities. These results are used to determine the activities of students during learning takes place. Activity was observed by 6 observers. When learning takes place, the activity is said to be active seen from the enthusiasm of students such as asking questions about their curiosity and working together in groups and being responsible for the tasks that have been given by the teacher. Furthermore, students are asked to express their ideas and theories about the problems that exist in teaching materials. Students also discuss with their groups when doing practicum to test their hypotheses and try to finish it on time according to the time given by the teacher. Learning activities during the limited trial get an average percentage of 97.43% categorized as very good. Learning can be carried out very well based on the scenario that has been planned. This is of course strongly supported by the use of valid teaching materials so that it directs the activities of students in the classroom and the learning process is said to be smooth and practical [20]. However, there are still those who are less active when learning takes place. Students are reluctant to express their opinions and choose to remain silent. Sometimes, the teacher appoints students to want to express their answers in class to solve given problem. KPS needs to be developed through direct experience by the teacher but focuses on student-centered [2].

Learning direct experience through the process of solving problems and capturing knowledge from reality will develop children's intellectual, mental and emotional [23]. If KPS is accustomed to being trained continuously in learning activities, then KPS will be formed and developed in students [24].

The effectiveness of teaching materials

Assessment of the effectiveness of teaching materials is reviewed through KPS tests and learning outcomes. The KPS tests taken were designing research, recording research data, analyzing data, and making conclusions. Before being trained in KPS, students were given pretest questions to use know their initial abilities.

Then, proceed with giving posttest questions after using KPS-based teaching materials. The assessment of the pre-test and post-test test sheets is to find out the improvement in students' KPS tests. The increase in the KPS test was then measured using the gain score. The increase in the KPS test must be in the "medium" and "high" categories so that a media can be said to be effective [25]. This gain score measurement is carried out for each KPS component taken. The first KPS component is designing the research presented in table 7.

Table 7. Research Data Design Skills

	Pretest	Posttest	Gain score
the average value of designing research data XI KI 3	37,47	83,06	0,72

Prior to the use of KPS-based teaching materials, students' skills in designing research data were still lacking. This is evidenced by the results of a low pretest score of 37.47%. The low value of the pretest based on the answers obtained lies in designing the experimental steps for identifying hydrocarbon compounds and producing ethyne gas (the reaction of calcium carbide with water). Most answers in making a move or the experimental procedure is not appropriate or incomplete with the answer key owned by the teacher. After implementing the use of KPS-based teaching materials, there was a significant increase of 83.06% with a gain score > 0.7 which was categorized as high. KPS is needed when a student conducts an experiment in practicum activities. The concept of learning lasts a long time in the brains of students when students

carry out experiments with their group mates [26].

The second KPS component is recording research data. The data results are presented in table 8.

Table 8. Research Data Recording Skills

	Pretest	Posttest	Gain score
the average value record research data XI KI 3	20,59	98,79	0,91

Prior to the use of KPS-based teaching materials, students' skills in recording research data were lacking. This is evidenced by the results of a low pretest score of 20.59%. After implementing the use of KPS-based teaching materials, there was a significant increase in posttest results of 98.79% with a gain score > 0.7 which was categorized as high. Individual completeness > 75%.

The third component is analyzing research data. The data results are presented in table 9.

	Pretest	Posttest	Gain score
the average value record research data XI KI 3	39,75	87,06	0,11

Based on table 9, analyzing student research data is still lacking. Most students write reactions that are correct, but the reactions that occur are not equal. So this makes the answer wrong. Then another point, I don't know why a flame test was carried out in an experiment to make ethane gas. The flame test serves to determine the presence of ethane gas which is marked by a flame large, yellow and flammable gas.

After implementing the use of KPS-based teaching materials, it experienced a significant increase with a gain score > 0.7 which was categorized as high.

The fourth KPS component is making conclusions. The data results are presented in table 10.

Table 10. Conclusion Skills

	Pretest	Posttest	Gain score
Average score Make a Conclusion	26,47	94,71	0,93

Based on the table above, after implementing the use of KPS-based teaching materials, there was a significant increase in posttest results of 94.71% with a gain score > 0.7 which was categorized as high. Individual completeness > 75. It is proven that there is an influence of the use of KPS-based teaching materials developed in the form of increasing the value of KPS skills. this is in line with the research of Salam A., Miriam, S., Arifudin, M., & Ihsan, Imam N. (2016) where the increase makes a very good conclusion 84.21% [20]. The KPS that is accustomed to being trained continuously in learning activities, the longer the KPS will be formed and develop in students [24].

The effectiveness of the second in terms of learning outcomes. Learning outcomes are the achievement of learning objectives that are assessed by the teacher towards students based on mastery of the concepts of the subject matter. Assessment of learning outcomes is carried out to determine understanding of the material and completeness of learning outcomes in a classical manner. The learning outcomes test is shown in table 11.

Table 11. Learning Outcomes Test

Score Interpretation Criteria	Amount (%)
Complete	26 (76,5)
Not complete	8 (23,5)

Based on the results presented in table 11, it was found that 76.5% of students completed which exceeded classical completeness by 75%. This is in line with the research of Ningsih, R., K. (2019).

Students' KPS learning outcomes have scored above 75 which indicates that the KPS aspect has been completed classically with a percentage of 100%. The results obtained prove that providing KPS training can increase students' knowledge and learning outcomes [27]. So that this can improve student academic achievement [28]. However, there were still 8 students who scored below the KKM. The

cause can be influenced by several factors such as the cognitive level of students.

Piaget explained how children adapt to the environment and interpret the events around it. Even so, the test results showed that on average students passed the test to practice their KPS abilities [29]. So that the developed KPS-based teaching materials facilitate students' understanding in learning.

Based on these results, the use of KPS-based teaching materials for SMK students is declared valid, practical and effective.

CONCLUSIONS

1. Teaching materials based on KPS on the developed hydrocarbon compounds are declared valid in terms of content, presentation, and language components by obtaining 78.00%.
2. The KPS-based teaching materials on hydrocarbon compounds that were developed were stated to be very practical based on the results of the student response assessment with an average percentage interpretation value of 95.15% and the activities of students during the limited trials obtained an average percentage of 97.43%.
3. Teaching materials based on KPS on hydrocarbon compounds that were developed were declared effective in training students' KPS based on an increase in KPS tests which were categorized as high and classical learning outcomes mastery of 76.5%.
4. Teaching materials based on KPS on hydrocarbon compounds are appropriate to be used as a source of learning while at the same time training KPS students because they have been declared valid, practical and effective

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