

# The Effect of Scientific-Based E-Worksheet on Hydrocarbon Material on Students' Critical Thinking Ability at Vocational High Schools

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## ABSTRACT

The purpose of this research was to know the effect of scientific-based e-worksheets on hydrocarbon material on student's critical thinking ability at vocational high schools. The method used in this study was pre-experimental and the research design was one group pre-test and post-test with one experimental class and no control class. The population in this study were students of class X of a state vocational high school in Pekanbaru, while the number of samples were 30 students in class X RPL (Software Engineering), who were selected by purposive sampling technique. The instrument used to obtained data of students' critical thinking skills was multiple choices (a, b, c, d and e) with a total of 25 questions and each question has 4 points. Data of pre-test and post-test was analyzed with N-gain score. The results showed that pre-test was 44% and post-test was 88%. The average N-Gain score was found to be 0.7745 with high criteria. It could be stated that there was a significant difference between the pre-test and post-test scores on students' critical thinking skills. Furthermore, the average percentage of the N-Gain score was 77.4483% with effective criteria. It could be concluded that the scientific-based e-worksheet on hydrocarbon material was declared effective for training students' critical thinking skills at vocational high school.

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## 1. INTRODUCTION

The quality of education in Indonesia needs to be continuously improved. One of them is by making efforts to train high-level thinking skills, which is a demand for 21<sup>st</sup>-century competencies including 4C namely critical thinking and problem-solving, creativity, communication skills, and ability to work collaboratively (Fernanda et al. al, 2019; Novitasari & Puspitawati, 2022). One of the four competencies in the 21<sup>st</sup> century is the ability to think critically for students. This ability is very important to be mastered and it is the key to success for professional educators (Changwong et al. 2018). Efforts by educators to assist students in facing 21<sup>st</sup>-century abilities are urgently needed so that students can further develop their abilities.

To prepare students to face the demands of 21<sup>st</sup>-century learning, educators must focus on developing students' critical thinking skills. With the increasing of technological advances, there will be

more challenges and problems for students and educators. Therefore, educators must apply their best efforts to overcome them (Ningrum et al, 2021). The world's rapid developments have an impact on educational competition, where students must be equipped with a critical attitude as a cognitive strategy to solve problems effectively (Ismail et al., 2018). That is, educators should focus on developing critical thinking skills to prepare students for 21<sup>st</sup> century learning.

Critical thinking is a perspective that generates interest and reflection by highlighting choices about what to do (Nold, 2017). Critical thinking skills have 6 aspects namely explanation, investigation, inference, assessment, explanation and self-regulation (Facione, 2015). Therefore, critical thinking is a cognitive ability in making a decision or conclusion based on logical reasons and accompanied by empirical evidence. The conclusions made are in accordance with an assessment based on empirical evidence (Agnafia, 2019). Critical thinking is very important for students to have because it can help them draw conclusions based on empirical facts and also make the right decisions in dealing with problems.

Chemistry learning is part of science which includes legal facts and principles resulting from scientific processes that require problem solving through critical thinking skills. Therefore, critical thinking skills are needed in the learning process at school, especially in chemistry learning (Irwanto et al, 2018). This is supported by the abstract concepts contained in the material of hydrocarbons. It is considered a difficult learning material (Kristin et al, 2019). Therefore, it required high-level thinking skills to understand it. However, based on previous studies, students' critical thinking skills were found to be still in the unsatisfactory category (Agnafia, 2019; Azrai et al, 2020; Benyamin et al, 2021; Irwanto et al, 2018; Suraya et al, 2020). Critical thinking skills are needed for chemistry learning, which is difficult and requires high-level thinking skills.

Based on interviews conducted by the chemistry teacher, and questionnaires distributed to students as a preliminary study in 3 vocational high schools, namely SMKN 2 Pekanbaru, SMKN Riau Pekanbaru, and SMK TELKOM Pekanbaru. The results of the interviews and questionnaires were obtained from many students whose chemistry scores had not yet reached the standard. The hydrocarbon material was considered difficult because it only contained rote material. Even though practically, hydrocarbon material is an influential material for vocational students. In addition, the application of learning focused on critical thinking skills has not been widely implemented in schools. Fernanda et al. (2019) revealed that one of the causes of students' low critical thinking skills was the lack of application of critical thinking skills exercises carried out by the teacher. Therefore, it really needs the effort to train students to use critical thinking skills and present interesting learning for students related to everyday events.

There are many ways to train students' critical thinking skills (Karakoç, 2016). Good critical thinking skills can be enhanced with the support of teaching materials that are attractive, appropriate, and designed by educators to accommodate critical thinking skills (Ega & Ratnasari, 2021). E-worksheet is a teaching material, which can help students to practice critical thinking skills (Fitria & Suparman, 2019; Habsyi et al, 2022; Novitasari et al, 2022). Learning activities in the e-worksheets can be structured in such a way as to accommodate students' critical thinking skills (Sujatmika et al, 2018). The e-worksheets in this study were created in the form of a flip book using the 3D Pageflip Professional application. This application has advantages such as being able to integrate various kinds of multimedia such as audio, music, animation, video, and hyperlinks into the e-worksheet. (Friska et al, 2022). E-worksheet made learning would be more interesting and easier for students to understand the content (Wahdatillah et al, 2022). E-worksheets are a teaching material that can help students practice critical thinking skills. They can be structured to accommodate students' critical thinking skills and can be created in the form of a flip book using the 3D Pageflip Professional application.

E-worksheets are developed on a scientific basis, which is a scientific approach to teach material can stimulate students to be more active, because this approach involves indicators such as observing, asking, gathering information, associating, and communicating (Amthari et al, 2021). The scientific approach is also included in the 2013 curriculum and is recommended by the Ministry of Education and Culture to be applied in learning (Munawarah & Surya, 2017). The application of scientific

indicators can also stimulate students' critical thinking skills. This is also supported by several previous studies that state that scientific-based e-worksheets can train students to improve their critical thinking skills (Ariq & Fitrihidajati, 2021; Herlyana et al, 2022; Wahono et al, 2022;).

The literature review from several relevant studies, namely the effect of mobile problem-based learning application did science PBL on students' critical thinking in physics concepts (Ismail et al, 2018); effectiveness of problem-solving based e-modules on students' critical thinking skills in motion and parabolic motion material (Wahyuni et al, 2020); and the effectiveness of using flipped classroom-based e-modules to train critical thinking skills (Rokhmania & Kustijono, 2017). However, there is no research yet about the effect of scientific-based e-worksheets on hydrocarbon material to students' critical thinking ability at vocational high school. It can be used as a solution to problems found in research introduction, that's why this research needs to be done.

Based on the description above, this study was focused on analyzing the effect of scientific-based e-worksheets on hydrocarbon material to students' critical thinking ability at vocational high school. This e-worksheet has been created with the 3D Pageflip Professional application.

## 2. METHODS

The purpose of this research was to know the effect of scientific-based e-worksheet on hydrocarbon material on student's critical thinking ability at vocational high schools. The method used in this research was a pre-experimental research method with a one-group pretest-posttest design. This test involved one class as an experimental class and no control class (Sugiyono, 2019). To find out students' critical thinking ability, the data was taken twice, namely a pre-test before treatment with scientific-based e-worksheet and a post-test after treatment. The research design can be seen in Table 1.

**Table 1.** One group pretest-posttest design

Subject	Pretest	Treatment	Posttest
Experiment Group	O <sub>1</sub>	X	O <sub>2</sub>

<sup>1</sup>O<sub>1</sub> is the pre-test score before being given treatment, X is the treatment, and O<sub>2</sub> is the post-test score after being given treatment.

The population in this study were students of class X SMKN2 in Pekanbaru, while the research sample was 30 students of class X RPL (Software Engineering). The sample was selected by using purposive sampling technique. The research was conducted in the odd semester of the 2021/2022 school year.

The test was used to determine the increase in students' critical thinking ability through pre-test and post-test. The test was multiple-choices (a, b, c, d and e) with total of 25 questions and each question has 4 points. The questions were made in Indonesian and based on indicators and sub-indicators of critical thinking ability by Robbert H. Ennis, one of the greatest figures of critical thinking (Sani, 2019). The indicators and sub-indicators can be seen in Table 2.

**Table 2.** Indicators and sub-indicators of critical thinking ability

Indicator	Sub-Indicator
Give a simple explanation	1. Focus on the problem 2. Analyze the arguments 3. Ask and answer questions, clarifications, or challenging questions
Build a basic ability	4. Consider the credibility of a source 5. Observe and consider the results of observations
Making inferences	6. Make deductions and consider the results of the deductions 7. Make an induction and consider the results of the induction 8. Make decisions and weigh the results
Give a further explanation	9. Defining terms and considering definitions 10. Identify assumptions
Setting strategies and techniques	11. Formulate and decide on an action 12. Present arguments orally or in writing

Several sub-indicators (Table 2) were not used in this study, namely (1) focusing on the problem, (7) making deductions and considering the results of the deductions, (8) making inductions and considering the results of the induction, and (12) presenting arguments orally and writing. The total sub-indicators used in the research are 8 sub-indicators.

The focus of this research is to determine the effect of scientific-based e-worksheet on hydrocarbon material on students' critical thinking abilities at vocational high schools, so that the test instruments used have been examined by Supervisor I and Advisor II. Pre-test was given to students before the treatment with scientific-based e-worksheet. Learning activities on hydrocarbon materials with scientific-based e-worksheet were carried out in 4 weeks with 4 meetings; (1) Specificity of the carbon atom; (2) hydrocarbon structure; (3) isomers of hydrocarbons; and (4) reaction of combustion of hydrocarbons. Students were directed to carry out learning activities with e-worksheet in 4 meetings. Each meeting carried out a learning evaluation. After 4 concepts of hydrocarbon material were studied with the e-worksheet, then students were given a post-test to measure their critical thinking ability after receiving treatment with the e-worksheet.

The difference between before and after treatment was analyzed with N-gain (Normalized gain) score. The N-gain score was calculated using Equation 1 with SPSS V 23 program application (Nashiroh et.al, 2020).

$$N - Gain = \frac{\text{Value of pretest} - \text{value of posttest}}{\text{Maximum value} - \text{value of pretest}} \quad (1)$$

The N-gain score was calculated based on the pre-test and post-test scores and could be interpreted with the criteria that can be seen in Table 3. Next, the N-gain score was made in the form of a percentage. This was used to illustrate the effectiveness of scientifically based E-worksheets on hydrocarbon material already applied to learning. The effectiveness criteria based on the percentage of the N-gain score can be seen in Table 4. This study was designed based on the research flow which can be seen in Figure 1.

**Table 3.** Criteria of N-Gain score

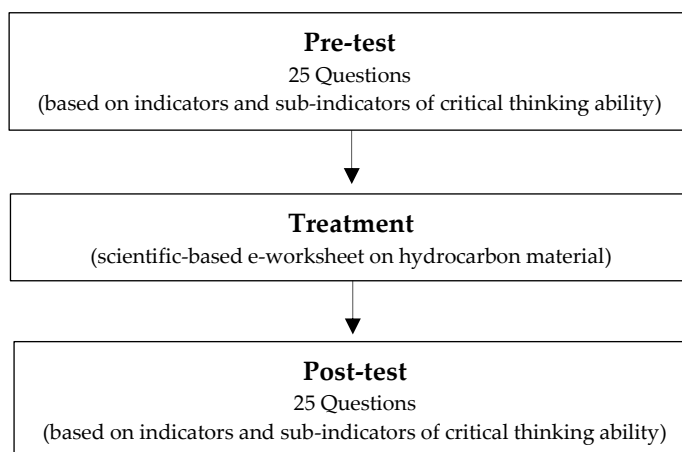
N-Gain score	Criteria
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Moderate
$g < 0,3$	Low

(Nashiroh et al., 2020)

**Table 4.** The effectiveness criterion obtained from the N-gain score

Percentage (%)	Criteria
< 40	Ineffective
40 - 55	Less effective
56 - 75	Effective enough
> 76	Effective

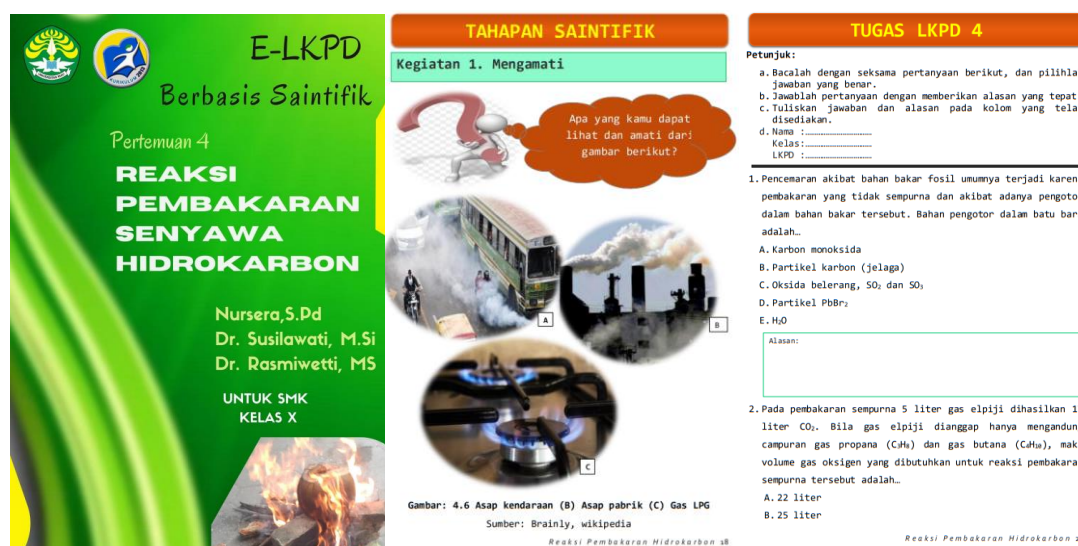
(Nashiroh et.al, 2020)



**Figure 1.** Research flow

### 3. FINDINGS AND DISCUSSION

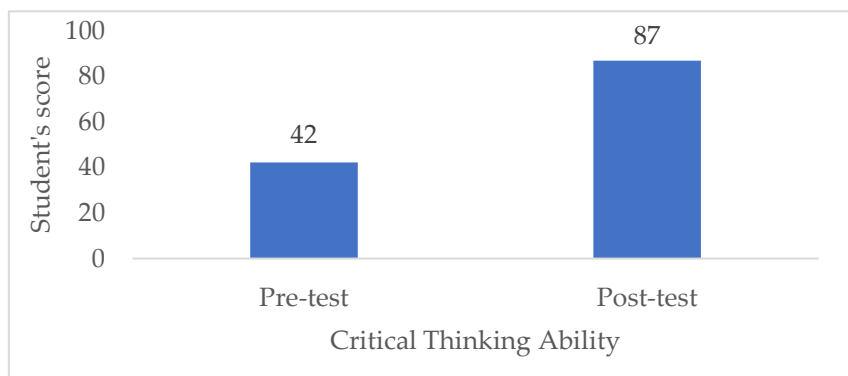
A scientific-based e-worksheet on hydrocarbon materials was developed using 3D Pageflip Professional and was designed in Indonesia. This study explored the results of its effect on students' critical thinking ability at vocational high schools. The display of the applied e-worksheet is shown in Figure 2.



**Figure 2.** The appearance of the E-Worksheet is scientifically designed

To find out students' critical thinking ability, the data was taken twice, namely a pre-test before treatment with scientific-based e-worksheet and a post-test after treatment. The results of the student Nurseira, Susilawati, Rasmiwetti / *The Effect of Scientific-Based E-Worksheet on Hydrocarbon Material on Students' Critical Thinking Ability at Vocational High Schools*

pre-test and post-test comparison are shown in Figure 3, and based on the sub-indicators of the pretest-posttest results are shown in Table 5.



**Figure 3.** Percentage of pre-test and post-test for critical thinking ability analysis

**Table 5.** Data on pre-test and post-test results obtained for students' critical thinking skill

Sub-indicator of Critical Thinking	Percentages (%)	
	Pretest	Posttest
1. Analyze the arguments	67	93
2. Ask and answer questions, clarifications or challenging questions	39	87
3. Consider the credibility of a source	37	91
4. Observe and consider the results of observations	27	83
5. Make deductions and consider the results of deductions	54	91
6. Defining terms and considering definitions	30	88
7. Identify assumptions	22	82
8. Formulate and decide action.	67	94
Average (%)	44	88

Based on Figure 2, students' critical thinking ability before using the e-worksheet obtained an average percentage of 44% and after learning to use the e-worksheet it was found to increase to 88%. This value indicates that the application of e-worksheets based on scientific material on hydrocarbons can be used to train students' critical thinking ability.

The difference in students' critical thinking abilities before and after the application of e-worksheets based on scientific hydrocarbon material or pretest and posttest can be shown by the N-Gain score. The results of calculating the N-Gain score can be seen in Table 6.

**Table 6.** The data obtained from the calculation of the N-Gain score

	N	Minimum	Maximum	Average	Std. Deviation
Values of N-Gain	30	0,23	1.00	0,7745	0,27848
Persentase nilai N-Gain	30	23.08	100.00	77.4483	27.84807
Valid N (listwise)	30				

Based on Table 6, the average N-Gain value is 0.7745 and the interpretation based on Table 2 is found to be high. It can be seen that there was improvement on students' critical thinking ability after the application of scientific-based e-worksheets. Based on the N-Gain score, it can be stated that there is a high difference in the pre-test and post-test scores. It means that there is a significant difference between before and after the application of scientific-based e-worksheets on hydrocarbon material on

students' critical thinking ability. Furthermore, Table 6 also shows the average percent value of N-Gain is obtained at 77.4483%, based on the criteria in Table 3, the percentage of N-Gain is found in the effective criteria. Furthermore, Table 6 also shows the average value of percent N-Gain obtained 77.4483%, based on the criteria in Table 3, the percentage of N-Gain is found in the effective criteria. It means that scientifically based e-worksheets on hydrocarbon material are effectively applied to train the critical thinking ability of vocational high school students.

The existence of a large difference between the pre-test and post-test of students' critical thinking ability after participating in learning using scientific-based e-worksheets was contributed because the used e-worksheets were made using scientific approach steps. These steps were applied in e-worksheets to accommodate students' critical thinking ability (Sujatmika et al, 2018). Asking questions and gathering information helps students criticize and analyse a problem. While the activities of associating and communicating information are used to assist students in concluding. Where these conclusions can be conveyed in accordance with the understanding of the students.

As mentioned in Table 5, the sub-indicator showing the greatest increase was identifying assumptions with a pre-test of 22% and a post-test of 82%. This result was contributed by an e-worksheet, which was given scientific steps in observing a problem or phenomenon in everyday life, for example, the presence of vehicle fumes, factory smoke, and gas stove fires. Students were then directed to make assumptions about the process by which these phenomena occur, which were associated with the concept of the occurrence of a hydrocarbon combustion reaction through a scientific step in the 'asking' activity. To prove this assumption, the e-worksheet provided a complete explanation accompanied by relevant videos through scientific steps in the 'information gathering' activity. Then through a scientific step in the 'associate' activity, students were asked to summarize the results of the analysis of the given phenomena based on the information obtained in the e-worksheet. Furthermore, in the 'communicating' activity, students were asked to argue about the initial assumptions, the information obtained and the conclusions drawn. This argument is supported by the opinion of Costa & Kallick (2014), that critical thinking is a mental process, and from this ability, individuals need to be active and skilled at conceptualizing, applying, analysing, synthesizing, and evaluating information to reach answers or conclusions.

Table 5 also shows the largest percentage value in the post-test was obtained in the sub-indicator 'formulate and decide on an action' with a percentage value of 94%. This was because the e-worksheet contains practice questions that could see students in determining actions in taking and solving problems related to hydrocarbon material. The questions given are shown in Figure 3.

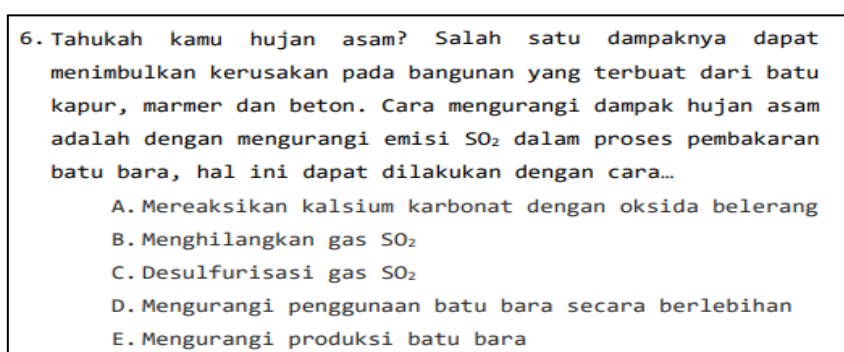


Figure 3. Display of Questions on the Sub-Indicator Formulating and Deciding an Action

Students analyzed the problem given, then students could be assisted by the content in the e-worksheet, then students should take action to solve the problem according to the concept of hydrocarbons. Thus, students could understand what was happening around them, for example, the area around an industry occurred in acid rain, because SO<sub>2</sub> and NO<sub>2</sub> gases were produced by the industry. Acid rain with a pH below 7 contributed to the corrosion of metals. To reduce the impact of

acid rain, the coal industry conducted desulphurization of SO<sub>2</sub> gas (SO<sub>2</sub> emissions). This aimed to absorb sulfur dioxide before it entered the chimney as a residue from burning hydrocarbon compounds using calcium carbonate. According to Ismail et al (2018), Ningrum et al (2021) and Novitasari et al (2022), that teaching materials that provide problems and problem-solving processes could have a positive influence on students' critical thinking abilities.

The research results were supported by several previous studies. The reasearch by Herlyana et al (2022) stated that scientific-based worksheets could be used to train students' critical thinking ability. The result of study by Ariq & Fitrihidajati (2021) stated the similar argument. Wahono et al (2022) stated that scientific-based e-worksheets used to improve students' critical thinking ability. The finding of research by Ismail et al (2018) showed that the electronic-based learning material had a positive effect on the students' critical thinking. E-worksheets could be used as effort to train and improve students' critical thinking ability, so it could be concluded that scientific-based e-worksheets have effect on students' critical thinking ability and it was effectively used to train students' critical thinking ability at vocational high school.

#### 4. CONCLUSION

Based on the results of the study it could have concluded that the scientific-based e-worksheets on hydrocarbon material can have effect on students' critical thinking ability. Furthermore, the e-worksheets was effectively used to train students' critical thinking ability at vocational high school. For further research, the effect of the scientific-based e-worksheets can be analyzed to carried out on other materials and other higher-order thinking ability.

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