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THE EFFECT OF PROBLEM BASED LEARNING MODELS BASED ON SOCIO-SCIENTIFIC ISSUES ON STUDENTS' CRITICAL THINKING SKILLS ON HYDROCARBON BURNING MATERIALS

Dewi Linda Ardianti✉[1], **Tonih Feronika**[1], **Miessya Wardani**[1]

[1]Pendidikan Kimia, Universitas Islam Negeri Syarif Hidayatullah, Jakarta, 15412, Indonesia.
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ABSTRACT
Critical thinking skills in high school chemistry are still relatively low. One of the factors that causes students' low critical thinking skills is teachers who still dominate learning activities. This research aims to determine the effect of the Problem Based Learning (PBL) model based on Socio-scientific Issues (SSI) on students' critical thinking skills on hydrocarbon combustion material. This research was carried out at SMAN 11 South Tangerang City. The research method used in this research is a quantitative method with a quasi-experimental research method. The research sample was XI IPA 1A (as the experimental class) and XI IPA 1B (as the control class) with 16 students each. The instrument used was a description test with 22 questions representing 12 indicators of Robert H. Ennis' critical thinking. The results of the N-Gain data hypothesis test using the t-test (Independent Sample t Test) obtained a sig (2-tailed) < α, namely 0.00 < 0.05 so H_1 *was accepted and* H_0 *was rejected. This shows the influence of the problem based learning model based on socio-scientific issues on students' critical thinking skills on hydrocarbon combustion material.*

ABSTRAK
Keterampilan berpikir kritis di SMA pada ilmu kimia masih tergolong rendah. Salah satu faktor yang menyebabkan rendahnya keterampilan berpikir kritis siswa ialah guru yang masih mendominasi dalam kegiatan pembelajaran. Penelitian ini bertujuan untuk mengetahui pengaruh model *Problem Based Learning (PBL)* berbasis *Socio-scientific Issues (SSI)* terhadap keterampilan berpikir kritis siswa pada materi pembakaran hidrokarbon. Penelitian ini dilaksanakan di SMAN 11 Kota Tangerang Selatan. Metode penelitian yang digunakan dalam penelitian ini adalah metode kuantitatif dengan metode penelitian eksperimen kuasi. Desain penelitian yang digunakan adalah *nonequivalent control group design*. Sampel penelitian yaitu XI IPA 1A (sebagai kelas eksperimen) dan XI IPA 1B (sebagai kelas kontrol) dengan jumlah masing-masing sebanyak 16 siswa. Instrumen yang digunakan yaitu tes uraian sebanyak 22 butir soal yang mewakili 12 indikator berpikir kritis Robert H. Ennis. Hasil uji hipotesis data *N-Gain* menggunakan Uji T (*Independent Sample t Test*) memperoleh nilai sig (*2-tailed*) < α yaitu 0,00 < 0,05, sehingga H_1 diterima dan H_0 ditolak. Hal ini menunjukkan bahwa terdapat pengaruh model *problem based learning* berbasis *socio-scientific issues* terhadap keterampilan berpikir kritis siswa pada materi pembakaran hidrokarbon.

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✉Correspondence Author:
dewilinda861@gmail.com
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INTRODUCTION

One of the factors that influence the improvement of critical thinking skills is the use of learning models that can actively involve students in learning activities (Syamsuri, 2021). Learning is an active communication interaction between teachers and students with learning resources (Sujana & Sopandi, 2020). Learning that focuses on student activity will certainly affect the students' own abilities in learning and thinking. In realizing this, there is a role for a teacher as an educational facilitator. Therefore, teachers are expected to produce active learning activities so that they can develop the thinking skills of each student.

There are several skills that a person needs to have, including critical thinking skills, creative thinking skills, problem solving skills, creativity, communication, and collaboration (Susanti et al., 2022). Some of these skills are able to support students to become students in the 21st century who are required to be able to adapt to every development that occurs. With critical thinking skills, students are able to be actively involved in learning activities because they participate in analyzing and evaluating the problems raised as learning topics.

Students' critical thinking skills are currently still relatively low. Previous research found that high school students in Central Java Province have a relatively low level of critical thinking, especially in the field of chemistry (Susanti et al., 2022). In addition, research conducted at SMAN Tangerang Selatan found that students' critical thinking skills in 21st-century learning have not been achieved optimally, as indicated by the absence of several aspects in the teaching and learning process (Ardelia & Juanengsih, 2021). One of the causes of low critical thinking skills in students is that teachers are still actively dominating learning activities, while students as the main actors become passive (Helmiati, 2012). This habit seems to be inherent in every school that still maintains old habits, making it difficult to change. A teacher should be able to facilitate students' development of their competencies through the experiences provided in learning activities. The selection and use of the right learning model to enable students to be actively involved in learning activities is very necessary and can develop students' critical thinking skills. According to Sani (2017), learning will be able to form higher-order thinking skills and can improve students' ability to think critically. There are various innovative learning models that can be chosen and used by teachers in learning activities, such as problem-based learning models, cooperative learning models, project-based learning models, contextual learning models, and so on (Sujana & Sopandi, 2020). The use of the problem-based learning model can create an active learning atmosphere so that it can encourage students to be able to work together in a group to solve problems in life that are raised as learning topics (Sidiq et al., 2021). Problem-based learning is a learning model about learning to solve problems in the real world. We are often faced with problems that in reality all of these things have causes and effects. So the Problem Based Learning (PBL) learning model is appropriate if implemented in chemistry subject matter, for example in material related to problems in the environment. This is in line with the opinion of Hidayanti (2021), that chemistry is not only used by scientists to make commercial products in life, but is also used in building new chemical models to study climate change, environmental problems, and so on. Existing problems if implemented in learning activities can help develop students' critical thinking skills, namely through students' way of thinking in finding solutions to these problems. So by linking facts, concepts, and knowledge, students will feel that they understand the context they are studying better (Sa'diyah & Aini, 2022).

Problems in everyday life can be raised as topics of chemistry learning or commonly referred to as socio-scientific issues. One of the uses of socio-scientific issues is to improve students' critical thinking skills in exploring problems or issues in life. For example, students explore the causes of global warming or analyze diseases caused by environmental factors such as pollution (Sadler, 2011). So, Socio-scientific Issues (SSI)-based learning is a learning activity that involves issues or problems in life to be raised as learning topics so that it results in an increase in students' critical thinking skills towards science. This is in accordance with the opinion expressed by Rohmaya (2022), that Socio-scientific Issues (SSI)-based learning can be linked to the Problem Based Learning (PBL) model so that reasoning will be achieved that will lead students to gain interesting experiences on issues that are relevant in everyday life with science. One of the chemistry materials that is closely related to socio-scientific issues or socio-science issues in society is the impact of burning hydrocarbon compounds on the environment and health, precisely in the material on hydrocarbon combustion.

The application of the problem based learning model based on socio-scientific issues has been previously carried out by Utomo et al., (2020) which showed the results of the study that the application of the problem based learning model based on socio-scientific issues had a significant effect on the critical thinking skills of junior high school students. Therefore, further studies are needed at a higher level, namely the Senior High School level, to see how much influence the application of this learning model has on students' critical thinking skills. In addition, the application of the problem based learning model based on socio-scientific issues has also been carried out by Wilsa et al., (2017) with research results showing that the application of the SSI-based PBL model has an effect on the development of critical thinking skills, written and verbal communication, and cognitive learning outcomes. However, the study was conducted on biology learning, so further research is needed on other learning, such as chemistry.

Based on the explanation above, this study aims to determine the effect of the problem based learning model based on socio-scientific issues on students' critical thinking skills in the material of hydrocarbon combustion. The benefits of this study are divided into three, namely for teachers, students, and schools. The benefits of this research for teachers and schools are to provide information so that the Problem Based Learning (PBL) learning model based on Socio-scientific Issues (SSI) can be an alternative in designing the learning process, as an effort to improve student's critical thinking skills which are currently a demand in the 21st century and adapt to the times. Meanwhile, the benefits of this research for students are to provide a better understanding of the problems that occur around them, because students can relate the symptoms or phenomena that occur around them with the chemical material being studied, especially the material on hydrocarbon combustion. That way, the level of students' critical thinking skills will continue to develop towards problem solving.

METHOD

This research was conducted at SMA Negeri 11 Tangerang Selatan in the odd semester of the 2023/2024 academic year. The research method used was quasi-experimental with a nonequivalent control group design. This research method used experimental and control classes. The research design can be seen in Table 1.

Table 1. Research Design

Class	*Pretest*	Treatment	*Posttest*
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Description:

O1, 3 : pre-test (initial test) given to the experimental class and control class before being given treatment

O2, 4 : post-test (final test) given to the experimental class and control class after being given treatment

X : treatment given to the experimental class, namely using learning with the SSI-based PBL model

The population in this study were all science students of class XI of SMA Negeri 11 Tangerang Selatan City in the odd semester of the 2023/2024 academic year. The sampling technique used in this study was Nonprobability Sampling with a purposive sampling/sample sampling technique, namely the sample is determined from a number of populations based on certain characteristics or properties and its determination is based on the research objectives (Abubakar, 2021). The sample in this study was divided into two, namely XI IPA 1A (as the experimental class) and XI IPA 1B (as the control class) with a total of 16 students for each group.

The procedure in this study consists of 3 stages, including the preparation, implementation, and completion stages of the study. The preparation stage begins with an analysis of Core Competencies and Basic Competencies, as well as indicators in the revised 2013 curriculum syllabus on the selected material, namely hydrocarbon combustion. Then, create research tools including test instruments, Lesson Plans, and Student Worksheets that apply the problem-based learning model based on socio-scientific issues. In the implementation stage, all students in the experimental class and control class do a pre-test to determine their initial abilities before implementing learning activities. Then, learning activities are carried out for 2 meetings on the material of hydrocarbon combustion. The experimental class uses a problem-based learning model based on socio-scientific issues and the control class uses a conventional learning model. Then, after being given different treatments for the two classes, students in the experimental class and control class carry out a post-test to measure the improvement of their critical thinking skills. The completion stage processes research data (pre-test, post-test, and student worksheet data) with various data analysis techniques. Then, conclusions are drawn from the research results that have been obtained.

The research instrument used in this study is a test instrument that measures students' critical thinking skills. The indicators of critical thinking skills used are critical thinking indicators according to Ennis (1985) totaling 12 indicators. Before the instrument was used in the study, a trial was conducted first (empirical test) on students who had received hydrocarbon combustion material in the previous academic year (grade 12 students). This was done to measure validity, reliability, level of difficulty, and discriminatory power so that questions were obtained that met the requirements and were worthy of being used as research instruments. The test instrument grid can be seen in Table 2.

Table 2. Test Instrument Grid

No	Critical Thinking Skills	Critical Thinking Indicators	Critical Thinking Sub-Indicators	Item No.
1	elementary clarification	a. Focusing questions	Identifying or formulating questions	1*, 6*
		b. Analyze arguments	Identify reasons/causes based on the information found	2*, 7*
			Looking for similarities and differences	11
		c. Asking and answering questions	Give examples	5*
			Providing a simple explanation	4
2	basic support	a. Consider the credibility of the source	Consider the use of appropriate procedures	22*
			Reasoning Ability	18*
		b. Observing and considering the results of observations	Using strong evidence	19*, 23*
3	Inference	a. Make deductions and consider the results of the deductions	Interpreting data	10*, 14*
		b. Making induction and considering the results of induction	Drawing conclusions based on facts	9, 12*
			Making reasonable opinions/assumptions	8*
		c. Making and determining the results of considerations	Create and determine consideration results based on alternative thinking	21*, 24*
4	advanced clarification	a. Identifying assumptions	Provide further explanation	20*, 25*
		b. Define terms and consider definitions	Creating a definition	3*, 10
5	strategy and tactics	a. Determine an action	Formulate alternative solutions	13*, 16*
		b. Interact with other people	Using arguments or opinions	17*, 26*

*valid item

The data obtained from the research results were analyzed so that the results can be used to answer research questions and test research hypotheses. Data analysis was carried out by comparing the test results between the experimental class and the control class using SPSS software version 25.0. The results of the test were subjected to a prerequisite analysis test using the Shapiro-Wilk test to test normality and the Levene's statistic test to test homogeneity. After the prerequisite test was carried out, a hypothesis test was then carried out to determine the effect of the treatment given to students' critical thinking skills in the experimental class and the control class. The hypothesis test used was a parametric statistical test, namely the t-test (Independent Sample t Test) because the data was normally distributed and homogeneous, and the data used was N-Gain. Decision making in this t-test is if the Asymp. Sig. (2-tailed) <0.05, then H_1 is accepted and H_0 is rejected. Meanwhile, if the Asymp. Sig. (2-tailed) value> 0.05, then H_1 is rejected and H_0 is accepted. In addition, an N-Gain test was conducted to determine and provide a general overview of the increase in learning outcomes between before and after learning, especially if research results were found with different initial abilities (Sundayana, 2018). According to Hake (1999) there is a normalized gain category (g), which can be seen in Table 3.

Table 3. Interpretation of Normalized Gain

Normalized Gain Value	Interpretation
0,00 < g < 0,30	Low
0,30 ≤ g < 0,70	Mid
0,70 ≤ g ≤ 1,00	High

RESULTS AND DISCUSSION

The data obtained from the study were pre-test and post-test results in the experimental and control classes. Students' critical thinking skills were measured using a descriptive test instrument consisting of 22 questions that had met the criteria of 12 critical thinking indicators. Then, based on the results of the overall observation sheet in the experimental class, teacher and student activities had been achieved in accordance with the stages of the problem-based learning model based on socio-scientific issues. The average pre-test and post-test scores obtained from the experimental and control classes can be seen in Figure 1.

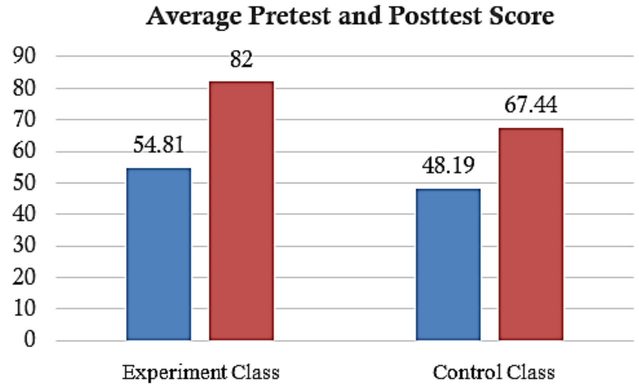


Figure 1. Average Pre-test and Post-test Scores of Experimental Class and Control Class

Based on the data in Figure 1, the pre-test results in the experimental class obtained an average of 54.81. Meanwhile, in the control class, the average pre-test score was 48.19. After the treatment, the post-test results were quite different between the experimental and control classes. In the experimental class, the average post-test score was 82.00, while in the control class, the average post-test score was 67.44. The difference in the average post-test scores of the two classes with the average score in the experimental class was 14.56 points higher than in the control class. This indicates that the learning outcomes of students in the experimental class were much better than in the control class.

Learning activities were carried out in two meetings. Learning in the experimental class used a problem-based learning model based on socio-scientific issues consisting of 5 stages according to Rizkita et al., (2016), namely 1) student orientation towards social science problems; 2) organizing students in learning; 3) assisting student and group investigations; 4) developing and presenting work results; and 5) analyzing and evaluating the problem-solving process. The stages of the socio-scientific issues-based problem-based learning model are implemented completely (five stages) in each meeting so that students are able to understand the problems or issues presented until they can finally relate them to the material being taught. Before carrying out the five stages of learning, the teacher reminds students of the previous material, namely regarding the formation of petroleum fractions. This is done because the material on hydrocarbon combustion is closely related to petroleum material, for example, the production of gasoline from petroleum is processed through the process of separating petroleum fractions and then when gasoline is used in vehicles it will produce a combustion reaction, and produce substances from vehicle combustion. The combustion reaction and the substances it produces are then discussed in the learning activities carried out.

The first stage is student orientation towards social science problems. The social science problems that are raised to become learning topics are problems that occur in the surrounding environment and are close to students' lives. This is because the learning that is carried out is based on socio-scientific issues. The socio-scientific issues theme presented in the learning is about hydrocarbon combustion which is divided into three groups, namely 1) problems related to CO_2, namely the phenomenon of forest fires and the greenhouse effect; 2) problems related to CO, namely the phenomenon of factory smoke pollution and cigarette smoke; and 3) problems related to carbon particulate matter, namely motor vehicle smoke pollution and Particulate Matter (PM) pollution. In accordance with the statement of Nurmilawati et al., (2021) that socio-scientific issues are sciences that are integrated into subjects to be taught to a group with the aim of overcoming a problem by involving science and social life. Linking socio-science issues with teaching materials will make students more actively involved in learning activities because students will analyze and provide solutions to a problem. In this study, the problems raised are regarding the problems that cause the production of substances from perfect and imperfect hydrocarbon combustion. The problems or issues raised in socio-scientific issues are different from ordinary issues, but rather controversial issues that can have social impacts and can influence society in terms of decision-making on problems that occur (Rohmaya, 2022). These problems are presented by the teacher through learning videos so that students get an idea of the problems raised as learning topics.

In this study, the problems raised are those that cause the production of substances from perfect and imperfect hydrocarbon combustion. The problems or issues raised in socio-scientific issues are different from ordinary issues, but rather controversial issues that can have social impacts and able to influence society in terms of decision-making on problems that occur (Rohmaya, 2022). These problems are presented by the teacher through learning videos so that students get an idea of the problems raised as learning topics.

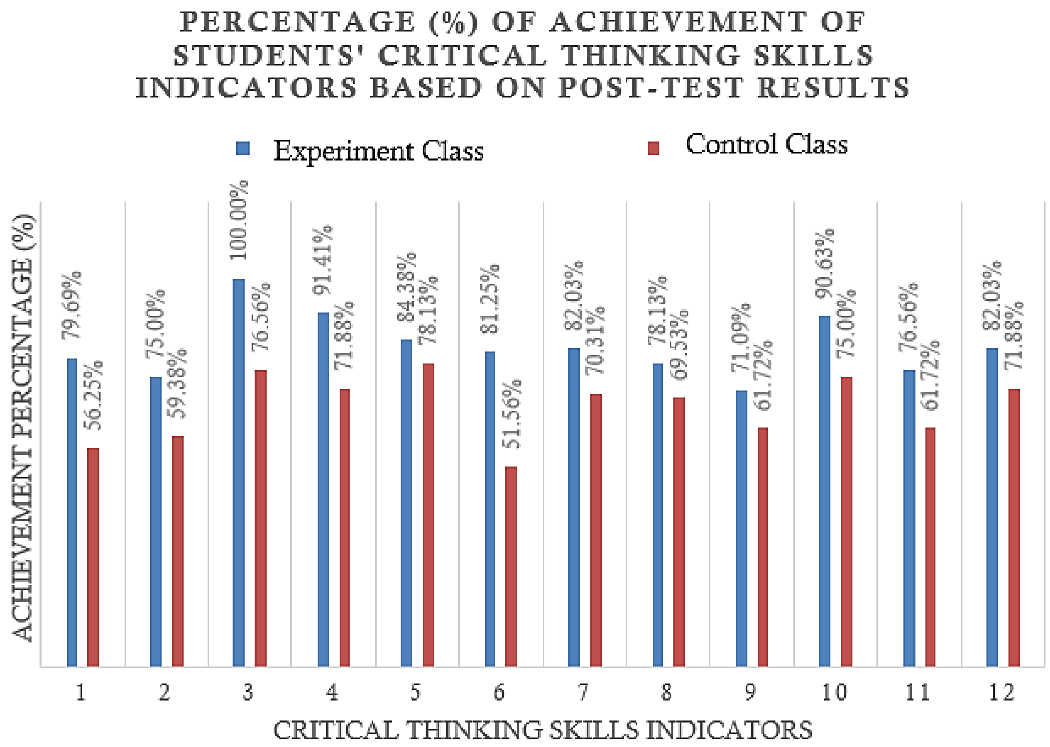
The second stage is organizing students in learning. In this stage, the teacher divides students into small groups to discuss further the problems presented in the learning video. The teacher invites students to sit together with their respective groups. Then, the teacher distributes Student Worksheets to each group for them to fill in. Student worksheets contain questions about the phenomena presented in the learning video and there is additional information in the form of discourse related to the problem. Through this stage, each group is asked to understand the problems previously witnessed in the learning video until finally, they can design ideas about alternative solutions to overcome the impact of the problem. This is in line with the statement of Hestiana & Rosana (2020) that problem-based learning based on social science problems will begin with identifying problems, then continue with assessing the impact of social science issues and formulating problems that occur.

The third stage is to help students and groups investigate. The teacher directs students in group discussion activities, for example when students are conducting information search activities, searching for answers to questions contained in the student worksheets, collecting information from relevant and accountable sources, and when students provide solutions to issues or problems presented. Group discussion activities are able to train cooperation among students because each group member expresses their opinions and searches for results regarding alternative solutions to overcome the impact of CO_2, CO, and carbon particulate pollution. This is in accordance with the statement made by Jariah & Aminatun (2022) that when group discussion activities are carried out, students will exchange ideas to unite views and opinions.

The fourth stage, developing and presenting the results of the work. After being able to design alternative ideas or solutions in the previous stage, then students write the design into the student worksheets. There are differences in the presentation of the design ideas made by students, for the design ideas in student worksheet 1 are made in the form of narratives or points, the design ideas in student worksheet 2 are made in the form of mind mapping, and the design ideas in worksheet 3 are made in the form of simple charts.

The results of the work that has been made are then presented by several group representatives (as the presenting group) and groups that do not act as presenters act as discussion participants, but the teacher still allows them to be able to provide opinions (either in the form of criticism, input or suggestions to the presenting group). The teacher leads and organizes the presentation activities of the students' work, and ensures that all students can be actively involved in the discussion activities. This is in line with the opinion of Lathifah et al., (2019) that at this stage the teacher has a role to organize the class and at the same time provide feedback on student performance so that they are able to understand the learning well.

The fifth stage, analyzing and evaluating the problem-solving process. This stage is the final stage in learning using the problem based learning model based on socio-scientific issues. In this stage, the teacher gives several final questions in each student's worksheets to be answered by students. This aims to measure the extent to which students understand and are able to link the issues or problems presented with the material being taught (hydrocarbon combustion) so that the teacher is able to analyze and evaluate the student's thinking process. After each group has carried out the information search process independently, the teacher then presents the results of the analysis and evaluation based on the results of the learning activities carried out. In addition, at this stage, the teacher provides clarification on student statements that are not appropriate during the group presentation, with the aim of avoiding misconceptions in students. Based on the discussion related to the stages of the problem based learning model based on socio-scientific issues, it can be concluded that students are actively involved in learning activities because they are directed to be able to express opinions, work together in groups, design ideas, provide suggestions and criticisms to the presenting group, and so on. This is in line with the research results of Utomo et al., (2020), stating that the learning process using the problem based learning model based on socio-scientific issues provides teachers with chances to give students the freedom to think and find the right solutions or decisions in solving social issues or problems while still considering ethics, morals, and social, so that students think more critically in solving problems presented in learning activities. Then, the success of implementing the problem based learning model based on socio-scientific issues is proven by the implementation of each stage of the learning model in the observation sheet of teacher and student activities. Based on the description above, it shows that the problem based learning model based on socio-scientific issues is very suitable to be combinedbecause students are trained to be able to solve an issue or problem. In addition, the application of the problem based learning model based on socio-scientific issues in learning activities can improve students' critical thinking skills, as evidenced by Figure 2 which shows that each indicator of critical thinking skills in the experimental class obtained a higher percentage compared to the control class.



Description of indicators 1-12:

1. Focusing on questions
2. Analyzing arguments
3. Asking and answering questions
4. Considering the credibility of sources
5. Observing and considering observations
6. Making and considering deductions
7. Making and considering induction results
8. Making and determining consideration results
9. Identifying assumptions
10. Defining terms and considering definitions
11. Determining an action
12. Interacting with others

Figure 2. Percentage of Achievement of Students' Critical Thinking Skills Indicators Based on Post-test Data

Then, a comparison of the N-Gain score data obtained by the experimental and control classes can be seen in Table 4 below:

Table 4. Comparison of N-Gain Data for Experimental and Control Classes

N-Gain Score average			
Experiment Class		**Control Class**	
Score	Category	Score	Category
0,61	Mid	0,38	Mid

Based on the results of the N-Gain test in Table 4 above, it show that there is a difference in the increase in students' cognitive abilities in the experimental class and the control class. The experimental class has an average N-Gain value of 0.61 with a moderate category, while the control class has an average N-Gain value of 0.38 with a moderate category. Based on these figures, the average n-gain score in the experimental class is much greater than the average n-gain score in the control class. The interpretation is that the use of a problem-based learning model based on socio-scientific issues in the experimental class has an effect on improving students' critical thinking skills when compared to the use of conventional learning models in the control class.

This is also in line with the results of the hypothesis test based on the pre-test and post-test data from this study. Before the hypothesis test was carried out to see whether or not there was an effect of the treatment given to the experimental class and the control class. First, a sample analysis prerequisite test was carried out using the normality test and homogeneity test on the pre-test data. The results of the normality test for the two classes based on the pre-test data can be seen in Table 5.

Table 5. Results of the Pre-Test Normality Test for the Experimental Class and Control Class

Test Type	**Class**	***Shapiro-Wilk***			
		Statistics	**df**	**Sig.**	**Status**
Pre-Test	Experiment	0,927	16	0,216	Normal
	Control	0,947	16	0,438	Normal

Based on Table 5, the significance value of the pre-test data is 0.216 and 0.438. These results indicate that the significance values of both (0.216 and 0.438) > 0.05, so it can be concluded that both data are normally distributed. After that, the pre-test data was tested for homogeneity to determine whether the variance of the experimental class and the control class was homogeneous or not homogeneous. The results of the homogeneity test for the two classes can be seen in Table 6.

Table 6. Results of the Pre-Test Homogeneity Test for the Experimental Class and Control Class

Test type	**Statistics**				**Significance Level (α)**	**Status**
	Lavene Statistic	**df1**	**df2**	**Sig.**		
Pre-Test	1,657	1	30	0,208	0,05	Homogen

Based on Table 6, the pre-test significance value is 0.208. This shows that the significance value of the data (0.208) > 0.05. Thus, it can be concluded that the pre-test data of the experimental class and the control class have homogeneous variance.

Based on the sample analysis prerequisite test that has been carried out, the results obtained are that the pre-test values in the experimental class and the control class are normally distributed. Then, the results of the homogeneity test of the two classes show homogeneous variance.

Therefore, the hypothesis test uses a parametric statistical test, namely the t-test (Independent Sample t-test). The results of the hypothesis test based on the sample analysis prerequisite test that has been carried out on the two classes can be seen in Table 7.

Table 7. Results of Hypothesis Testing of Pre-Test Data for Experimental Class and Control Class

Data	Significance Level (α)	Asymp.Sig. (2-*tailed*)	Conclusion
Pre-Test	0,05	0,017	There is a Difference

Based on the results of the t-test (Independent Sample t-test) of the pre-test data in Table 7, it can be seen that the Asymp. Sig. (2-tailed) value is 0.017. This shows that the Asymp. Sig. data value <0.05. Thus, H0 is rejected and H1 is accepted, which means that there is a difference in critical thinking skills between the experimental class and the control class based on the pre-test results. Based on the results of the sample prerequisite test, it was found that there was already a difference in students' initial abilities, so to find out how students' critical thinking skills improved before and after learning, the prerequisite test and hypothesis test used N-Gain data. The prerequisite tests carried out were normality and homogeneity tests. After the two tests were carried out, the hypothesis test was continued. The results of the normality test for the two classes based on the N-Gain data can be seen in Table 8.

Table 8. Results of the N-Gain Normality Test for the Experimental Class and Control Class

Test Type	Class	*Shapiro-Wilk*			
		Statistics	df	Sig.	Status
Pre-Test	Experimental	0,955	16	0,565	Normal
	Control	0,945	16	0,416	Normal

Based on Table 8, the significance value of the normality test using N-Gain data in the experimental and control classes is 0.565 and 0.416. These results indicate that the significance value in the experimental and control classes (0.565 and 0.416) > 0.05, so it can be concluded that both data are normally distributed.

The homogeneity test is a test to determine whether the variance of two classes is homogeneous or not homogeneous, using the Levene Statistic test with a significance level of 5% (α = 0.05). The results of the N-Gain data homogeneity test can be seen in Table 9.

Table 9. Results of the N-Gain Data Homogeneity Test for the Experimental Class and Control Class

Statistik				Significance Level (α)	Status
Lavene Statistic	df1	df2	Sig.		
2,109	1	30	0,157	0,05	Homogen

Based on Table 9, the significance value of N-Gain is 0.157. This shows that the significance value of the data (0.157) > 0.05. Thus, it can be concluded that the N-Gain data of the experimental class and the control class have homogeneous variance. Based on the prerequisite test of data analysis that has been carried out, the results obtained are that the N-Gain value in the experimental and control classes is normally distributed. Then, the results of the homogeneity test of the two classes show homogeneous variance. Therefore, the hypothesis test uses a parametric statistical test, namely the t-test (Independent Sample -test). Decision making in the t-test is if the Asymp.Sig. (2-tailed) <0.05, then H_1 is accepted and H_0 is rejected. Meanwhile, if the Asymp.Sig. (2-tailed) value > 0.05, then H_1 is rejected and H_0 is accepted. The results of the hypothesis test of the N-Gain data of the experimental and control classes can be seen in Table 10.

Table 10. Results of the t-test of N-Gain Data for the Experimental Class and Control Class

Significance Level (α)	Asymp.Sig. (2-*tailed*)	Conclusion
0.05	0.000	there is an effect

Based on the results of the t-test in Table 10, it shows that the Asymp. Sig. (2-tailed) value is 0.000. This means that the Asymp. Sig data value <0.05. Thus, H_0 is rejected and H_1 is accepted or it can be concluded that there is an effect of using the problem-based learning model based on socio-scientific issues on students' critical thinking skills in hydrocarbon combustion material. This is in line with research conducted by Utomo et al., (2020) that the application of the problem-based learning model based on socio-scientific issues has a significant effect on students' critical thinking skills. In addition, according to Rohmaya (2022), linking SSI with learning models can improve students' critical thinking skills in solving a problem that is raised in learning activities.

CONCLUSION

Based on the research conducted at SMA Negeri 11 Tangerang Selatan, the results of the parametric statistical hypothesis test using the t-test (Independent Sample t Test) were obtained, namely the Sig. (2-tailed) <α, namely 0.00 <0.05, then H_1 is accepted and H_0 is rejected. H_1 is accepted and it can be stated that there is an effect of the application of the Problem Based Learning (PBL) learning model based on Socio-scientific Issues (SSI) on students' critical thinking skills in the hydrocarbon combustion material. With a comparison of the average N-Gain score obtained by the experimental class of 0.61 with a moderate category and the control class of 0.38 with a moderate category. However, the average N-Gain score in the control class was much smaller than the average N-Gain score in the experimental class, namely there was a difference of 0.23. So, this shows that the use of the problem based learning model based on socio-scientific issues in the experimental class has an effect on improving students' critical thinking skills when compared to the use of conventional learning models in the control class.

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