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Note di Ricerca
Research Notes

Commenti, Riflessioni, Presentazioni, Resoconti, Dibattiti, Interviste
Comments, Reflections, Presentations, Reports, Debates, Interviews

Recensioni

Reviews

Profile of Student Analytical Thinking Skills in the Natural Sciences by Implementing Problem-Based Learning Model

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PROFILO DELLE CAPACITÀ DI PENSIERO ANALITICO DEGLI STUDENTI NELLE SCIENZE NATURALI BASATO SUL MODELLO DI APPRENDIMENTO PER PROBLEM SOLVING

Abstract

Analytical thinking skills are critical thinking skills and higher-order thinking skills that meet students' demands in the 21st century. This study aims to analyze the student's analytical thinking skills in the natural sciences, particularly in new and renewable energy. This study was a sequential explanatory design with quantitative and qualitative methods. Data was obtained from the interview, observation, and essay test to students of the

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* Suyatman contributed to developing instruments, collecting data, analyzing data, and writing manuscripts. S. Saputro guided the findings, discussed the results, and commented on the document. W. Sunarno gave the idea of discovery. Sukarmin contributed to developing theories and sharpening conclusions.

Madrasah Ibtidaiyah Teacher Education Program Study at IAIN Surakarta (Indonesia) to determine a characteristic of the students' analytical thinking skills. The results showed that the mean scores of the pre-test, post-test, and effect size were 54.34, 74.91, and 2.91, respectively. These results revealed that analytical thinking skills in the concept of new and renewable energy in the experimental group were higher than the control group. Innovative learning like PBL had a potential as the alternative method to increase the analytical thinking skills of student. These findings were expected to provide a general characteristic to lecturers and researchers on the students' analytical thinking skills in higher education in the natural sciences, particularly in the concept of new and renewable energy by implementing the Problem Based Learning (PBL) model.

Keywords: Analytical thinking skills; Mixed methods; Natural sciences; New and renewable energy; Problem Based Learning (PBL).

1. Introduction

Analytical thinking skill is higher-order thinking skills (Heong *et al.*, 2011; Permana *et al.*, 2019), and become high demands of human resources in the 21st century. It triggers student ability to solve a problem in their daily lives (Schumacher & Ifenthaler, 2018). Furthermore, it is crucial to improve the students' analytical thinking skills; to understand information comprehensively and be able to associate between components (Brookhart, 2010; Yilmaz & Saribay, 2017), and to explain problems into smaller pieces and understand the interrelationships between these components (Tian *et al.*, 2014; Yulina *et al.*, 2019).

Students' analytical thinking skills are low based on the indicators of analytical thinking skills (Prawita & Prayitno, 2019). Differentiation, organizing, and attributing are three indicators of students' analytical thinking skills with low levels (Winarti, 2015b). According to Trends in International Mathematics and Science Study (TIMSS), Indonesian students are not used to solving problems that required higher-level aspects such as reasoning, applying, analyzing, evaluating, and creating (Mullis *et al.*, 2012; Tajudin & Chinnappan, 2016). The student's analytical thinking skills are low because of the lack of stimulation in learning that involves an analysis of thought (Nisa *et al.*, 2019). Therefore, students need to improve their analytical thinking skills to develop new knowledge and innovation for themselves (Areesophonpichet, 2013; Changwong *et al.*, 2018).

The learning model is a factor that influences analytical thinking skills. Analytical thinking skills can be trained to students with practical learning models (Mardiansyah *et al.*, 2019). The learning model should have some characteristics: to determine the learning objectives, to teach through inquiry, practice, review, refine, enhance understanding, and practice feedback and assess learning (Limbach & Waugh, 2010). Problem Based Learning (PBL) has those characteristics to support student critical thinking skills (Kek & Huijser, 2011; Fidan & Tuncel, 2019). It helps students to develop their thinking and problem-solving skills (Arends, 2012). Furthermore, it is a learning method to improve students' high-level skills such as problem-solving and critical thinking to obtain information from personal experiences and gain knowledge of their learning (Ceker & Ozdamli, 2016). The implementation of PBL begins with a problem in real life and is developed by the group to obtain the problem solution (Ikawati & Suparman, 2020). Based on Kek and Huijser (2011) and Ceker and Ozdamli'sOzdamli's (2016) opinion, PBL is a learning model to develop high-level thinking students. This model is relevant to the natural sciences because it needs scientific concepts, high-level thinking, and encouraging students to be aware and care for the environment (Barton & Haslett, 2007). Besides, the natural sciences require skills to analyze that require analytical thinking skills (Živković, 2016; Qomariya *et al.*, 2018).

In the present study, we evaluated the student's analytical thinking skills in the natural sciences with the topic of new and renewable energy by implementing the PBL model. Our results are expected to provide a general description to lecturers and researchers about the condition of the student's analytical thinking skills in higher education, especially the concept of new and renewable energy, by implementing the PBL model.

2. Literature review

2.1. *Analytical thinking skills*

Analysis skills are the process that involves breaking down material into small parts. They connect between components and the overall structure (Winarti, 2015a). Similarly, Sitthipon (2012) and Al-Mohammadi (2017) expressed that analytical thinking skills are competencies in identifying and classifying various aspects of stories, or events into small parts and the relationships between the elements. Analysis skills provide ability to determine, organize, and the purpose behind relevant information (Anderson, 2001).

Indicators of analytical thinking skills are differentiating, organizing, and attributing (Anderson, 2001). Whereas, according to Marzano and Kendall (2008) there are five indicators of analytical thinking skills, namely matching, classifying, analyzing error, generalizing, and detailing. The results of analytical thinking skills are presented in *Table 1*.

Table 1. – Aspects of analytical thinking skills by researchers.

Anderson (2001)	Marzano and Kendall (2008)	Researchers' synthesis
Differentiating	Matching	Matching
Organizing	Classifying	Classifying
Attributing	Analyzing error	Organizing
	Generalizing	Attributing
	Detailing	

Indicators of the researchers' synthesis consist of four points: matching, classifying, organizing, and attributing. These indicators were used by researchers as a reference in developing instruments.

2.2. *Problem-Based Learning model (PBL)*

According to Susilawati (2017), PBL is a learning model that requires students' mental activities to grasp a concept through situations and issues at initial learning to stimulate students in solving problems (Susilawati *et al.*, 2017; Hursen, 2020). PBL models establish discussion activities more interesting than the regular ones. Therefore, students' activity is more active in learning activities (Wulandari *et al.*, 2018). Students have a role as active problem-solvers and teachers as facilitators or guides to increase higher-level thinking skills (Tan, 2009; Kaharuddin, 2019).

The PBL model has the advantage of increasing information retention, developing integration, pushing towards lifelong learning, and increasing overall motivation (Ruiz-Gallardo *et al.*, 2011; Sani & Malau, 2017). Other advantages of the PBL model: (1) meaningful learning, (2) integrating knowledge and skills simultaneously, and (3) enhancing critical thinking skills and fostering initiative (Kono, 2016). The PBL helps students to develop their thinking and problem-solving skills (Arends, 2012) as presented in *Figure 1*.

PBL model in the learning application refers to the syntax formulated by Arends (2012). It consists of triggering students to solve problem, organizing students for study, assisting independently and group investigation, developing and analyzing the problem-solving process.

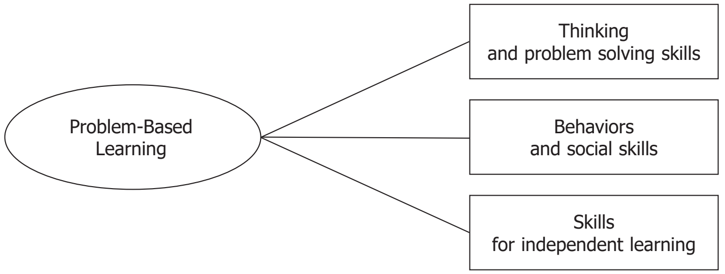


Figure 1. – PBL instructional impact.

3. Methodology

3.1. *Research method*

The sequential explanatory design was used in this study following by the quantitative and qualitative research methods (Sugiono, 2016). The application of the sequential explanatory design is presented in *Figure 2*.

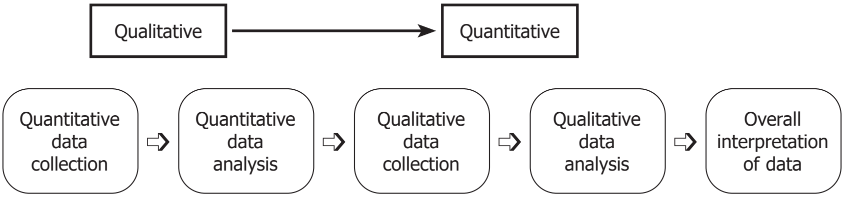


Figure 2. – Sequential explanatory research design (Creswel, 2013).

As shown in *Figure 2*, this study starts with collecting and analysing quantitative data, followed by qualitative data established based on the initial results of quantitative data (Creswell, 2013). The quantitative research design is a quasi-experiment with a nonequivalent control group design (Fraenkel *et al.*, 2007), as presented in *Table 2*. The qualitative research design was descriptive qualitative by describing the results of observations and interviews by students.

The sample was selected by purposive sampling because it was an experimental study. Therefore, all students in one class had to receive the same treatment.

Table 2. – Non-equivalent control group design.

Class	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3	–	O_4

Note: X = Treatment by problem based learning.

A total of 72 students of the Madrasah Ibtidaiyah was used in this study. The PGMI study program had various backgrounds, namely SMA (Sekolah Menengah Pertama), MA (Madrasah Aliyah), and SMK (Sekolah Menengah Kejuruan) with various majors; science, social sciences, electrical engineering, fashion, multimedia, administration, accounting, marketing, religion, and automotive. Therefore, students' analytical thinking skills by applying the PBL model with the basic science concepts material was performed objectively. The teacher education study program at IAIN Surakarta was determined and divided into two groups. There were 36 experimental and 36 control groups (*Tab. 3*).

Table 3. – The characteristics of the experimental class and the control class based on gender, social status, and age.

Group	Gender		Social status		Age	
	Male	*Woman*	*Civil servant's family*	*Non-civil servant's family*	*19 y.o*	*20 y.o*
Experiment	16 (44.44%)	20 (55.56%)	8 (22.22%)	28 (77.78%)	5 (13.89%)	31 (86.11%)
Control	13 (36.11%)	23 (63.89%)	12 (33.33%)	24 (66.67%)	7 (19.44%)	29 (80.56%)

The experimental group was treated by employing the PBL model and the control group with conventional learning, each of which had four face-to-face meetings. One student in each group was selected for the interview. This treatment was conducted as a comparison between the groups treated by implementing PBL and conventional learning.

The implementation of the PBL model was conducted by partner lecturers among lecturers in the basic concepts of science subject. The researcher had a role as a model lecturer by training and giving examples of the implementation of the PBL model before taking research data. It was conducted to ensure the implementing of PBL model. It was conducted in the science laboratory and observed by experts in science learning. There were four meetings after implementing the PBL model, including posttest and interviews. Interviews with students were taken randomly and conducted by researchers.

3.2. *Research instrument*

Data collection instruments of this study were: (1) pre-test-post-test of analytical thinking skills test (ATST), (2) interview sheets, and (3) observation sheets. This study administered a test that consisted of eight valid items from 10 items. ATST developed by the author has been adjusted with indicators of analytical thinking skills: matching, classifying, organizing, and attributing.

- Matching is analyzing the relevant and irrelevant parts of a given object.
- Classifying is analyzing the process of grouping objects based on similarities and differences.
- Organizing is in determining how the individual parts fit together and can function together in a structure.
- Attributing is analyzing in determining the point of view of an object presented.

Form of questions in the form of essays with a rating scale of 4; score 4 if the answer is complete, 3 if the answer is three criteria, 2 if the answer is two criteria, 1 if the answer is one criterion (*Fig. 3*).

a) **Data 3**

Dalam sebuah percobaan pembakaran tungku biomassa dengan menggunakan biomassa serbuk kayu diperoleh data sebagai berikut.

No	Hasil Pengukuran	Nilai Pengukuran
1	Masa air (m_a)	0,6 kg
2	Masa biomasa (m_b)	0,3 kg
3	Suhu awal air (T_{awal})	30°C
4	Suhu awal air (T_{akhir})	100°C

Pertanyaan

6. Hitunglah Kalor yang tersedia dan kalor yang digunakan bila diketahui Kalor Jenis air (Cp) = 4180 J/°CKg, dan nilai kalor serbuk gergaji (L) = 15269,256 10^3 J/kg!
7. Interpretasikan efisiensi penggunaan pembakaran tungku biomasa menggunakan serbuk gergaji!

b) Data 3

An experiment of burning a biomass stove using sawdust biomass is presented the following data:

Indicators	The value of measurement
Mass of water	0.6 kg
Massofbiomass	0.3 kg
Initialwatertemperature	30°C
The final temperatureofthewater	100°C

Question

6. Calculate the available heat and the heat used if the specificity of water (Cp) = 4180 J/°CKg, and the calorific value of sawdust (L) = 15269.256 103 J/kg!
7. Interpret the efficiency of using biomass stove combustion with sawdust !

Figure 3. – Examples of analytical thinking skills test instruments: a) original version written in Indonesian; b) English translation.

ATST was tested using Pearson product-moment correlation to ensure data validity. Data were classified as valid and tested for their reliability using Alpha Cronbach. The interview sheet comprised several components such as difficulty level, how to answer test questions, and the effect of following the lesson. Simultaneously, the observation sheet consisted of several parts: pre, whilst, and post activities by referring to the PBL model syntax. Experts had validated both the observation and the interview sheet.

Data collection were conducted in several stages:

1. Pre-testing both the experimental and control groups.
2. Providing treatment by implementing the PBL model for the experimental group and conventional learning for the control group.
3. Conducting post-test both the experimental and control groups.
4. Interviewing.

3.3. *Data analysis*

The analytical thinking skills test was analyzed by percentage to dertermine whether students meet each indicator of analytical thinking skills or not in solving problems of the test. The percentage value of analytical thinking skills was categorized as presented in *Table 4*.

Table 4. – Percentage and category of analytical thinking skills.

Interpretation (%)	Category
$81.25 < X \leq 100$	Very high
$71.50 < X \leq 81.25$	High
$62.50 < X \leq 71.50$	Medium
$43.75 < X \leq 62.50$	Low
$0 < X \leq 43.75$	Very low

Source: Karim & Normaya, 2015.

Table 5. – The score of effect size.

Equation	Effect size value	Interpretation
Effect size $\frac{\text{Post-test}_{average} - \text{Pre-test}_{average}}{\text{Standard Deviation}}$	0.00 – 0.20	Weak effect
	0.21 – 0.50	Modest effect
	0.51 – 1.00	Moderate effect
	> 1.00	Strong effect

Source: Cohen *et al.*, 2013.

The results of the pre-test and post-test of the students' analytical thinking skills in the experimental and control group were calculated with the effect size formula. The magnitude of the effect size was the mean of post-test score minus the mean of pre-test score and divided by the standard deviation, as presented in *Table 5*.

4. Results

4.1. *Student analytical thinking skills*

The mean score of analytical thinking skills of the experimental group was in the high category. Meanwhile, the control group was in a low category. The mean score of each aspect of indicators of the students' analytical thinking skills can be seen in *Figure 4*.

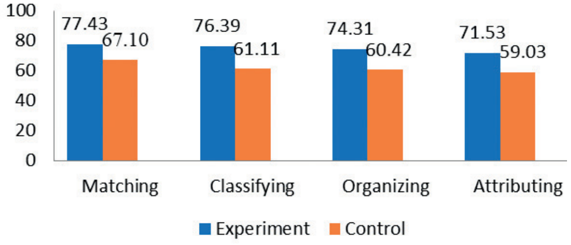


Figure 4. – Percentage of the student's analytical thinking skills.

As shown in *Figure 4*, the highest indicator was 77.43 in the experimental group, while the control group was 67.10. The second-highest value was 76.39 in the experimental group, while the control group was 61.11. Furthermore, the third-highest value was 74.31 in the experimental group, while the control group was 60.42 as the indicator organizing win. Furthermore, the lowest indicator was attributing with 71.53 in the experimental group and the control group was 59.03.

4.2. *Analysis of pre-test-post-test and effect size of analytical thinking skills*

The ANOVA test was conducted to determine the students' initial ability between the experimental class and the control class The ANOVA test was calculated using SPSS Version 20.

Table 6. – ANOVA test results for the control class and the experimental class pretest.

	Sum of squares	df	Mean square	F	Sig.
Between groups	57.672	7	8.239	2.325	.053
Within groups	99.217	28	3.543		
Total	156.889	35			

ANOVA test was conducted with the following condition; if Sig. > α, then Ho was accepted and if Sig < α, then Ho was rejected. This finding suggested that both groups had the same average score. As shown in *Table 6*, a Sig. value was 0.053. It showed that the Sig. > α value. Therefore, the two data groups had the same average score. Our finding revealed that the initial ability of students' analytical thinking skills between the control group and the experimental group was similar.

We further determined the effect of the PBL model on students' analytical thinking skills. The ANOVA test was carried out and calculated using SPSS Version 20.

Table 7. – ANOVA test results for the control class and the experimental class posttest.

	Sum of squares	df	Mean square	F	Sig.
Between groups	201.622	11	18.329	4.816	.001
Within groups	91.350	24	3.806		
Total	292.972	35			

Based on the *Table 7*, the value of Sig. < α, so the two data groups had different average scores. This finding showed that the analytical thinking skills between the control group and the experimental group were not similar, indicating the PBL model affected students' thinking skills.

The results of pre-test, post-test, and effect size data are presented in *Table 8*.

Table 8. – Recapitulation results of pretest and post-test.

Class (n)	Pre-test average	Post-test average	Standard deviation	Effect size	Interpretation
Experiment (36)	54.34	74.91	11.11	2.91	Strong effect
Control (36)	59.03	62.07	5.17	0.55	Moderate effect

Based on *Table 5*, the mean scores of the pre-test and post-test were 54.34 and 74.91 for the experimental group with effect size was 2.91, indicating the strong effect category. Whereas the mean scores of pre-test and pos-test score were 59.03 and 62.07 for the control group followed by the effect size was 0.55. These results was categorized as a moderate effect. Therefore, the students' analytical thinking skills in the concept of the new and renewable energy was higher in the experimental group than the control group.

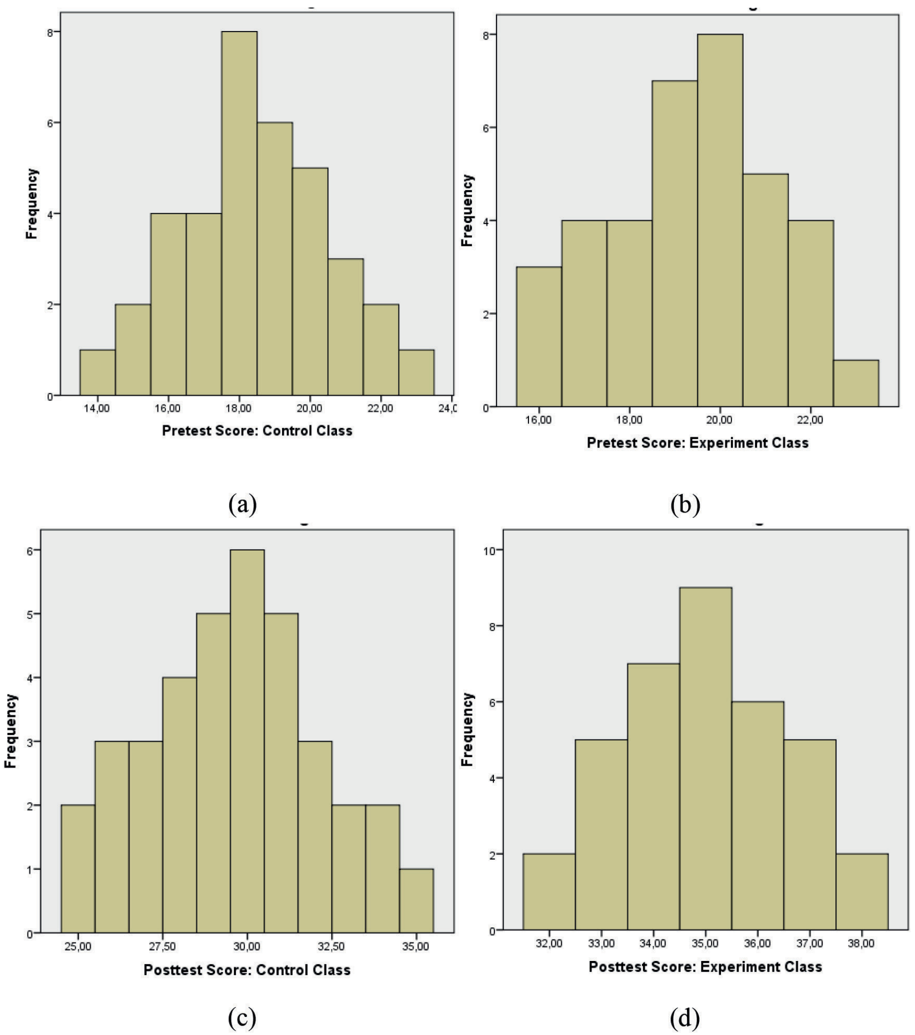


Figure 5. – The relationship histogram
between the analytical thinking skills score and the frequency.

As shown in *Figure 5*, histograms (a), (b), (c), and (d) can be seen easily forming a normal curve. By referring to the normal curve graph, it can be concluded that the pretest and poststest score data in the control class and the experimental class are normally distributed. The histograms (c) and (d) are presented the specific results after implementing the PBL model. According to the highest frequency on the histogram (c) and (d), it turns out that the histogram score (d) is higher than the histogram score (c). It indicates that the experimental class's post-test score is higher than the post-test score of the control class. Therefore, the implementation of the PBL model can affect students' analytical thinking skills, especially in new and renewable energy materials.

4.3. *Interview results*

Table 9 is presented the interview results.

Table 9. – The student interview results.

Questions	Answers	
	Respondent 1 (experimental group)	*Respondent 1 (control group)*
Could you answer the questions from the test given? Which part felt difficult?	Mostly I could, especially mathematical calculation of experimental data.	Some parts I could, but mostly I could not. The test applied was a difficult formula.
How did you answer the question about the experimental design of electric energy converting into kinetic energy?	I sketched experimental design.	It was very difficult in the learning process. There was no experimental practice.
Did you find difficult to calculate the efficiency of using biomass stove combustion with sawdust? How did you interpret the value obtained?	It was quite difficult, but when I remembered the formula of efficiency, I could do it. The greater the heat used, the greater the efficiency would be, and vice versa.	Yes, it was hard to imagine.
How did you explain the concept of energy conversion into the picture?	By observing one by one the picture. Observing windmill as a source of kinetic energy was converted by the generator to be electric.	I felt difficult to observe pictures and I tried to explain.

The interview results showed the student perception of the control group was difficult. It indicated by some students did not understand the concept and forgot the material. Students tended to memorize the learning material, so it was easily forgotten. While the student perception of the experimental group was relatively easy because they adopted the PBL model.

4.4. *Observation results*

The observations were conducted by the learning process that implemented the PBL model for four meetings. The results of the observations were listed in *Table 10*.

Table 10. – Observation results of the PBL model.

No	Activity	Assessment				Mean score	Score category	Category
	Pre-activity	I	II	III	IV			
1	Prepare both physics and psychic of students by greetings.	3	4	4	4	3.75	3.625	Very good
2	Relate current learning material with the student experience or previous learning.	3	3	4	4	3.50		
3	Deliver learning objectives.	4	4	4	4	4.00		
	Main activity							
4	Orient students to the problem.	3	3	4	4	3.50	3.60	Very good
5	Organize students to study.	3	4	3	3	3.25		
6	Assist independent and group investigation.	4	4	4	4	4.00		
7	Develop, present, and exhibits the artifacts.	4	3	4	3	3.50		
8	Analyze and evaluate the problem-solving process.	4	3	4	4	3.75		
	Closing activity							
9	Collect student works.	4	4	4	4	4.00	3.875	Very good
10	Conduct follow up by giving guidance to the next activity.	3	4	4	4	3.75		

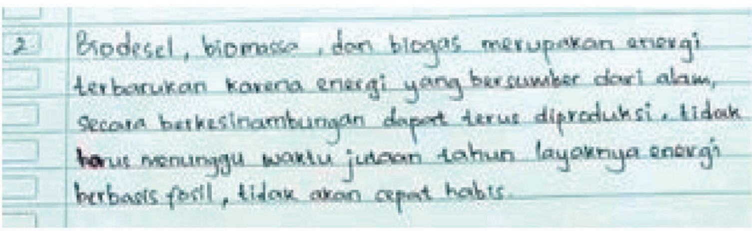
Based on *Table 7*, the average ability of lecturers to manage PBL learning for four meetings were very good. The value of a pre-activity was 3.625. The main activity was 3.60. The closing activity was 3.875 with a maximum score was four. These findings suggested there was a correlation between the activities of the PBL learning model and students' analytical thinking skills.

5. Discussion

5.1. *The student's response to the questions in the indicator of matching*

Students were expected to match relevant and irrelevant parts of an object presented with a table of new and renewable energy. Then, students matched and gave an explanation to classify as renewable energy. The results of the student's response in question number 2 can be seen in *Figure 5*.

a)


2 Biodesel, biomassa, dan biogas merupakan energi terbarukan karena energi yang bersumber dari alam, secara berkesinambungan dapat terus diproduksi, tidak harus menunggu waktu jutaan tahun layaknya energi berbasis fosil, tidak akan cepat habis.

b)

Biodiesel, biomass, and biogas are renewable energies because they source energy from nature and can be sustainably-produced, do not have to wait millions of years like fossil-based energy, which will not run out quickly.

Figure 6. – A student answer to question number 2,
a) original version written in Indonesian; b) English translation.

According to *Figure 6*, students could explain biodiesel, biomass, and biogas as renewable energy. These findings indicated a high category for the experimental group than the control group because students were accustomed to expressing ideas as practised in the learning process by using the PBL model. These data were consistent with the results of interviews with experimental class students who stated that most of the test items could be conducted. The PBL model implemented the practice of higher-order thinking skills (Mardiansyah *et al.*, 2019).

5.2. *The student's response to the questions in the indicator of classifying*

Classifying is the ability to grouping objects based on the characteristics of similarities and differences. This indicator was in questions 3 and 4. Students were expected to design a sketch of an experiment with the equipment provided. *Figure 7* is presented the student's response.

As shown in *Figure 7*, students could sketch experiment well. Achievement of this indicator was categorized high for the experimental group because it implemented the PBL learning model. They were trained on how to classify experimental equipment and arrange the equipment according to the experimental stages in the learning process. Student analytical thinking skills at the university can be directed to a more proper understanding of the mechanical process of analytical thinking (Bachmann, 2019). In the control class, the achievement of indicators was relatively low, because the way to classify was untrained.

a) b)

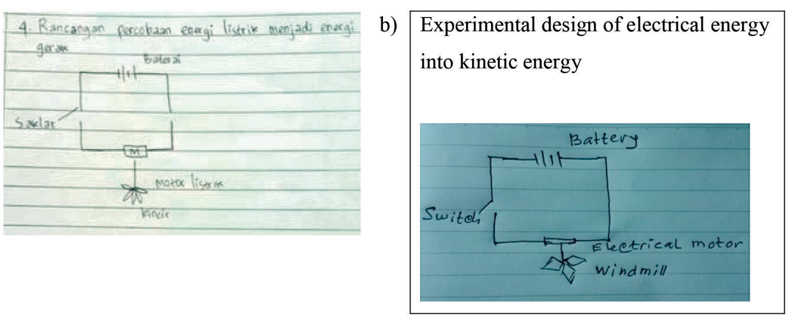
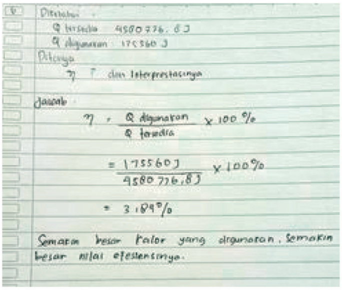


Figure 7. – A student answer to question number 4,
a) original version written in Indonesian; b) English translation.

5.3. *The student's response to the questions in the indicator of organizing*

The indicator of organizing requires the students' ability to determine how each part was suitable and can function together in a structure. The questions of this indicator were in question number 5 and 6. Students were expected to adopt the formula and calculate the efficiency of the experimental data obtained, the heat used, and the available heat. *Figure 8* is presented the student's response.

a)



b)

If:

$Q_{available}$ = 4580776.8 J

Q_{used} = 175560 J

Question: η = ...? and its interpretation

Answer:

$\eta = Q_{used} / Q_{available} \times 100\%$

= 175560 J / 4580776.8 J x100%

= 3.84%

The greater the heat used, the greater the value of the efficiency.

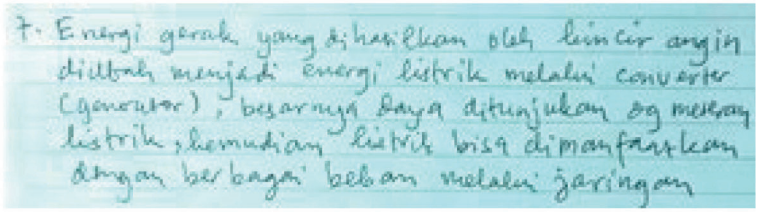
Figure 8. – A student answer to question number 5,
a) original version written in Indonesian; b) English translation.

As shown in *Figure 8*, students could answer and organize the questions well. Moreover, they could explain the physical meaning of the calculated amount. These findings were classified as a high category for the experimental group because they implemented the PBL learning models to organize a learning process problem. Hence, organizing information was analyzed to obtain data precisely (Areesophonpichet, 2013; Huang *et al.*, 2017). The achievement of indicators was low in the control group due to the learning process was conventional.

5.4. *The Student's response to the questions in the indicator of attributing*

The attributing indicators required students' ability to determine the point of view of an object presented. The attributing indicator was in questions number 7 and 8. Students were expected to connect between the amount of electric energy and wind energy. The higher wind energy indicated the higher electrical energy, and vice versa. The student's response can be seen in *Figure 9*.

a)



b)

The kinetic energy produced by windmills was converted into electrical energy through a generator, the amount of power was indicated by an electric meter. Then, electricity can be utilized with various loads through the electricity network.

Figure 9. – A student answer to question number 7,
a) original version written in Indonesian b); English translation.

According to *Figure 9*, students were able to answer questions except for students in the control group. This indicator's achievements were classified in the high category for the experimental group and low for the control class. The relationship between one variable with another variable developed by students could not construct the relationship of concepts (Saptono *et al.*, 2016).

The student analytical thinking skills in new and renewable energy were in the high category for the experimental group and the low category for the control group. Therefore, an alternative learning strategy was needed to improve the students' analytical thinking skills in the natural sciences. PBL model can be an alternative model and can be applied to the natural sciences to increase the students' analytical thinking skills. It was revealed in the experimental group. Analytical thinking skills can be trained to the students with effective learning models (Mardiansyah *et al.*, 2019). The PBL model effectively supports the development process of the students' critical thinking skills (Kek & Huijser, 2011; Ismail *et al.*, 2018). Besides, the PBL model helps the students develop their thinking and problem-solving skills (Arends, 2012). Analytical thinking skills are higher-order thinking skills trained through relevant learning programs. Researchers need to develop analytical thinking skills to promote the importance of analytical thinking skills for students (Thaneerananon *et al.*, 2016).

6. Conclusion

There was a significant difference among indicators of analytical thinking skills. The results of the pretest and posttest between the experimental class and the control class showed a significant difference in the matching indicator, classifying indicator, organizing indicator, and attributing indicator as indicators of analytical thinking skills. Our findings provided a general description to lecturers and researchers about analytical thinking skills in higher education, particularly in natural science with the topic of new and renewable energy by implementing the PBL model. Researchers recommend that lecturers should be participated in promoting the importance of student's analytical thinking skills in facing the challenges of the 21st century.

6.1. *Limitation and suggestion*

This study limitation has only used the concept of new and renewable energy for students in Indonesia. Our study results highlight an overview of lecturers and researchers about students' analytical thinking skills in science learning, especially in the concept of new and renewable energy. Lecturers need to be more creative in selecting and managing the learning process to increase students' analytical thinking skills.

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Riassunto

Le capacità di pensiero analitico sono abilità di pensiero critico e abilità di pensiero di ordine superiore che soddisfano le esigenze degli studenti nel 21° secolo. Questo studio mira ad analizzare le capacità di pensiero analitico dello studente nelle scienze naturali, in particolare nell'ambito delle energie nuove e rinnovabili. Questo studio segue un disegno esplicativo sequenziale con metodi quantitativi e qualitativi. I dati sono stati raccolti tramite intervista, osservazione e analisi del saggio di prova degli studenti nell'ambito *del programma di formazione per insegnanti Madrasah Ibtidaiyah presso IAIN Surakarta (Indonesia), al fine di determinare le caratteristiche delle loro capacità di pensiero analitico. I risultati hanno mostrato che i punteggi medi di pre-test e post-test e dimensione dell'effetto erano rispettivamente 54.34, 74.91 e 2.91. Questi risultati hanno rivelato che le capacità di pensiero analitico del concetto di energia nuova e rinnovabile nel gruppo sperimentale erano superiori rispetto al gruppo di controllo. L'apprendimento innovativo basato su PBL appare costituire un potenziale come metodo alternativo per aumentare le capacità di pensiero analitico dello studente. Questi risultati possono fornire una guida per docenti e ricercatori per la promozione delle capacità di pensiero analitico degli studenti nello studio delle scienze naturali, in particolare per i concetti di energia nuova e rinnovabile, grazie all'implementazione del modello di apprendimento basato sui problemi (PBL).*

Parole chiave: Apprendimento basato sui problemi (PBL); Capacità di pensiero analitico; Energia nuova e rinnovabile; Metodi misti; Scienze naturali.

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