ANALYTICAL THINKING SKILLS OF TEACHER CANDIDATE STUDENTS BY APPLYING RESEARCH-BASED LEARNING (RBL) MODEL IN NATURAL SCIENCE

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Abstract:
This study aims to analyze the analytical thinking skills of prospective teacher students in scientific learning of energy materials by applying a Research-Based Learning model (RBL). This study used a mixed method with a sequential explanatory design. The respondents selected through purposive sampling were 70 students, and 2 of them were for interview data. The research data was collected using a test instrument in the form of 10 essay questions and a non-test in the form of open interviews to students. The average pre-test score for the essay test was 45.71, the post-test score was 68.71, and the N-gain value was 42.37%. These results provide information about analytical thinking skills on energy concepts which are still in the moderate category, so alternative learning strategies are needed to improve the ability of prospective teachers in science learning. This research has recently developed five indicators of analytical thinking skills based on quantitative and qualitative studies on energy materials in science learning.

Abstrak:
Penelitian ini bertujuan untuk menganalisis keterampilan berpikir analitis mahasiswa calon guru dalam pembelajaran saintifik materi energi dengan menerapkan model pembelajaran berbasis penelitian (RBL). Penelitian ini menggunakan mixed method dengan desain sequential explanatory. Responden yang dipilih melalui purposive sampling sebanyak 70 siswa, dan 2 diantaranya untuk data wawancara.. Data penelitian dikumpulkan dengan menggunakan instrumen tes berupa 10 soal essay dan non-test berupa wawancara terbuka kepada siswa. Rata-rata nilai pretest tes esai adalah 45,71, nilai posttest 68,71, dan nilai N-gain 42,37%. Hasil tersebut memberikan informasi tentang keterampilan berpikir analitis pada konsep energi yang masih dalam kategori sedang, sehingga diperlukan alternatif strategi pembelajaran untuk meningkatkan kemampuan calon guru dalam pembelajaran sains. Penelitian ini memiliki kebaruan mengembangkan lima indikator kemampuan berpikir analitis berdasarkan kajian kuantitatif dan kualitatif pada materi energi dalam pembelajaran IPA.

Keywords:
Analytical Thinking Skills, Energy, Science Learning, Student Teacher Candidates

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INTRODUCTION

Challenges in the 21st century require humans to master many competencies. Hard skills and soft skills are a more serious challenge because they cannot be instantly trained like hard skills through workshops. Soft skills, one of which is Higher-Order Thinking Skills (HOTS), must be prepared from an early age, starting at the school level. Thus, when students have completed their studies and entered working age, these abilities are mature.

HOTS in education are included in the science curriculum reform agenda. Science curricula in various countries define HOTs as skills students must achieve (educational objectives) (Fensham & Bellocchi, 2013). Unlike in Indonesia, HOTS is still in the stage of adaptation and development (Learning Objective). This fact is shown by the pattern of science learning that is carried out. Most of the learning that targets training HOTS is in research schemes. Outside of this situation, the learning carried out tends to be the same as the previous learning process, emphasizing mastery of the topic. As a result, when students are presented with problems in a more complex context, i.e., which requires advanced analytical skills, students in Indonesia get unsatisfactory results. As evidence, the results of tests conducted by the Program for International Students Assessment (PISA) for science subjects show that Indonesian students are ranked 71 out of 79 countries surveyed (OECD, 2016).

This fact becomes an evaluation material for educators and practitioners in Indonesia because Indonesian students' higher thinking order ability is still relatively low. HOTS are needed to survive as human learners in the 21st century. There are many types of HOTS in education, such as creativity and innovation, critical thinking, problem-solving, communication, collaboration, and literacy skills (Van Laar, Van Deursen, Van Dijk, & de Haan, 2017). However, Rasheva-Yordanova, Iliev, & Nikolova (2018) define Analytical Thinking Skills (ATs) as the core of HOTS. This claim is confirmed in the PISA test criteria, which refers to HOTS with many analytic questions.

As a complex system, analytical capabilities are not only up-down. This means that teachers with inadequate ATs cannot train ATs to students. So that before looking at students as learning subjects, ATs must first be trained to teachers (in this case prospective teachers) in order to facilitate ATs well. Limbach & Waugh (2010) provide examples of the teachers' role in training ATs, including determining learning objectives; inquiry learning process; practicing, reviewing, refining, and improving comprehension; and practicing feedback and assessing learning. Therefore, the first improvement that must be made is on the teachers' side as the achievement of the long-term goals of national education.

Analytical thinking skills are a core part of critical thinking skills (Rasheva-Yordanova, Iliev, Nikolova, 2018). One of Bloom's taxonomies that ranks fourth after knowledge, understanding, and application is analytical thinking skills (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1979). Analytical thinking skills are active when students are confronted with unusual problems (Astriani, Susilo, Suwono, & Lukiati, 2018). According to Prawita, Prayitno, & Sugiyarto (2019), analytical thinking skills are used to identify and connect between statements, concepts, descriptions, or other forms of knowledge. Indicators of analytical thinking skills are distinguishing, organizing, and attributing (Anderson & Krathwohl, 2001). Meanwhile, according to Marzano & Kendall (2008), there are five indicators of analytical thinking skills: matching, classifying, analyzing errors, generalizing, and detailing. Other experts opine that indicators of critical thinking skills consist of elemental analysis, relationship analysis, principle analysis, and organizing (Montaku, Kaittikomol, & Tiranathanakul, 2012). Based on experts' opinions, the researchers synthesized indicators of analytical thinking skills, namely, matching, classifying, analyzing principles, organizing, and analyzing relationships.

The provision of ATs capabilities to prospective teachers is part of efforts to improve the quality of teachers in the future. Limbach & Waugh (2010) explained that the ability of ATs can be optimized with a Research-Based Learning model (RBL). In addition to training ATs, RBL can also improve five other skills: cognitive skills; knowledge skills; ethical skills; social skills; and communication, arithmetic, information, and technology skills (Sota & Peltzer, 2017).

In practice, RBL can develop a critical attitude of inquiry so that it can produce many solutions and creative ideas. Furthermore, Yulhendri, Syofyan, & Afridona (2019) stated findings related to the benefits of RBL, including (a) encouraging students' roles in the learning process; (b) training natural thinking skills with a scientific approach; (c) optimizing their independence, logic, critical thinking, and creativity; and (d) strengthening scientific ethics and avoiding plagiarism. Other research results suggest that RBL can improve academic achievement, practice learning about learning, and build new knowledge independently (Srikoon, Bunterm, Samranjai, Wattanathorn, 2014).

RBL is a model that has characteristics to develop students' thinking skills. This is in line with the goal of learning science to facilitate the development of students' thinking skills because thinking skills are an important foundation for learning and living life (Hewitt, Lyons, Suchocki, & Yeh, 2013). This is also in line with Marzano's opinion that analytical thinking can help develop the main components in the learning process that are beneficial for students (Marzano, 2001).

The RBL model encourages participants to conduct research activities. This model can train students to think critically and conduct research activities such as tracing, compiling hypotheses, collecting and processing data, and drawing conclusions (Ramahwati, Chamdani, & Salimi, 2016). The implementation of this model in learning follows the Syntax (Tremp, 2010), consisting of seven steps of RBL procedures in learning: (a) formulating a general question; (b) overview of research literature; (c) defining the question; (d) planning research activities and clarifying methods/methodologies; (e) undertaking investigations and analyzing data; (f) interpreting and considering the results; and (g) reporting and presenting the results. Table 1 describes the activities of educators and students in the learning process using the RBL model.

Table 1. Activities of educators and learners (Forijati, 2019)

RBL Syntax	Educators	Students
Formulating a general question.	Educators help students to find problems.	Students are divided into groups and then identify problems through group discussions.
Overview of research literature; Defining the question.	Educators provide direction relating to the material.	Students actively engage in two-way communication with educators and other students.
Planning research activities and clarifying methods.	Educators provide guidance and monitoring of research undertaken by students.	Students who have been guided conduct activities to interpret, analyze, reference, and evaluate research data with group members.
Undertaking investigation and analyzing data.	Educators facilitate when students do research.	Learners conduct group discussions.
Interpreting and considering the results; Reporting and presenting the result.	Educators act as facilitators when conducting discussions.	The results of the analysis are presented in front of the class to get input from educators and fellow students.

This study aims to analyze the ATs of prospective teachers through implementing scientific learning with the RBL model in universities. The results of this study can be used as initial evaluation material regarding the condition of prospective teachers so that lecturers, researchers, and related stakeholders can prepare a more optimal learning process to produce prospective teachers who can facilitate ATs training in schools. In addition, this research has a novelty by developing five indicators of analytical thinking skills based on quantitative and qualitative studies on energy materials in scientific learning.

RESEARCH METHOD

This research used mixed methods with a sequential explanatory design that combined quantitative and qualitative methods. The first stage used quantitative methods, and the second used qualitative methods (Sugiyono, 2016). The implementation of the sequential explanatory design starts with the collection and analysis of quantitative data, followed by the collection and analysis of qualitative data that are built based on the initial results of quantitative data (Creswell, 2012). Fig. 1 describes the sequential explanatory research design according to Creswell (2012).

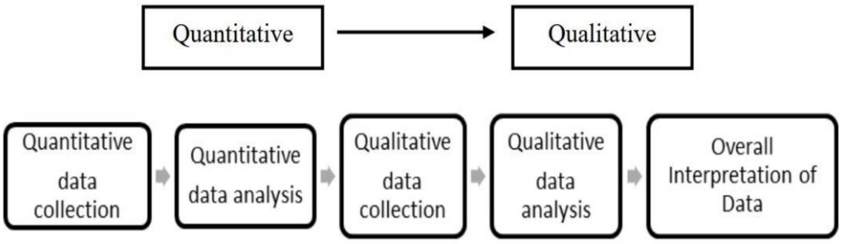


Figure 1. Sequential explanatory research design (Creswell, 2012)

The priority of the method is given to quantitative data. Quantitative methods have the role of obtaining descriptive quantitative data, while qualitative methods have the role of deepening and expanding quantitative data. Quantitative methods were used to obtain data on students' analytical skills by providing essay tests before and after learning in the pre-test and post-test forms. Qualitative methods are used to obtain in-depth data about students' analytical skills in the science teaching process. The quantitative research technique was a quasi-experimental one-group pre-test post-test design without a control group (Fraenkel, Wallen, & Hyun, 2007). The qualitative research design used was descriptive qualitative, which examined students' analytical skills through student answer sheets.

Samples were selected by purposive sampling. This sampling technique established special characteristics that follow the research objectives to answer research problems. The research subjects were determined before the study was conducted. They consisted of 70 students of Islamic Elementary Teacher Education Study Program in Surakarta, Indonesia. At the interview stage, two respondents were selected based on the scores obtained from the results of analytical thinking skills tests. One respondent had the highest score, and another had the lowest score compared to high analytical thinking.

Data collection in this study was carried out in two ways. At the initial stage, students were given a pre-test of 10 essay questions regarding the ATs indicator in Table 2. The research was conducted in the even semester of the 2020/2021 academic year in 3 months from March to May 2021. Students carried out individually their research projects on the subject of new and renewable energy. After following the learning process using the RBL model, students were given a final test in the form of 10 essay questions which also referred to the ATs indicators. To confirm the students' ATs, the researchers conducted nonrandom interviews with students using open-ended questions. The goal was to confirm the ability of students' ATs after participating in learning activities. Experts have reviewed and declared both test questions and interview guides valid.

Table 2. Indicators of analytical thinking skills

Anderson & Krathwohl (2001)	Marzano & Kendall (2008)	Montaku et al. (2012)	Synthesis
Distinguish	Match	Element analysis	Match
Organize	Classify	Relationship analysis	Classify
Connect	Error analysis	Principle analysis	Principle Analysis
	Generalize	Organize	Organize
	Detail		Relationship Analysis

After the student ATs data was collected, a quantitative and qualitative descriptive analysis was carried out. Quantitative descriptive was intended to profile students' abilities on each ATs indicator. Students' profiling was done using equation 1 and then classified into five categories based on Table 3.

$$\text{Interpretation } \% = \frac{score}{\max} \times 100$$

Table 3. Category of analytical thinking skills (Karim & Normaya, 2015)

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

The results of the students' pre-test and post-test analytical thinking skills then calculated the increase expressed in the form of N-gain (gain normalization) (Hake, 1998).

RESULTS AND DISCUSSION

Students' Analytical Thinking Skills

The average student's analytical thinking skills were categorized as medium based on the test analysis results. The average results of each indicator of the students' analytical thinking skills can be seen in Table 4.

Table 4. Results of data analysis indicators for analytical thinking skills

Indicators of ATs	Code	%	Indicator Category
Matching	KBA1	72.68	High
Classifying	KBA2	64.11	Moderate
Principle analysis	KBA3	69.29	Moderate
Organize	KBA4	74.46	High
Relationship analysis	KBA5	63.04	Moderate

Based on Table 4, the analysis results obtained by the students' average analytical thinking skills were classified as moderate. The highest achievement was in the organizing indicator, and the lowest was in the relationship analysis indicator.

Pretest, Post-test, and N-gain analysis

The research results on the pre-test and post-test data were described in Table 5. Next, the N-gain value was obtained from the pre-test and post-test to measure the improvement of the subject's analytical thinking skills before and after applying the RBL model.

Table 5. Summary

Score	Amount	Score			
		Ideal Score	Min	Max	Average
Pre-test	70	100	30.00	57.50	45.71
Posttest	70	100	55.00	77.50	68.71

The analysis results of the value <g> = 0.43 were to the medium category. The pre-test, post-test, and N-gain average data are illustrated in the bar diagram in Figure 2.

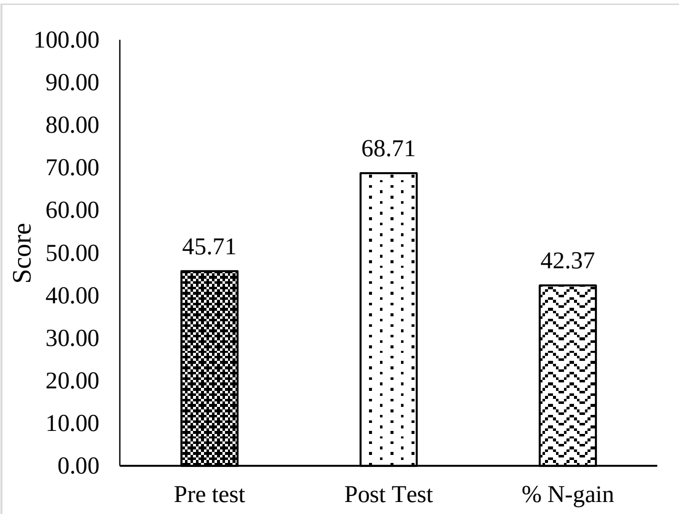


Figure 2. Percentage of pre-test, post-test, and N-gain scores

Figure 2 shows an increase in the analytical thinking skills indicator, with an N-gain value of 42.37%. The lack of students' analytical thinking skills was because the applied RBL model was a new learning model.

Interview Results

Interviews were conducted with two students, one who received the highest and the other who received the lowest. This interview aimed to explore the experiences experienced by students in designing and conducting experiments, as well as experience in doing tests. The findings obtained from the interviews are presented in Table 6.

Table 6. Interview Results

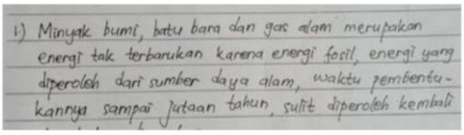
Question	Responses	
	Respondent 1	**Respondent 2**
Are you having difficulty answering the test?	A little difficult, especially about questions 6 and 7.	Yes, mostly, I cannot answer.
In data 1: Energy Table, questions no. 1 to 3: Can you do it?	Yes, I can. The hard one is no. 3 when making a comparison table for the impact of energy use.	I can answer number 1, but numbers 2 and 3 are difficult, but I do everything I can.
Questions 4 and 5 ask you to design an energy change experiment. What did you do?	I identified the tools provided, sketched a picture, and explained the steps of the experiment.	I read the tools provided and want to try to imagine stringing rather difficult. There are some names of tools that are forgotten.
How do you work on questions 6 and 7 that are asked to calculate the heat energy and interpret it?	I wrote down the unknown, then asked when I wanted to write the formula. I forgot a little. Then, calculate the heating value.	I forgot the formula for finding heat, which I wrote is only known.
What are the steps you take to conclude problem number 8?	I looked at the data, tried to analyze it, and concluded.	Observe the two data and compare them. To conclude, I feel it is still difficult.
In questions 9 and 10, you are asked to explain the process of obtaining electrical energy from the motion energy of an image. How do you read the picture?	Observing images of windmills, which is the energy of motion. Then converted by the generator into electrical energy.	Difficult, not accustomed to reading images. I tried to answer it, and I repeatedly watched the picture.

Table 6 shows that respondent 1 had the perception that the questions of the test given were easy. However, for questions 6 and 7, respondent 2 perceived the questions as challenging, saying that most questions could not be answered. The questions provided were a matter of analysis that requires HOTS. High-level thinking is the ability to memorize, remember, and understand information toward the ability to analyze, evaluate, and create (Lee & Choi, 2017).

The Answer to Questions on the Matching Indicator

Students numbers 1 and 2 were able to identify the data presented in a tabular form related to the concept of energy form. From the table in the questions, the students matched and gave explanations classified as conventional and renewable energy. The answer of one student to question number 1 is presented in Figure 3.

A



B

1) Crude oils, coals, and natural gaseous are non-renewable energy derived from fossil-fuel which is obtained from nature and need billion years for its production so that it is very difficult to renew

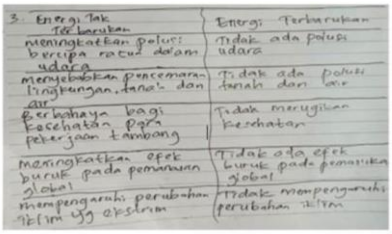
Figure 3. A sample of students' answers on matching indicator
(A) original (B) translation

Figure 3 reveals that students can answer the questions well and provide an explanation of oil, coal, and natural gas categorized into non-renewable energy. Achievement on this indicator was in the high category because students were accustomed to expressing ideas, which was done when learning using the RBL model.

Student Ability of the Classifying Indicator

This indicator existed in questions 3 and 4. Students could apply the concept of data presented in a tabular form by comparing the negative impacts of using conventional and renewable energy. The answer given by one of the students is presented in Figure 4.

a



b

Non-renewable energy	Renewable energy
Increase air pollution	Minimize the air pollution
Pollution to environment including soil and water	No soil and water pollutions
Carrying toxicity towards miners	No toxic production
Increase the global warming effect	Have no effect on the global warming phenomena
Increase the possibility of extreme climate change	No effect towards climate change

Figure 4. A sample of students' answers on classifying indicator

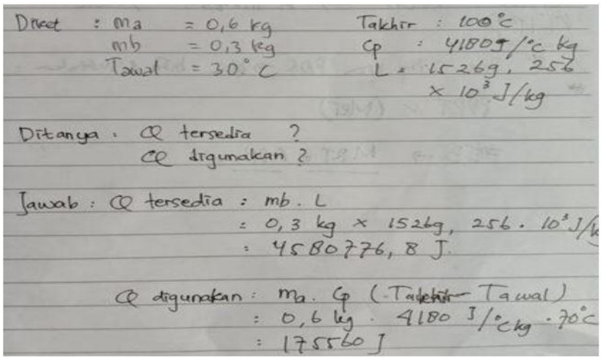
(A) original (B) translation

From Figure 4, the student answered questions quite well and classify the impact of conventional and renewable energy use in tabular form. Achievements on this indicator were average in the medium category because some students found it difficult to present answers in a tabular form.

The Answer to Questions on the Principle Analysis Indicator

This indicator was in questions 5 and 6. Students could calculate the value of the variable sought from the experimental data and interpret it. The answer given by one of the students is shown in Figure 5.

A



Diket : ma = 0,6 kg   Takhir : 100 °c
mb = 0,3 kg   Cp : 41809 /°c kg
Tawal = 30° C   L : 15269, 256 × 10³ J/kg

Ditanya : Q tersedia ?
Q digunakan ?

Jawab : Q tersedia : mb . L
: 0,3 kg × 15269, 256 . 10³ J/kg
: 4580776,8 J

Q digunakan : ma . Cp (Takhir - Tawal)
: 0,6 kg . 4180 J/°Ckg . 70°C
: 175560 J

B

If:
ma= 0.6 kg T_{final}= 100 °C
mb= 0.3 kg   Cp= 41809 °CKg^{-1}
$T_{initial}$= 30 °C   L = 15269. 256 × 10^3 J Kg^{-1}
Question: available Q and used Q
Answer: available Q = mb×L
= 0.3 × 15269.256×10^3
= 458-77.8 J
Used Q = ma × Cp (T_{final}-$T_{initial}$)
= 0.6 × 4180 × 70
= 175560 J

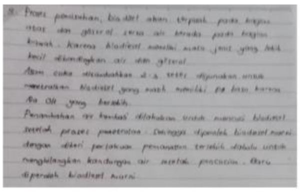
Figure 5. A sample of students' answers on principle analysis indicator
(A) original (B) translation

Figure 5 illustrates that the students were able to answer questions quite well and applied the formula to calculate heat. However, the answer was still lacking in explaining the physical meaning of the calculation results, so the average achievement of this indicator was the moderate category.

The Answer to Questions on Organizing Indicators

This indicator was in questions number 7 and 8. Students were able to communicate the results of the experiment to conclude the experimental data provided. The answer given by one of the students is presented in Figure 6.

A



B

8. Separating process of biodiesel: Biodiesel will be separated on the upper layer from glycerol and water which will stay on the lower layer. It is because biodiesel have lower mass than water and glycerol. Acetic acid is added 2-3 drops to neutralize the alkaline biodiesel due to the excess of NaOH. Water is re-added to wash biodiesel after neutralization step. Then, the water is evaporated through heating technique to separate it from biodiesel. Finally, pure biodiesel is obtained.

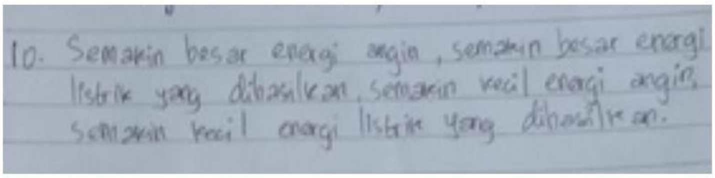
Figure 6. A sample of students' answers on organizing indicator
(A) original (B) translation

Figure 6 indicates that students answered the questions well, communicated and organized the experimental data to be analyzed, and then made conclusions. Achievements on this indicator were in the high category because only a few students were wrong in answering this problem.

The Answer to Questions on the Relationship Analysis Indicator

Students were expected to be able to analyze the relationship between the amount of wind energy with the electrical energy produced in questions 9 and 10. One student's answer to question number 10 is shown in Figure 7.

A



B

10. The higher amount of wind energy will derived to the production of higher amount of electrical energy. In contrast, the smaller energy of wind will produce lower energy of electricity.

Figure 7. A sample of students' answers on relationship analysis indicator (A) original (B) translation

Figure 7 shows the students answered questions quite well and analyzed the relationship between one variable and another, in this case, between the amount of wind and electrical energy. Achievements on this indicator were average in the medium category because some students did not answer correctly. The research results indicated that the analytical thinking skills of prospective teachers in the energy concept were still in the medium category, so an alternative learning strategy was needed to improve their skills in scientific learning. The RBL model was used as an alternative model that was applied to learning because, through this model, students explored, interpreted, and synthesized information to obtain various learning outcomes, including knowledge, skills, and attitudes (Fitriah, 2017). In contrast, instructors used this model to challenge the teaching that was normally used (Brew & Saunders, 2020).

Analytical thinking skills became an important part of solving problems of wind and electrical energy so that students made the right decisions to determine solutions and other impacts of the problems (Sartika, 2018). Analytical thinking skills arose when students faced unusual problems, uncertainties, questions, or dilemmas (Prawita, Prayitno, & Sugiyarto, 2019); the results of this study revealed that some of the students' answers were incorrect because of their inability to analyze a new problem properly.

CONCLUSION

Based on data analysis and discussion, it can be concluded that the average value of students' analytical thinking skills is 68.71%, which is in the medium category. The results obtained for matching indicators were 72.68%, which is in the high category; for classifying, 64.11%, which is in the medium category; principle analysis indicators, 69.29%, which is in the medium category; organizing indicators, 74.46%, which is in the high category; and relationship analysis indicators, 63.04%, which is in the medium category. The average pre-test score was 45.71, the average post-test score was 68.71, and the N-gain value was 42.37%. The results of this study provide a general description to lecturers and researchers about the condition of students' analytical thinking skills in tertiary institutions in scientific learning, especially in energy material, by applying the RBL model. Data on the student responses to the tests given are also provided.

REFERENCES

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Dazu.

Astriani, D., Susilo, H., Suwono, H., & Lukiati, B. (2018). Profil keterampilan berpikir analitis mahasiswa calon guru IPA dalam perkuliahan biologi umum [Profile of analytical thinking skills of prospective science teacher students in general biology lectures]. *Jurnal Penelitian Pendidikan IPA*, *2*(2). https://doi.org/10.26740/jppipa.v2n2.p66-70.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1979). *Taxonomi of education objectives: The classification of educational goals, handbook 1, cognitif domain*. London: Longman Group Ltd.

Brew, A., & Saunders, C. (2020). Making sense of research-based learning in teacher education. *Teaching and Teacher Education*, *87*. https://doi.org/10.1016/j.tate.2019.102935.

Creswell, J. W. (2012). *Research design: pendekatan kualitatif, kuantitatif, dan mixed [Research design: Qualitative, quantitative, and mixed approach]*. Yogyakarta: Pustaka Pelajar.

Fensham, P. J., & Bellocchi, A. (2013). Higher order thinking in chemistry curriculum and its assessment. *Thinking Skills and Creativity*, *10*. https://doi.org/10.1016/j.tsc.2013.06.003.

Fitriah, E. (2017). *Model research-based learning etnozoologi untuk meningkatkan keterampilan generik sains dan sikap ilmiah mahasiswa guru biologi. [Ethnozoology research based-learning model to improve generic science skills and scientific attitudes of biology teacher' stu*. Yogyakarta.

Forijati, R. (2019). Model Pembelajaran berbasis riset pada matakuliah ekonomi mikro di Program Magister Pendidikan Ekonomi Pascasarjana Universitas Nusantara PGRI Kediri. *Jurnal Pendidikan Ekonomi*, *4*(1). https://doi.org/10.29100/jupeko.v4i1.1035.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2007). *How to design and evaluate research in education*. New York: McGraw Hill.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1). https://doi.org/10.1119/1.18809.

Hewitt, P. G., Lyons, S. A., Suchocki, J. A., & Yeh, J. (2013). *Conceptual integrated science*. New York: Pearson.

Karim, K., & Normaya, N. (2015). Kemampuan berpikir kritis siswa dalam pembelajaran dalam pembelajaran matematika dengan menggunakan model Jucama di Sekolah Menengah Pertama. *Jurnal Pendidikan Matematika*, *3*(1). https://doi.org/10.20527/edumat.v3i1.634.

Lee, J., & Choi, H. (2017). What affects learner's higher-order thinking in technology-enhanced learning environments? The effects of learner factors. *Computers & Education*. https://doi.org/10.1016/j.compedu.2017.06.015.

Limbach, B., & Waugh, W. (2010). Developing higher level thinking. *Journal of Instructional Pedagogies*. https://files.eric.ed.gov/fulltext/EJ1097083.pdf.

Marzano, R. J. (2001). *Designing a new taxonomy of educational objectives: Experts in assessment*. Thousand Oaks, CA: Corwin Press.

Marzano, R. J., & Kendall, J. S. (2008). *Designing and assessing educational objectives: Applying the new taxonomy*. Thousand, CA: Corwin Press.

Montaku, S., Kaittikomol, P., & Tiranathanakul, P. (2012). The model of analytical thinking skill training process. *Research Journal of Applied Sciences*, *7*(1).

OECD. (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education, PISA*. OECD Publishing. https://doi.org/10.1787/9789264266490-en.

Prawita, W., Prayitno, B. A., & Sugiyarto. (2019). Students' profile about analytical thinking skill on respiratory system subject material. *Journal of Physics: Conference Series*, *1157*(2). https://doi.org/10.1088/1742-6596/1157/2/022078.

Ramahwati, S., Chamdani, M., & Salimi, M. (2016). Penerapan model Research Based Learning (RBL) dengan pendekatan saintifik dalam peningkatan pembelajaran IPS pada siswa kelas V SDN 1 Sukomulyo tahun ajaran 2015/2016. *Kalam Cendekia Kebumen*, *4*(1.1). https://jurnal.fkip.uns.ac.id/index.php/pgsdkebumen/article/view/7991.

Rasheva-Yordanova, K., Iliev, E., & Nikolova, B. (2018). Analytical thinking as a key competence for overcoming the data science divide. *10th International Conference on Education and New Learning Technologies*. https://library.iated.org/view/RASHEVAYORDANOVA2018ANA2.

Sartika, S. B. (2018). Teaching models to increase students' analytical thinking skills advances in social science. *Education and Humanities Research (ASSEHR)*. https://doi.org/10.2991/icigr-17.2018.52.

Sota, C., & Peltzer, K. (2017). The effectiveness of research-based learning among Master Degree student for health promotion and preventable disease, Faculty of Public Health, Khon Kaen University, Thailand. *Procedia-Social and Behavioral Sciences*. https://doi.org/10.1016/j.sbspro.2017.02.226.

Srikoon, S., Bunterm, T., Samranjai, J., & Wattanathorn, J. (2014). Research synthesis of research-based learning for education in Thailand. *Procedia-Social and Behavioral Sciences*. https://doi.org/10.1016/j.sbspro.2014.01.319.

Sugiyono, S. (2016). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Bandung: Alfabeta.

Tremp, P. (2010). *Research-based teaching and learning, A LERU Project*. University of Zurich.

Van Laar, E., Van Deursen, A. J. A. M., Van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-Century skills and digital skills: A systematic literature review. *Computers in Human Behavior*. https://doi.org/10.1016/j.chb.2017.03.010.

Yulhendri, Y., Syofyan, E., & Afridona, S. (2019). The development of research-based learning model and journal as for Graduate Students' Scientific Publications of M. Pd. E on Economic. *Internasional Journal of Scientific and Research Publications*, *8*(5). https://doi.org/10.29322/IJSRP.8.5.2018.p7764.