



**EFFECT OF LEARNING MODEL APPLICATION OF  
GUIDED LABORATORY INQUIRY TO LOGICAL THINKING  
ABILITY OF STUDENTS ON HEAT TO ELECTRICITY  
CONVERSION MATERIAL**

**Fitri Fauziah<sup>1\*</sup>, Eko Suyanto<sup>1</sup>, Ismu Wahyudi<sup>1</sup>, Kartini Herlina<sup>1</sup>**

<sup>1</sup>Department of Physics Education, Lampung University

Email: fitri.fauziah.9197@gmail.com

DOI: <http://dx.doi.org/10.26418/jpmipa.v13i1.47821>

**Abstract**

*This research aims to determine the application effect of guided inquiry laboratory model on students' logical thinking ability on the material of heat to electricity conversion. The population in this research were all students of class XII MIA at SMA Negeri 15 Bandar Lampung for the 2019/2020 academic year. The technique used is purposive sampling, so that the sample in class XII MIA 1 is obtained in the form of a one group pretest-posttest design. The process of collecting data using interview techniques as a preliminary study and through pretest-posttest. The test question used is the Logical Thinking Test which measures five indicators of logical thinking. Hypothesis testing is done by using Paired Sample T-Test. The results of the analysis showed that the average difference between the posttest and pretest scores was 30.80 for all indicators. Data analysis also obtained an average n-gain of 0.55 which is included in the medium category. The n-gain test was also carried out on each indicator and was in the medium category. The variable controlling indicator shows n-gain of 0.65; probabilistic reasoning of 0.66; correlational reasoning of 0.62; proportional reasoning of 0.51; and combinatorial 0,36. Based on the entire analysis test, the results of the research showed that there was a significant effect of applying the guided inquiry laboratory model on the students' logical thinking ability on the material of heat to electricity conversion.*

**Keywords:** *guided inquiry laboratory, logical thinking ability, heat to electricity conversion*

**INTRODUCTION**

Science learning is oriented to the nature of science which contains three things, namely products,

processes, and attitudes through process skills (Rustaman et al., 2005). The process in the scientific approach will find the term reasoning. Definition



**Received** : 01/07/2021

**Revised** : 21/12/2021

**Accepted** : 04/01/2022

of reasoning by Rusman (2017) is a process of thinking logically and systematically on facts observed to obtain conclusion. Physics is part of sciences whose mastery of the material requires the ability to think logically, critically, and creatively (Setiono & Tadeus, 2018). So, in the process the teacher must provide opportunities for students to play an active role, so not only cognitive aspects will develop but also affective and psychomotor aspects. Based on the results of the interview with the physics teacher for class XII MIA at SMA Negeri 15 Bandar Lampung, due to limited time and learning tools, most of the teaching is done using the lecture method which tends to be unidirectional. The results of preliminary study directly shows that the learning process is still carried out textually, as a result, students do not get empirical experience. Meanwhile, the ability to understand and apply concepts is a requirement in achieving learning success. However in reality, textual learning is more often applied, included converting heat to electricity as an effort to utilize renewable energy. Applications should be more meaningful if activities are held by students actively and directly through practicum. However, giving awareness, especially to students as the next generation, is still lacking in the world of education. Based on a review of syllabus, several printed books, modules and worksheets, there is also no detailed explanation on the use of renewable energy for converting heat to electricity.

Based on these problems, it is necessary to make simple efforts to improve the knowledge and abilities of students. Actually, the high school curriculum is appropriate and supports

the times that emphasize the participation of students in obtaining a product. Thus, it is hoped that a process can be held that provides awareness for the empowerment of renewable energy into practical applications. These improvement efforts can be initiated by changing the paradigm of teaching into learning. The process of activating is done by getting students to be active and developing logical thinking skills. Logical thinking is the process of reasoning by connecting a series of opinions to arrive at a conclusion according to the rules of logic (Lestari et al., 2019). Based on the results of interviews, it is known that students' logical thinking skills tend to be low which is probably due to their tendency to memorize information. Therefore, in its application, especially learning Physics, not only by rote, but also requires understanding and even application of concepts. Memorizing activities are not too demanding of thinking activities, where children will lose their sense of learning which results in not getting used to thinking logically. Thus, the process requires systematic reasoning activities.

One of the supporting models to be applied is the guided inquiry laboratory by Wenning (2011) which contains five syntaxes in the form of observation, manipulation, generalization, verification, and application. In particular, inquiry is part of social constructivism. This theory views learning as mediation, knowledge as construction, and completion based on social practice (Folmer et al., 2009). This theory also states that effective learning occurs when teachers and students work collaboratively to find solutions (Baloyi, 2017). Collaborative focus is

working with each other for the same goal (Davidson & Major, 2014). Inquiry is also described as cooperative learning. Definition of cooperative according to Cohen (1994), ie students work in small groups, where members have participation. In addition, participants are expected to be able to carry out their duties. In this learning process, equipment should not be given directly. Students are given problem situations or phenomena and asked to formulate hypotheses, design experiments, verify, record data results, and interpret findings (Gulpepe & Kilic, 2015).

Inquiry learning is based on participation in data collection, and analysis of facts to provide an understanding of the nature and ways of science based on logical testing (Koray & Köksal, 2009). Inquiry is student centered, and able to develop hands on and minds on activity. Hands on is a direct activity with something that involves students manipulating objects to gain knowledge (Haury & Rillero, 1994). When doing hands on, Ateş & Eryilmaz (2011) explained that students also do minds on through the process of thinking about the process of what is being learned. Based on all these characteristics, this model tends to be better to apply. If this model is applied, the skills and knowledge of students will increase, it will also affect the ability to think logically. This inductive learning model is a way to motivate students by providing case studies or real problems to be analyzed in improving logical thinking skills (Prince & Felder, 2007). Students will be actively involved in solving problems through guided social interaction (Ketpichainarong et al., 2010). Thus, the skills and knowledge

of students will increase in producing products, also affecting the ability to think logically. This presentation is supported by research of Maretasari & Subali (2012) that inquiry has a significant effect on learning outcomes. Research by Purwanto (2012) also shows that guided inquiry practicum on physics material has an effect on increasing students' logical thinking skills.

The observed logical thinking ability refers to five indicators by Tobie & Capie (1981) which are netted with TOLT (Test of Logical Thinking), namely variable control, proportional reasoning, probabilistic, correlational, and combinatorial. The five indicators have been described by Trifone (2011), the first is proportional reasoning in assessing work ability and understanding quantitative aspects (proportions). Furthermore, the ability to identify, distinguish, and manipulate variables in designing experiments. Then probabilistic reasoning, namely the ability to solve a problem with possibilities. The next indicator is correlational reasoning, namely the ability to identify and verify the relationship between variables. The last indicator is combinatorial reasoning, which is solving a problem by involving all possible lists in one item. Thinking logically itself has a difference with memorizing, according to Saragih (2004) memorization only refers to mere memory ability, while logical thinking refers to understanding understanding, application, analysis, synthesis, and even evaluation ability to form a skill. The characteristics of logical thinking, including the ability to make generalizations and causal relationships (Diana, 2018).

The application of the guided inquiry laboratory model is through the active role of students in practicum. However, it is known that one of the success factors for conducting practicum is adequate equipment. In fact complete equipment is not owned by every school. The implementation of this conversion is also only found on a large scale, while simple products are still difficult to find. Thus, technology is needed to demonstrate it in schools, one of which is TEG (thermoelectric generator). The thermoelectric generator consists of three components (Vazquez et al., 2002), namely supports, modules and heat dissipation systems. The principle works by utilizing the temperature difference in the environment into electrical energy. The heat will enter on one side of the module and be discharged from the other side. Heat transfer will produce a voltage across the module proportional to the temperature gradient gradient (Ryuanargo et al., 2014). The module will continue to generate electricity as long as there is a temperature difference between the sides (Djafar et al., 2011). This technology has several advantages, namely noiselessness, small size, operating at high temperatures and small scale, environmentally friendly, and flexible (Riffat & Ma, 2003). The results of the study show that this technology is not widely known. So, with the use of appropriate syntax applied, participants have new knowledge and skills, especially in the material. The material for converting heat to electricity is in fact more often given in theory, so an update is needed. Based on the problems that have been described, in the form of dominant activities by the teacher, applications

that tend to be unidirectional, as well as the availability of media in the preliminary study, it is necessary to make improvements. The improvement step is to apply the guided inquiry laboratory model to improve students' logical thinking skills, and to provide awareness to the next generation in producing practical alternative energy. With the implementation of this model, learning will be centered on students, which means that the responsibilities of students are more than lecture-based learning (Prince & Felder, 2006). The benefits of applying this activity by emphasizing the ability to think logically can also increase student activity and learning quality, as well as a simple effort in utilizing renewable energy. Thus, students will be more motivated if they benefit from what they learn and what they use directly.

## **METHODS**

The population in this study were all students of class XII MIA SMA Negeri 15 Bandar Lampung for the 2019/2020 school year. The research sample was selected using purposive sampling technique, so that one experimental class was obtained, namely XII MIA 1 with a total of 34 students. As for the implementation process, the sample received treatment in the form of applying the guided inquiry laboratory model for Experiments topics 1 and 2 material conversion of heat to electricity. The design of this research is one group pretest-posttest. This design does not use a control class, where in its application there is a pretest and posttest. The shape of the design can be seen in Figure 1.

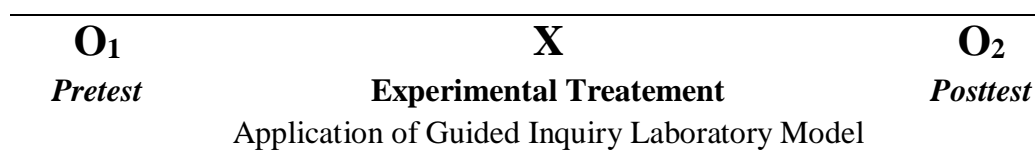


Figure 1. Research design form

The data collection techniques used, namely through interviews and tests related to heat-to-electricity conversion material from the experimental results. The interview technique was carried out as a preliminary study to obtain information related to the variables to be studied. Then the test results are used to determine the effect of the application of the guided inquiry laboratory model on the logical thinking ability of students on heat-to-electricity conversion material. Every item of questions in the form of descriptions that represent all indicators on the Test of Logical Thinking. The maximum total score for each question is 20, if the answer is correct and appropriate. However, if the answer is wrong or does not answer, it will get a score of 1. Before conducting research, first a test is carried out on student worksheets and test instruments. The validity test of the worksheet was assessed by experts using a Likert scale. Meanwhile, on the test instrument, expert tests and analysis were carried out using SPSS 26.

The whole test is carried out to determine whether or not an instrument is suitable for use as teaching materials and data collection tools. The validity test on the worksheet functions to measure the suitability of the material content and construction. Expert validation was

carried out by two validators, namely the Lecturer of Physics Education at the University of Lampung and a high school teacher. Based on the results of the validation test by the lecturer, a score of 0.90 was obtained and by the teacher was 0.83. Thus, obtained an average of 0.86 or 86%, where the percentage is included in the very valid category. Then the items that have been compiled are also tested for validity by experts. The assessment is carried out on aspects of construction, substance, and language. The results of the validation test by the lecturer obtained an average score of 0.88, and the validation test by the teacher obtained an average of 0.91. The average value of the two validators is 0.90 which is converted to 90%. Based on this value, the test instrument is classified as valid with very high criteria. The item validity test was also analyzed using the product moment correlation formula by Pearson with the help of the SPSS 26 program. The test results show that the 10 questions used have  $r_{arithmetic} > r_{table}$ , where  $r_{table}$  with value 0,36. Thus, all questions are said to be valid.

Furthermore, a reliability test was conducted using the Alpha Cronbach formula with the help of the SPSS 26 program. The test results showed a value of 0.69 at  $n = 10$ . Based on this value, the instrument has a high level of reliability. Then test the level of difficulty of the questions to find out

the degree of difficulty of a question through the ratio between the correct answerers and the number of incorrect answerers (Azwar, 1997). Based on the results of the analysis, it is known that the level of difficulty in 6 items is included in the easy category, while the other 4 items are categorized as moderate. The last instrument test is discriminatory power, and results in a weak category. according to Azwar (1997) Distinguishing power is the ability of a question to distinguish between students who have been able to master the material being asked and those who are still unable. From the results of the analysis and calculations, the researchers used all 10 items to measure students' logical thinking skills.

Then the normality test, n-gain test, hypothesis testing, and effect size test were carried out on the test result data. Normality test was conducted to determine whether the research sample came from a normally distributed population or not. Furthermore, the n-gain test aims to determine the increase in the pretest and posttest scores of the research sample. If the data is normally distributed, then the hypothesis test can be done by using a parametric statistical test using paired sample t-test. This test was used to determine how the effect of the application of the guided inquiry laboratory model on students' logical thinking skills. However, if the data is not normally distributed, then a non-parametric statistical test in the form of the Wilcoxon test is performed. This test is used to test the differences in two paired samples. The effectiveness of the application of the guided inquiry laboratory model was also analyzed by means of an effect size test. The

magnitude of the effect size value is obtained using the Cohen's d formula with the help of SPSS 26.

## **RESULTS AND DISCUSSION**

Students' learning activities in their application are adapted to the guided inquiry laboratory syntax contained in the worksheet. Then the increase in students' logical thinking skills was measured using pretest and posttest questions. The activities held in the form of experiments on the conversion of heat to electricity. It is known that experimental learning is a much better activity because it is supported by experiments by the teacher or the participation of students in a guided manner. One model that can be applied in emphasizing student participation is according to Maretasari & Subali (2012), namely the guided inquiry model which is also applied in this study. The syntax used refers to Wenning (2011) which has 5 stages. The first syntax is to make observations, which is to orient students to a problem. The next stage, students determine the control, manipulation, and response variables, then explain the relationship between these variables. The third syntax is generalization, where students assemble and conduct experiments.

The next step is to discuss and process the experimental data. Based on the data obtained, students are asked to communicate the results. Other groups were also given the opportunity to respond for comparison of data. If there are different results, then verification between groups based on theory is carried out. The last syntax, which is solving problems on the worksheet as an application.

Furthermore, the data from the students' pretest and posttest results were analyzed to prove the hypothesis that had previously been formulated. In the normality test, P value  $> 0.05$  was obtained, so that  $H_1$  was accepted or the research sample was normally distributed. In the following,

quantitative data from the research results are presented in the form of an assessment of the improvement in logical thinking skills obtained from the results of the pretest and posttest conducted at the beginning and end of learning as presented in Table 1.

Table 1. Result of pretest, posttest, n-gain

Parameter	Pretest	Posttest	N-Gain
Lowest Value	37.50	65.00	0.42
Highest Value	53.50	84.00	0.67
Standard deviation	3.89	4.77	0.72
Average	43.80	74.60	0.55

Based on the data presented in Table 1, it can be seen that the average pretest score before the guided inquiry laboratory model was applied was only 43.80 points. The value obtained can be said to be still low. However, after the treatment was given, there was a difference in score of 30.80 points with the posttest average being 74.60. The value obtained shows that there is an increase in results due to the application of guided inquiry laboratory on all ability indicators by Bilgin (2009) described as learner-

centered learning. Where the results of his research also show a positive influence on academic scores. Based on the results of the analysis, obtained an average n-gain of 0.55 which is classified as moderate. From the results obtained, it can be said that there is an increase in the ability to think logically in a sufficient category. Analysis was also carried out on each indicator of logical thinking by Tobin & Capie (1981). The results of the analysis on each indicator can be seen in Table 2.

Table 2. Result of pretest data

No.	Indicator	Pretest			Posttest		
		Total Lowest Score	Total Highest Score	Average of Value	Total Lowest Score	Total Highest Score	Average of Value
1.	Controlling Variable	16.00	26.00	19.68	16.00	26.00	19.68
2.	Probabilistic Reasoning	14.00	24.00	19.35	14.00	24.00	19.35
3.	Correlational Reasoning	14.00	23.00	18.62	14.00	23.00	18.62
4.	Proportional Reasoning	12.00	20.00	15.26	12.00	20.00	15.26
5.	Combinatorial Reasoning	10.00	19.00	14.59	10.00	19.00	14.59

From the overall data in Table 2, it can be concluded that there was an increase in the scores on all indicators of logical thinking ability. The five indicators are contained in each item of the questions. During learning, students are also trained in developing aspects of each indicator according to the syntax applied to the worksheet. Other data that can be known is the average of the lowest pretest-posttest scores on the combinatorial reasoning indicator, and the highest average on

the controlling variable. Combinatorial reasoning functions to measure students' ability to solve problems by involving all possibilities in a set of items. Then the indicator of variable control, namely the ability to determine, distinguish or manipulate variables (Trifone, 2011). The results of the analysis for the average total pretest and posttest scores for each indicator are completely presented in Figure 2.

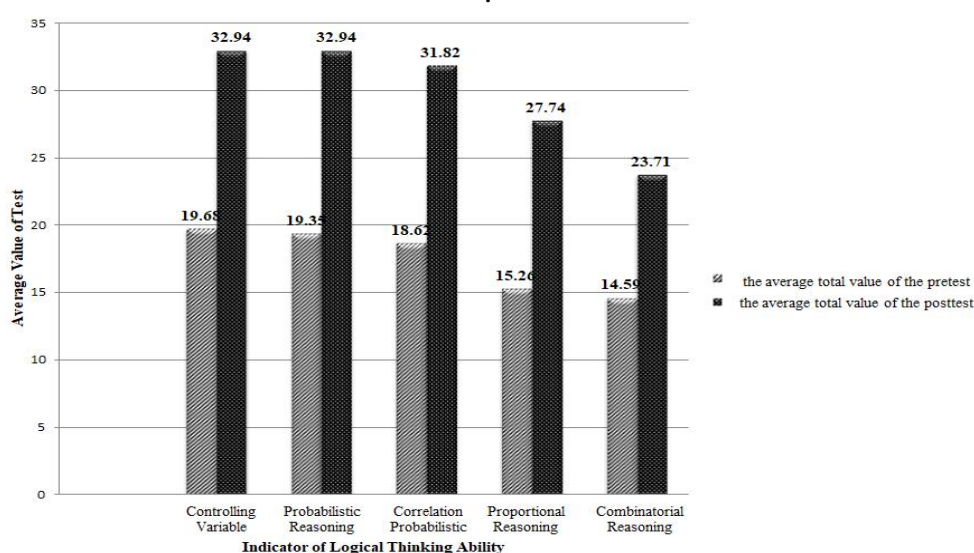


Figure 2. Graph of test results on each indicator

Indicators on controlling these variables are trained when students will design experiments by looking at the relationship between these variables. Students will find it easier to identify, determine, and manipulate variables, because basically they are faced with the phenomena of everyday life. This allows students to better understand even in context different supplies. The ability to think logically

alone, as a whole has an influence on academic achievement in constructing concepts. Students who have a high level of logical thinking ability will be able to change to alternative concepts more easily (Oliva, 2003). Calculations were also carried out to determine the difference in the average test for each indicator presented in Figure 3.



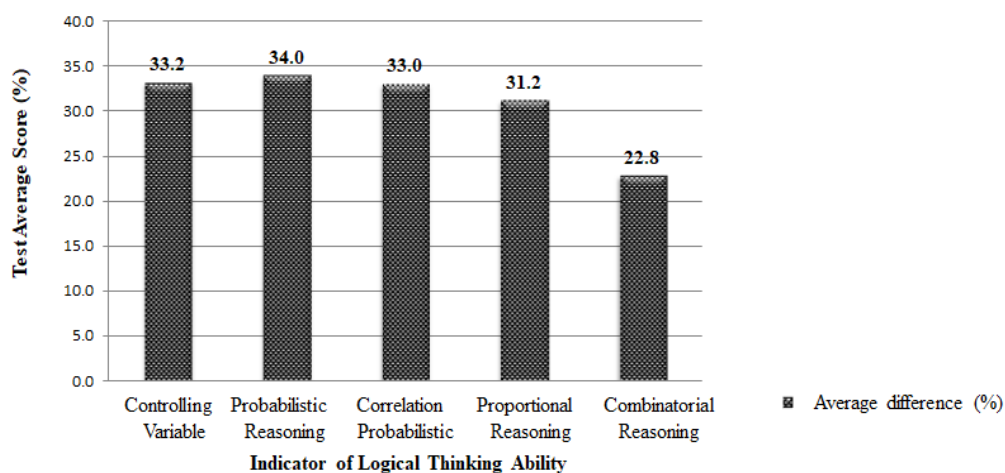


Figure 3. Difference in average value on each indicator

Based on the graph presented in Figure 3, it can be seen that the highest average difference is in probabilistic reasoning of 34.00%. This reasoning measures the ability to solve problems with probability or a possibility. The ability on this indicator is obtained when conducting repeated experiments to show relevant results. Students seem to be able to master this indicator, especially in determining quantitative aspects and what might happen from the facts seen. An example of a given item on this type of reasoning is about the possibilities for energy that will be available based on current consumption, or the probability that something will happen when viewed from a supportive situation. Then on the quantitative aspect of the current and voltage generated if the temperature difference is greater or from the form of the module circuit. Based on these questions, students are easier to answer because of the knowledge and experience gained from repeated experiments.

Furthermore, the lowest difference is also in the combinatorial reasoning indicator of 22.80%. The cause of the low test results on this

reasoning, because students have not been able to enter the analysis in conclusions that are inconsistent with evidence or illogical. The preparation of questions is also denser, so it is possible for participants to divert them to other questions. An example of a question for this indicator, which is asked to describe the impact of burning fossils, then explains how all items work and their measurements. Then in controlling variables, proportional reasoning, and correlational obtained the difference is not much different. Proportional reasoning is related to the ability to measure ratios, meaning to determine sums and compare ratios. Then correlational reasoning serves to identify the relationship between variables. The data obtained are also almost the same as research by Purwanto (2012), where learning Physics with guided inquiry can develop students' logical thinking skills. The value for the lowest indicator, namely combinatorial reasoning is 40.74%. Meanwhile, the highest is proportional at 55.56%.

After knowing the amount of data on increasing logical thinking skills from the test results, then a

statistical test in the form of an n-gain test is carried out on each indicator. Based on the test results, obtained an average n-gain of 0.65 on the indicator controlling the variable; 0.66 on probabilistic reasoning; 0.62 on correlational reasoning; 0.51 on proportional reasoning; and 0.36 on combinatorial reasoning. The data shows all values are included in the medium category. After the n-gain test was carried out, then the hypothesis was tested using a paired sample t-test because the data obtained were normally distributed. The results showed there was a significant effect of the application of the guided inquiry laboratory learning model on the logical thinking ability of students based on the increase in test scores on the heat-to-electricity conversion material. Then the results of the effect size test also show that the treatment applied is very effective in measuring students' logical thinking abilities.

When viewed from the average percentage of student test results, it only reached 31.00%. This shows that the high test results are not fully influenced by the treatment given, but there are other factors. These factors can be internal factors, one of which is psychological (Purwanto, 2012). There are six psychological factors affect learning outcomes, namely intelligence, attention, interest, talent or ability, motivation, and also readiness. Based on the final results obtained, it has answered the problem formulation. Where the process of activating is developed by familiarizing students to think logically in each syntax. Habits that are repeated will shape the character of students compared to conventional ones. The activities have been carried

out so far have activated the role of teachers who have not trained the reasoning power of students (Saragih, 2004). However, with the application of this model, the reasoning power and logical thinking ability of students will increase. The increase in test results on logical thinking skills is also due to the fact that in the process students are required to solve problems actively and directly. During the learning process, students are trained to find solutions with practicums that were previously rarely held in schools. The benefits obtained from this hands on activity are increasing interest, strengthening memory, avoiding misunderstandings, and connecting concrete and abstract things (Kartono, 2010). It seems that students show their interest by taking part and asking for curiosity. The fourth syntax also trains activeness and knowledge through presentation for verification. Based on all the attitudes shown, it is in accordance with the characteristics support inquiry by Suyanti (2010), namely being curious, wanting to talk, making something, and expressing it. At the end of each meeting, the researcher also invites participants to reflect. This encourages participants to better interpret the activities have been held, so that the memory range is better. The results of this study are in line with those proposed by Sundari et al.,(2017), inquiry requires students to interpret knowledge and practice thinking skills.

The novelty in this activity, namely producing a simple product as a supporting medium, can increase understanding of concepts, and skills. The use of worksheets is also adapted to the guided inquiry laboratory syntax. Overall, from the research data,

it shows the treatment given has a significant effect on increasing students' logical thinking skills in converting heat to electricity. Thus, this model can be used as an alternative by teachers to measure students' logical thinking skills, especially in learning Physics.

### CONCLUSION

Based on the results, it can be concluded there is a significant effect of learning model application of guided inquiry laboratory to logical thinking ability of students on heat to electricity conversion material. The results of analysis show the highest average difference is in probabilistic reasoning, while the lowest value is in combinatoric reasoning indicators. Based on the activities carried out, the researcher gives suggestions that this model should be used as an effort to increase students' logical thinking skills. Practicum activities can also be used as a starting point in providing participants with awareness to empower renewable energy into practical applications in the field.

### REFERENCES

- Ateş, Ö., & Eryilmaz, A. (2011). Effectiveness of hands-on and minds-on activities on students' achievement and attitudes towards physics. *Asia-Pacific Forum on Science Learning and Teaching*, 12(1), 1-22.
- Azwar, S. (1997). *Reliabilitas dan validitas*. Yogyakarta: Pustaka Pelajar.
- Baloyi, V. M. (2017). *Influence of Guided Inquiry-Based Laboratory Activities on Outcomes Achieved in First-Year Physics*. Pretoria: Faculty of Education.
- Bilgin, I. (2009). *The Effects of Guided Inquiry Instruction Incorporating a Cooperative Learning Approach on University Student Achievement of Acid and Bases Concepts and Attitude Toward Guided Inquiry Instruction*. *Scientific Research and Essays*, 4(10), 1038–1046.
- Cohen, E. G. (1994). *Restructuring the Classroom: Conditions for Productive Small Groups*. *Review of Educational Research*, 64(1), 1–35.
- Davidson, N., & Major, C. H. (2014). *Boundary Crossings: Cooperative Learning, Collaborative Learning, and Problem-Based Learning*. *Journal on Excellence in College Teaching*, 25(3&4), 7–55.
- Diana, N. (2018). Mengembangkan Kemampuan Berpikir Kreatif dan Berpikir Logis Mahasiswa dengan Adversity Quotient dalam Pemecahan Masalah. *Prosiding Seminar Nasional Matematika dan Pendidikan Matematika II*, pp. 101–112.
- Djafar, Z., Putra, N., & Koestoer, R. A. (2011). Pengaruh Variasi Temperatur Fluida Panas terhadap Karakteristik Modul Termoelektrik Generator. *Jurnal Teknik Mesin*, 11 (1): 32-41.

- Folmer, V., Barbosa, N. B. D. V., & Soares, F. a. (2009). Experimental activities based on ill-structured problems improve Brazilian school students' understanding of the nature of scientific knowledge. *Revista Electrónica de Enseñanza de Las Ciencias*, 8(1), 232–254.
- Gultepe, N., & Kilic, Z. (2015). Effect of Scientific Argumentation on the Development of Scientific Process Skills in the Context of Teaching Chemistry. *International Journal of Environmental and Science Education*, 10(1), 111–132.
- Haury, D. L., & Rillero, P. (1994). *Perspectives of Hands-On Science Teaching*. Columbus: The Ohio State University.
- Kartono. (2010). Hands On Activity pada Pembelajaran Geometri Sekolah sebagai Asesmen Kinerja Siswa. *Jurnal Matematika Kreatif-Inovatif*, 1(1), 21–32
- Ketpichainarong, W., Panijpan, B., & Ruenwongsa, P. (2010). Enhanced Learning of Biotechnology Students by an Inquiry-Based Cellulase Lab. *International Journal of Environmental and Science*, 5(2), 169–187.
- Koray, Ö., & Köksal, M. S. (2009). The Effect of Creative and Critical Thinking Based Laboratory Applications on Creative and Logical Thinking Abilities of Prospective Teachers. *Asia-Pacific Forum on Science Learning and Teaching*, 10(1), 1–13.
- Lestari, H., Usman, M., & Hasmawati, H. (2019). Kemampuan Berpikir Logis dan Penguasaan Kosa kata Bahasa Jerman. *Eralingua: Jurnal Pendidikan Bahasa Asing Dan Sastra*, 3(2), 123–128.
- Maretasari, E., & Subali, B. (2012). Penerapan Model Pembelajaran Inkuiri Terbimbing Berbasis Laboratorium Untuk Meningkatkan Hasil Belajar dan Sikap Ilmiah Siswa. *Unnes Physics Education Journal*, 1(2), 27-31.
- Oliva, J. M. (2003). The Structural Coherence of Students' Conceptions in Mechanics and Conceptual Change. *International Journal of Science Education*, 25(5), 539-561.
- Purwanto, A. (2012). Kemampuan Berpikir Logis Siswa Sma Negeri 8 Kota Bengkulu Dengan Menerapkan Model Inkuiri Terbimbing Dalam Pembelajaran Fisika. *Exacta*, 10(2), 133–135.
- Prince, M. J., & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education*, 95(2), 123–138.
- Prince, M. J., & Felder, R. M. (2007). The Many Faces of Inductive Teaching and Learning. *Journal of College S. Teaching*, 36(5),

14–20.

- Riffat, S. B., & Ma, X. (2003). Thermoelectrics: A review of present and potential applications. *Applied Thermal Engineering*, 23(8), 913–935.
- Rusman. (2017). *Belajar dan Pembelajaran*. Jakarta: Kencana.
- Rustaman, N., Dirjosoemarto, S., Yudianto, S. A., Achmad, Y., Subekti, R, Rochintaniawati, D., & Nurani, M. (2005). *Strategi Belajar Mengajar Biologi*. Bandung: UPI Press.
- Ryanuargo, Anwar, S., & Sari, S. P. (2014). Generator Mini dengan Prinsip Termoelektrik dari Uap Panas Kondensor pada Sistem Pendingin. *Jurnal Rekayasa Elekrika*, 10(4), 180–185.
- Saragih, S. (2004). Menumbuhkembangkan Berpikir Logis dan Sikap Positif terhadap Matematika melalui Pendekatan Matematika Realistik. *Jurnal Pendidikan dan Kebudayaan Departemen Pendidikan Nasional. Badan Penelitian dan Pengembangan*, 1589, 551-565.
- Setiono, I., & Tadeus, D. Y. (2018). Hubungan antara Mata Kuliah Fisika Terapan dalam Kontribusinya terhadap Mata Kuliah Keahlian pada Mahasiswa Program Diploma III Teknik Elektro Sekolah Vokasi Universitas Diponegoro. *Gema Teknologi*, 20 (1): 6-9.
- Sundari, T., Pursitasari, I. D., & Heliawati, L. (2017). Pembelajaran Inkuiri Terbimbing Berbasis Praktikum pada Topik Laju Reaksi. *JPPS*, 6(2), 1340-1347.
- Suyanti, R. D. (2010). *Strategi Pembelajaran Kimia*. Yogyakarta: Graha Ilmu.
- Tobin, K. G. & Capie, W. (1981). The Development and Validation of A Group Test of Logical Thinking. *Educational and Psychological Measurement*, 41: 413-423.
- Trifone, J. D. (2011). Logical Thinking Applications for Teaching and Placing Science Students. *Thinking*, 49(8), 411–416.
- Vazquez, J., Sanz-Bobi, M. a, Palacios, R., & Arenas, A. (2002). State of the art of thermoelectric generators based on heat recovered from the exhaust gases of automobiles. *7th European Workshop on Thermoelectrics*, 17, 1-9.
- Wenning, C. J. (2011). The Levels of Inquiry Model of Science Teaching. *J. Phys. Tchr. Educ*, 6(2): 9-16.