Impact of Project Based Learning on Creative Thinking Skills and Student Learning Outcomes

M Fadhil¹, E Kasli², A Halim²,³, Evendi³, Mursai³, Yusrizal³

¹Program Studi Pendidikan IPA PPs Universitas Syiah Kuala, Banda Aceh, Indonesia
²Program Studi Pendidikan Fisika FKIP Universitas Syiah Kuala, Banda Aceh, Indonesia
³Program Studi Fisika FMIPA Universitas Syiah Kuala, Banda Aceh, Indonesia

*bdhalim@yahoo.com

Abstract. The purpose of the study was to determine the effect of the application of Project Based Learning (PjBL) on creative thinking skills (CTS) and student learning outcomes on vibrations and waves. The approach and design used were Quasi Experimental and the one-group posttest-pretest. Purposive sampling technique has been used to select 2 classes of research samples, namely class VIII-A (control) and VIII-B (experiment) high school students. Data collection on CTS and student learning outcomes (LO) using a test instrument in the form of multiple choice questions developed by the researcher. The data analysis used the normalized N-gain score formula and the percentage formula. The results of the data analysis show that the PjBL learning model can improve the CTS of the experimental class students with a high category compared to the control class. Student learning outcomes through the PjBL learning model show better than through non-PjBL. The conclusion in this study is that the PjBL model can improve creative thinking skills and student learning outcomes.

1. Introduction
The Ministry of Education and Culture said that one of the objectives of the 2013 curriculum, especially in science subjects including physics, is to prepare students to have creative thinking skills [1,2,3]. Creative thinking skills are the ability to reveal new relationships, see a problem from a new perspective, and form new combinations of some previously mastered concepts, are practical, and come up with unusual but useful solutions [4,5,6]. Another definition is said that the ability to think creatively is the ability to generate new ideas or ways of producing a product [7,8,9]. Some other experts say that creative thinking is a very important skill to develop, because creative thinking is not given from birth but is obtained and built from learning activities [10,11,12,13].

The low of students' creative thinking skills in vibration and wave material is due to the application of physics concepts carried out by the teacher which is very tedious and boring, the learning process is still dominated by teachers (teacher centered) not dominated by students (student centered), so they are unable to improve creative thinking skills impact on low learning outcomes and misunderstanding of concepts [14,15,16].

Based on the results of a preliminary study with a class VIII teacher of Science (physics) at Madrasah TSanawiyah Jeumala Amal class VIII, it was found that vibration and wave material had not obtained maximum results with minimum completeness criteria (MCC) 72. Student Exam Results at
MTsS Jeumala Amal in 3 years lastly for the material vibrations and waves respectively (52.4) in 2016/2017, (56.3) in 2017/2018, and (50.45) in 2018/2019. Students often experience difficulties with vibration material in learning because they should need understanding of the concept before understanding the formula, but in reality learning is more emphasized on solving this problem because of the limited facilities in Teaching and learning process, even though it is possible to carry out simple experiments both in the laboratory and in the classroom. so it is necessary to do an improvement by applying the appropriate learning model. One of the learning models that can answer the above problems is Project Based Learning (PjBL).

Several previous research results indicate that learning activities through Project Based Learning (PjBL) can improve creative thinking skills and student learning outcomes[17,18,19]. The results of other studies indicate that the project-based learning model has a significant effect on creative thinking skills and student learning outcomes, with the N-gain in the moderate category, while the increase in the affective aspect is in the very good category[20,21,22]. Besides that, there are also the results of the study showing that the average creative thinking skills of students in the first cycle is 74.57%, while in the second cycle it is 89.75%. Meanwhile, the completeness of students in the first cycle was 65.21% and 82.60% in the second cycle, indicating that the application of project-based learning models can improve creative thinking skills and learning outcomes[23]. The results of other studies indicate that there is an effect of PjBL on creative thinking skills where creative thinking skills during the Posttest have increased and have an influence on student learning outcomes with a strong difference in scores in criteria[24], can improve science learning outcomes and students' creative thinking skills. In the first cycle, the students' ability to think creatively was 75%. In the second cycle the students' creative thinking ability increased to 85% and the achievement of student learning outcomes in the first cycle was 75%, while in the second cycle student learning outcomes increased to 90% [25,28], and it could also affect students' creative thinking skills with Posttest 83 , 9% and learning outcomes with Posttest 85.421%. [17].

Based on the results of preliminary studies and also some previous research results show that through the implementation of learning with Project Based Learning (PjBL) can improve creative thinking skills and student learning outcomes on vibrations and wave material. The results of the research have an impact on the implementation of physics learning in junior high schools, especially related to the material of vibrations and waves in the future. It is hoped that teachers will be motivated to use learning activities with PjBL in order to improve higher-order thinking skills and also increase mastery of the concepts of vibrations and waves.

2. Research Methods

2.1. Research Approach
The approach used in this research is a quantitative approach, the type of method used is quasi-experimental and the research design chosen is the groups pretest-posttest design. In summary, the research design is shown in table 2.1 [26].

| Groups     | Pre-test | Treatments | Post-test |
|------------|----------|------------|-----------|
| Experiment | Q1       | X1         | Q3        |
| Control    | Q2       | X2         | Q4        |

Sources : [26]

Two groups of students were randomly selected to be the control and experimental groups. The control group was taught using the non-PjBL model or method which was denoted by "X2", while for the experimental group it was taught using the Project-Based Learning (PjBL) learning model which was denoted by "X1". Before the implementation of the treatment, the two groups were given a test or pre-test with the same questions which were denoted by "Q1" and "Q2". After the treatment is carried out, a retest is carried out in the form of a Post-test with the same questions and
difficulty levels as before the treatment, however, order the questions and choose the answer for each question randomly which is notated with "Q3" and "Q4".

### 2.2. Population and Sample

The target population in this study were all students of Madrasah Tsanawiyah Jeumala Amal Aceh Pidie district, while the population that could be reached was all grade VIII students of Madrasah Jeumala Amal, Aceh Province. The research sample was only selected by two groups using the Simple Random technique and the control group for class VIII-B consisted of 30 students and the experimental group was class VIII-A with 31 students. The research site was conducted at Madrasah Tsanawiyah Jeumala Amal.

### 2.3. Collection of Data

#### 2.3.1. Creative Thinking Skill.

There are two types of quantitative data that were collected through this study, the first is data on students' Creative Thinking Skills (CTS) and data on students' Learning Outcomes (HB). Both data were collected through control and experimental classes before and after the implementation of the learning treatment. CTS data collection uses a test instrument in the form of descriptive questions of 5 items about vibrations and waves. The CTS test instrument developed by researchers includes 5 main indicators or 5 main aspects, namely: (a) sensitivity, (b) fluency, (c) flexibility, (d) elaboration, (e) originality by referring to several definitions of KBP in the research results, previous [28,12,13].

#### 2.3.2. Student learning outcomes.

Meanwhile, students' learning outcomes (HB) data were collected using a test instrument with multiple choice questions of 25 items developed by the researcher. The development of the test is based on the indicators of Vibration and Wave material for the cognitive domain, including (a) knowledge, (b) understanding, (c) application, (d) analysis, (e) synthesis, and (f) evaluation with reference to several results, previous research [29,30,31].

#### 2.3.3. Student response.

In addition to the quantitative data, there is also qualitative data in the form of student responses that were collected using a non-test instrument in the form of a student response questionnaire as many as 15 items developed by the researcher with reference to the components; the material taught, the classroom atmosphere, the way the teacher teaches, the advantages of the PjBL model, and about the learning that has been implemented. The answers to each student's response are stated in four choice categories using a four-point Likert scale, namely SS (strongly agree), S (agree), TS (disagree), and STS (strongly disagree).

#### 2.3.4. Data analysis.

There are two quantitative data in this study, namely CTS data and student HB data. Based on these two data, what we want to know is the increase in student behavior before and after treatment with the PjBL and non-PjBL models.

#### 2.3.5. Analysis of CTS data.

Therefore, the statistical formula used is N-gain and descriptive analysis with reference to several examples that have been used in previous studies [32,33,34]. The criteria for the level of N-gain can be seen in table 2.2.

| Table 2.2 Criteria of the N-gain level |
|-------------------------------|-------------------|
| Level            | Criteria           |
| \( g \geq 0.7 \)     | High              |
| \( 0.3 \leq g < 0.7 \) | Midle             |
| \( g < 0.3 \)         | Low               |

Sources: [34]
Students' CTS data analysis techniques are adjusted to indicators of creative thinking skills, namely: (a) sensitivity, (b) fluency, (c) flexibility, (d) elaboration, (e) originality. In other words, the N-gain and descriptive analysis is carried out for each indicator, so that detailed information is obtained on the student's CTS improvement on each indicator.

2.3.6. Analysis of Learning Outcomes data. To find out the student learning outcomes, the test used is multiple choice questions based on indicators that have been developed and equipped with an answer key with four answer choices, and there is only one correct answer. Data analysis also used descriptive statistics and N-gain to determine the increase in students' cognitive abilities before and after the implementation of learning with the PjBL and non-PjBL models [34].

2.3.7. Analysis of student response data. Questionnaires to find out students' responses to learning vibrations and waves through the application of the PjBL model were only distributed to students in the experimental group or to classes taught using the PjBL model. The statements in the response questionnaire totaled 15 items consisting of positive statements with a choice of answers using a four-point Likert scale, namely: SS (strongly agree = 4), S (agree = 3), TS (disagree = 2), and STS (strongly disagree = 1). As for knowing the categories of student responses to the application of the PjBL model can be seen in table 2.3.

Table 2.3. Category of Students Response Scores

| No | Score       | Category |
|----|-------------|----------|
| 1  | 1.00 - 1.69 | Less Good|
| 2  | 1.70 - 2.59 | Midle    |
| 3  | 2.60 - 3.50 | Good     |
| 4  | 3.50 - 4.00 | Very Good|

Sources: [34, 35]

3. Result and Discussion

3.1. Creative Thinking Skills (CTS)
The CTS results were analyzed using the N-gain equation. The purpose of using the N-gain equation is to determine the comparison of students' CTS in the experimental class and students' CTS in the control class. The experimental class is a class that is given learning treatment through PjBL, while the control class is a class that carries out non-PjBL learning. The results of the student's CTS analysis can be seen in Table 3.1 and Table 3.2.

Table 3.1. Students' CTS per Indicator for experiment group

| Items | Indicators   | Symbols | Pretest | Posttest | N-gain | Criteria of N-gain |
|-------|--------------|---------|---------|----------|--------|--------------------|
| 1     | Sensitivity  | IDC1    | 24,5    | 92,3     | 0,89   | High               |
| 2     | Fluency      | IDC2    | 40,8    | 91,4     | 0,85   | High               |
| 4,5   | Flexibility  | IDC3    | 32,1    | 83,7     | 0,75   | High               |
| 6     | Elaboration  | IDC4    | 10,6    | 53,1     | 0,47   | Midle              |
| 7     | Originality  | IDC5    | 43,9    | 91,6     | 0,85   | High               |

Based on Table 3.1 shows that the results of the CTS analysis of students in the experimental class through the application of PjBL learning have increased. The analysis results prove that IDC1, IDC2, IDC3 and IDC5 are included in the high criteria, while IDC4 is included in the medium criteria. Based on the data in table 3.1, it can be understood that the creative thinking skills of Madrasah Tsanawiyah students are very good (high) related to sensitivity, fluency, flexibility and originality. While the IDC 4 indicator related to Elaboration is in the medium category, it means that students still lack the ability
to describe the answers as a whole or the amount of answers to the questions given is still not detailed. However, overall in IDC4 students still lack good thinking skills, because students tend not to be able to solve problems systematically, consecutively, in detail and with detailed explanations. The critical thinking skills profiles for the control group are shown in Table 3.2.

### Table 3.2. Students’ CTS per Indicator for control group

| Items | Indicators | Symbols | Pretest | Posttest | N-gain | Kriteria N-gain |
|-------|------------|---------|---------|----------|--------|----------------|
| 1     | Sensitivity | IDC1    | 24,9    | 35,3     | 0,14   | Low            |
| 2,3   | Fluency     | IDC2    | 41,1    | 52,0     | 0,19   | Low            |
| 4,5   | Flexibility | IDC3    | 32,5    | 45,0     | 0,19   | Low            |
| 6     | Elaboration | IDC4    | 10,9    | 25,0     | 0,16   | Low            |
| 7     | Originality | IDC5    | 43,1    | 55,3     | 0,21   | Low            |

Based on Table 3.2, it shows that the results of the CTS analysis of students in the control class did not increase. The results of the IDC1, IDC2, IDC3, IDC4, and IDC5 analysis obtained N-gain values <0.3 with low N-gain criteria. This proves that the students’ CTS in the control class did not increase, so that non-PjBL learning applied to the control class was not able to improve the students' CTS to be better. In other words, students of class VIII-B who were taught by the method or model in addition to the PjBL model did not experience an increase in creative thinking skills, only slightly increased their skills related to the authenticity of how to answer questions. In other words, students of class VIII-B are only able to duplicate the answers as they are in the textbook.

Several previous research results indicate that there are several models or methods that have been used to improve CTS, including using Problem Based Learning (PBL) [8,37], inquiry learning based on virtual labs [6,11,36], increasing thinking skills The creative experimental class and the control class differed significantly as shown by the results of the N-gain test (0.004 <0.05) with a higher average than the control class [39], there was a difference in creative thinking where students had higher creative thinking than the control class. did not use PjBL [40], and from other researchers the mean value of the pretest CTS for the experimental class was 36.96 and the control class was 36.43. The mean value of the experimental posttest was 74.46 and control was 68.30, there was a significant difference, which meant that there was an effect of PjBL [41].

#### 3.2. Learning Outcome (LO)

Furthermore, to determine the increase in student learning outcomes, it is analyzed using the N-gain equation. The results of the N-gain analysis can be seen in Table 3.3.

### Table 3.3. Analisys of the N-gain of Learning Outcome at control and experiment class

| No | class   | N-gain | Categories |
|----|---------|--------|------------|
| 1  | Experiment | 0.69  | Midle      |
| 2  | Control   | 0.11  | Low        |

Based on Table 3.3, it shows that the results of the N-gain analysis for the experimental class are included in the medium category and the N-gain analysis for the control class is in the low category. This proves that the application of PjBL learning can improve student learning outcomes in the experimental class compared to non-PjBL learning activities in the control class. This increase in student learning outcomes is in accordance with previous research where there are differences in the increase in student learning outcomes between groups of students who learn with project-based learning models and direct learning models [42]. Improved learning outcomes were also obtained by other studies with an average percentage of the experimental class of 79.9% with a high category [43], in addition to improving learning outcomes there can also be real learning experiences [44], there is a
very significant difference where learning with PjBL towards student learning outcomes with high creative thinking categories [45], and after implementing project-based learning (PjBL) can improve student learning outcomes with a sig value of 0.013 <0.05 [46].

3.3. Results of Student Response Analysis

The results of the analysis of student responses in the experimental class can be seen in Table 3.4. Based on Table 3.4 shows that the results of the analysis of student responses in the experimental class obtained the average percentage of students who answered strongly agree reached 61.3%, which can be seen from the results of the responses of students who answered strongly agree, namely the pretest and posttest questions given made it easier for students to understand it 74.2%, learning makes students independent 74.2%, and students gain new knowledge by following worksheets in learning that has been done 71%.

| No | Item | Statement | STS | TS | S | SS | Mean |
|----|------|-----------|-----|----|---|----|------|
|    |      |           | F  | F  | F | F  | F    |
| 1  | The pretest and posttest questions are easy for me to understand | 0  | 0  | 0  | 8  | 25.8 | 23   | 74.2 | 3.74 |
| 2  | The pretest and posttest questions given are in accordance with the material being taught | 0  | 0  | 0  | 9  | 29   | 22   | 71   | 3.71 |
| 3  | The learning was carried out very interesting and fun | 0  | 0  | 1  | 3.2 | 10   | 32.3 | 20   | 64.5 | 3.61 |
| 4  | Learning carried out is easy to understand | 0  | 0  | 0  | 11 | 35.5 | 20   | 64.5 | 3.61 |
| 5  | The learning that was carried out encouraged me to cooperate with friends | 0  | 0  | 1  | 3.2 | 12   | 38.7 | 18   | 58.1 | 3.55 |
| 6  | This learning makes it easy for me to express ideas or opinions about a given problem | 0  | 0  | 0  | 12 | 38.7 | 19   | 61.3 | 3.61 |
| 7  | The learning that was carried out encouraged me to be independent | 0  | 0  | 1  | 3.2 | 7    | 22.6 | 23   | 74.2 | 3.71 |
| 8  | This study can make it easier for me to draw conclusions | 0  | 0  | 0  | 9  | 29   | 22   | 71   | 3.71 |
| 9  | I am very motivated to learn about vibration and wave material | 0  | 0  | 0  | 12 | 38.7 | 19   | 61.3 | 3.61 |
| 10 | The teaching materials in the LKS make it easier for me to understand the vibration and wave materials | 0  | 0  | 1  | 3.2 | 10   | 32.3 | 20   | 64.5 | 3.61 |
| 11 | The assignments in the worksheets gave me a challenge in learning | 0  | 0  | 1  | 3.2 | 10   | 32.3 | 20   | 64.5 | 3.61 |
| 12 | I can gain new knowledge by following the LKS in the lessons that have been done | 0  | 0  | 0  | 9  | 29   | 22   | 71   | 3.71 |
| Sum |     |           | 0  | 0  | 5  | 16 | 119  | 383.9| 248  | 735.6| 43.83 |
| Mean|     |           | 0  | 0  | 0.42 | 1.33 | 9.91 | 31.99 | 20.67 | 61.3 | 3.65 |

While the average percentage of students who answered agreed reached 31.99%, which can be seen from the results of the responses of students who answered agree, namely the pretest and posttest questions given in accordance with the material taught 29%, the learning carried out encouraged students to cooperate with friends 38.7%, as well as the teaching materials on the LKS make it easier for students to understand the material of vibrations and waves 32.3%. This proves that the application
of PjBL learning on vibrations and waves can encourage students to be interested in learning, so that it can improve CTS and student learning outcomes. In addition, the overall mean score of the students was 3.65, which was categorized as quite good

4. Conclusion
Based on the results of the research that has been done, it can be concluded that the application of PjBL can improve CTS and student learning outcomes on vibration and wave material at Madrasah Tsanawiyah Jeumala Amal. Besides, students' responses to the implementation of PjBL to improve creative thinking skills and learning outcomes at Madrasah Tsanawiyah Jeumala Amal are also good or positive, making it easier for students to understand vibration and wave material.

Acknowledgment
I thank my parents M. Nasir Hasan and Kasmi Yahya who always pray for me. Also to Dr. Evendi, M.Pd and Dr. Mursal, M.Si as my thesis supervisor and to Dr. A. Halim, M.Si as the correspondence author who has helped revise and publish this article in the IOP journal.

References
[1]. Kemendikbud Panduan Implementasi Kecakapan Abad 21 Kurikulum 2013 di Sekolah Menengah Atas (Direktorat Pembinaya SMA Ditjen Pendidikan Dasar dan Menengah, Jakarta, 2017).
[2]. Merisa, Halim A and Mahzum E, 2020 Asian J. Sci. Educ. 2, 24.
[3]. Ernawati, Halim A and Syukri M, 2020 J. Phys. Conf. Ser. 1460, 1.
[4]. Nurmalia, Halim A and Syahrur N, 2020 J. Phys. Conf. Ser. 1460, 1.
[5]. Razali, Halim A, Haji A G and Nurfadilla E, 2020 J. Phys. Conf. Ser. 1460, 1.
[6]. Wati S, Halim A and Mustafa, 2020 J. Phys. Conf. Ser. 1460, 1.
[7]. Nasir M, Fakhurunnisa R, Ranggi I N 2019 International Journal Of Environmental & Science Education 14 229
[8]. Sucirahayu S, Halim A and Idris N 2015 J. Pendidik. Sains Indones 3, 207.
[9]. Birgili B 2015 Journal of Gifted Education and Creativity 2, 71
[10]. Khoiril N, Riyadi S, Kaltsum U, Hindarto N, and Rusilawati A 2017 International Journal of Science and Applied Science 2, 256.
[11]. Muzakkir M, Halim A and Syukri M, 2015 J. Pendidik. Sains Indonesia. 3, 125
[12]. Halim A, Yusrizal, Susanna and Tarmizi, 2016 J. Pendidik. IPA Indones 5, 1.
[13]. Zubaithah S, Fuad N, Mahanat S and Suarsini E 2017 Journal of Turkish Science Education (TUSED) 14, 77
[14]. Halim A, E Mahzum, Zanaton H H, 2020 J. Phys. Conf. Ser. 1521, 1.
[15]. Halim A, Lestari D and Mustafa 2019 J. Phys. Conf. Ser. 1280, 1.
[16]. Halim A, Ngadimin, Soewarno, Sabaruddin and Susanna A 2018 Journal of Physics: Conference Series 1116, 3.
[17]. Rahardjanto A, Husamah, and Fauzi A 2019 International Journal of Instruction, 12 179.
[18]. Junina I, Halim A and Mahidin 2020 J. Phys. Conf. Ser. 1460, 1.
[19]. Rahmawati R, Halim A and Yusrizal Y, 2014 J. Pendidik. Sains Indones. 2, 27.
[20]. Wahida F, Rahman N and Goggo, T S Pengaruh Model Pembelajaran Berbasis Proyek Terhadap Keterampilan Berpikir Kreatif dan Hasil Belajar Siswa Kelas X SMA Negeri 1 Parigi, Thesis (Mahasiswa Program Studi Magister Pendidikan Sains Pascasarjana Universitas, Tadulako, 2015)
[21]. Maidan, Halim A Safitri R and Nurfadilla E, 2020 J. Phys. Conf. Ser. 1460, 1.
[22]. Halim A, Suriana S and Mursa M, 2017 J. Peneliti. Pengemb. Pendidik. Fis. 3, 1.
[23]. Zuhara N H, Suryawati and E, Arnentis The application of Project- Based Learning model to improve the skills of creative thinking and learning outcomes students learning outcomes in learning Biology class XI-science 1 Senior High School Muhammadiyah 1 Pekanbaru. Thesis,
(Graduate, Biology Education Faculty of teacher training and Education, Universitas Riau, Pekanbaru, 2015).

[24]. Sari W P dan Hidayat A 2018 *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan* 3 751

[25]. Gunawan B, Relmasira C S and Hardini A T A 2018. JTIEE, 2 1.

[26]. Fraenkel J R and Hyun N W H *How to design and evaluate research in education*, (McGraw-Hill, N.Y, 2012).

[27]. Maulana. 2016. *Konsep Dasar Matematika dan Pengembangan Kemampuan Berpikir Kritis-Kreatif*, (UPI Press, Sumedang, 2016).

[28]. Leandro S, Almeidaa, Lola P P, Mercedes F, Emma O, Carmen F 2008 *Thinking Skills and Creativity* 3 53

[29]. Maulina R, Wahyuni A and Halim A, 2020 *Asian J. Sci. Educ.* 2 41.

[30]. Yusrizal, Halim A, Daud M and Saminan, 2020 *J. Phys. Conf. Ser.* 1460, 1

[31]. Halim A, Yusrizal, Mazlina H, Melvina and Zainaton, 2018 *J. Phys. Conf. Ser.* 1088 1.

[32]. Tarmizi, Halim A and Khaldun I 2017 *J. Pendidik. Sains Indones.* 5, 5.

[33]. Fajria F, Rahmatan H and Halim A, 2017 *J. Pendidik. Sains Indones.* 5, 87.

[34]. Hake, R *Analyzing Change/Gain Scores*, (Woodland Hills, USA, 1998).

[35]. Suwa A M, Halim A and Zainuddin, 2020 *Asian J. Sci. Educ.* 2, 18.

[36]. Muslim I, Halim A and Safitri R, 2015 *J. Pendidik. Sains Indones.* 3, 35.

[37]. Zarita S, Halim A and Syukri M, 2015 *J. Pendidik. Sains Indones.* 3, 96.

[38]. Kim K H 2011 *Creativity Research Journal*, 23 285.

[39]. Antika N R 2017 *Pendidikan Biologi Indonesia* 3 72.

[40]. Zubaaidah S, Fuad N M, Mahanal S and Suarsini E 2017 *Journal of Turkish Science Education (TUSED)*, 14 77.

[41]. Mawarni R, and Sani A R *Pengaruh Model Project Based Learning Berbasis STEM Terhadap Kemampuan Berfikir Kreatif Siswa Pada materi Pokok Fluida Statis Di Kelas Xi SMA negeri 4 Tebing Tinggi*. Thesis (Jurusan Fisika FMIPA Universitas Negeri, Medan 2019)

[42]. Jagantara W M, Adnyana B P and Widiyanti M P L N 2014 *E-Journal Program Pascasarjana*, 4, 21

[43]. Rauziani 2016 *Jurnal Pendidikan Sains Indonesia*. 4 23

[44]. Yance, Ramli E, Mufit F 2013 *Pillar of Physics Education*. 1 48

[45]. Daulay W R, Tarigan, S, dan Jahro, S I 2017 *Journal of Research & Method in Education* 3 34

[46]. Liliawati W 2011 *Jurnal Pengajaran MIPA*, 16 93.