IJSL, 2021, *2*(2), 61-71/ ISSN: 2745-3480
INDONESIAN JOURNAL OF SCIENCE LEARNING
http://jurnalftk.uinsby.ac.id/index.php/IJSL

Creative Thinking of Middle School Students in Solving Physics Problems

Septin Grahaning Tyas[1*], Erman[1]
[1,2] Jurusan IPA, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Surabaya
*Corresponding author: *septin.17030654050@mhs.unesa.ac.id*

ARTICLE INFO

Keywords:
Creativity in thinking, physics concept, problem solving.

ABSTRACT

This study aims to describe the creativity in thinking of junior high school students in solving physics problems. Creativity in thinking is important for students to make themselves understand a physics concept, such as force, work, etc. Creativity in thinking is also needed so that students can find several possible problem solving according to their potential and are not fixated on a method because basically every student has their own imagination and thought process. Twelve students in the class VIII J of SMP Negeri 1 Jombang participated in the study. Data obtained from student's thinking creativity test instrument which is strengthened by data from student and teacher interviews. Data analysis referred to three indicators of creativity used in the study: fluency, flexibility, and originality. The results showed that the students' thinking fluency with high ability and some students with medium and low abilities got high scores. The highest score of the flexibility indicator was obtained by students with low abilities. High scores for the originality indicator were also obtained by several students from the high, medium, and low ability groups. High creativity scores are not only obtained by high-ability students but also medium, and low-ability students. The creativity of students' thinking in solving physics problems is different. Students' knowledge and experience play a role in the differences in students' creativity in thinking fluently, flexible, and new. So that teachers can use learning methods that provide direct experience to students to make it easier for students to understand a concept and also improve students' mathematical operational abilities to make it easier for them to solve a problem that requires mathematical calculations.

Published by Department of Science Education, UIN Sunan Ampel Surabaya
DOI: https://doi.org/10.15642/ijsl.v2i2.1631

INTRODUCTION

One part of the Natural Sciences taught at the junior high school level is physics which tries to explain natural phenomena in a simple way and tries to find the relationship between these phenomena (Sambada, 2012). Some physics concepts are abstract concepts such as force, work, weight, and so on. Abstract concepts can cause difficulties for students in understanding them because they are not in a tangible form that can be seen by students (Gunawan, et al., 2017; Suseno, 2014). A person in understanding abstract concepts requires the ability to find relationships between objects, not the objects themselves (Hayes & Kraemer, 2017). For example, students cannot see the force, but can see the ball. The force can then be imagined as something pushing the ball. If students are not able to transform abstract information into something concrete in their minds, the information may only become information and not become understood knowledge.

Several studies have shown that solving problems in physics problems also often requires an understanding of mathematical concepts and calculations (Azizah, R, et al., 2015; Suseno, 2014). It also requires students' creativity in thinking to make themselves understand so that they can be used in problem solving. For example, a student who cannot understand the force in his mind may find it difficult to solve a balance problem. Another example is if students have difficulty in operational algebra and are not creative in looking for operational possibilities to solve an equation, students will also have difficulty solving problems. Students will also have difficulty if they cannot represent calculations in their imagination (Solso et al., 2008).

Students can make the information they receive into knowledge only if the student is able to make the information make sense to him. Piaget has the view that in order to make sense of the world, one coordinates and adapts the experiences and ideas one already has (Nursalim, 2016). Students can use their creativity in thinking to make something reasonable and meaningful, including understanding concepts and solving problems.

Yuliani (2017) mentions that understanding of physics concepts can be increased by increasing creative thinking skills. As stated by Dwi Sambada (2012), Physics involves creative activities and imagination. Students who have the ability to think creatively will have their own way of understanding a concept and are expected to be able to apply the physics knowledge they have acquired in everyday life.

Guilford states that creativity is a characteristic of a creative person (in Runco & Jaeger, 2012). Creativity is a cognitive activity that produces a new view of a problem and is not limited by pragmatic results (Solso et al., 2008). Creativity according to the Big Indonesian Dictionary means the ability to create; creativity. Ekasari, et al. (2017) states that creativity is a person's ability to produce products from things that already exist, which are useful, and understandable. Solso et al. (2008) describe thinking as an internal process of transforming information in a complex interaction of mental attributions that include consideration, abstraction, reasoning, delineation, logical problem solving, concept formation, creativity, and intelligence. Based on these definitions, the creative thinking referred to in this study is a cognitive activity in processing or

combining existing information to build ideas and solve problems. Creative students can be seen from the indicators of creative thinking, namely: fluency, originality, flexibility (Almeida et al., 2008; Siswono, 2010).

Fluency refers to the ability of students to provide varied and correct answers. Flexibility refers to the ability to solve problems in different ways. Students use various points of view to solve problems. Novelty refers to the ability to answer with answers that are not commonly done by individuals.

Problem solving is the ability to find a solution to a problem. Hayes suggests the stages of problem solving, namely identifying problems, problem representation, planning a solution, realizing plans, evaluating plans, and evaluating solutions (Solso et al., 2008). Identifying problems includes identifying information and facts. Problem representation includes finding the purpose and focus of the problem. Planning solutions by building ideas from the information they have to find possible solutions that might answer the problem. At this stage, students need fluency in finding.

Students who tend to solve physics problems with calculations that are exemplified by the teacher without understanding the concept as a whole can have difficulty solving physics problems when the problem is presented in a different way (Madyani, et al., 2019). Creativity is needed so that students can find several possible solutions to problems according to their potential and are not fixated on a method because basically every student has their own imagination and thought process. This study aims to describe the creativity of students' thinking in solving physics problems. By knowing how creative students think, it is hoped that it can help teachers to choose learning methods that are more in line with students' thinking.

METHODS

This research is a descriptive study that aims to describe the creativity of students' thinking in solving physics problems. The subject selection technique used purposive sampling with the aim of obtaining creativity data from students with high, medium, and low abilities in science lessons.

The research subjects were 12 students of class VIII-J of SMP Negeri 1 Jombang. The twelve students are students who have various abilities from high (students A, B, C, D), medium (students E, F, G, H), and low (students I, J, K, L) based on the advice of the science teacher who is also the homeroom teacher of the class. Each there are four people in different ability levels based on learning outcomes in class. This is intended to be able to know the creativity of students in various abilities.

The research instrument used was a test of students' thinking creativity and interview guidelines for students and teachers. Thinking creativity test questions were adapted from the Scientific Creativity Test by Hu and Adey in 2002. The test instrument contains 8 open-ended questions so that it does not limit students' answers. These questions test students' creativity in using objects for unusual functions, the ability to increase the value of an engineering product, imagination, problem solving, experimentation,

product design, and the ability to analyze graphics. Most of the test questions are adapted to the simple plane material that students have ever received. The adopted test questions were then validated by two expert lecturers.

Data was collected by giving written tests to students. Then, interviews were conducted with students and science subject teachers who teach students as data reinforcement. Students' written test answers were then analyzed based on the correctness of the answers and the help of scoring guidelines. The results of the analysis carried out on the results of the written test refer to the three indicators of creativity used in the research, namely fluency, flexibility, and novelty.

The scoring guidelines used also refer to the assessment method used by Hu and Adey, which refers to the Scientific Structure Creativity Model (SSCM). The total score for the creative thinking test is the sum of the scores for fluency, flexibility, and novelty.

The scores for questions numbered 1 to 4 are the sum of the fluency scores, flexibility scores, and novelty scores. The scoring guidelines for questions number 1 to 4 can be seen in Table 1.

Table 1. Guidelines for Scoring Thinking Creativity Test No. 1 to 4

Criteria	Description
Fluency	The fluency score is obtained by counting the total number of subjects' answers, regardless of the quality.
Flexibility	The flexibility score for each question is obtained by counting the number of approaches or points of view used.
O*riginality*	The novelty score was obtained by tabulating all the answers obtained. Then calculate the probability of each response. If the probability of a response is less than 5%, a score of 2 points is awarded. If the probability is 5-10% given a score of 1 point. If the probability of the response is >10%, 0 points are given.

(Hu & Adey, 2002)

Question score no. 5 is calculated by tabulating all subject responses to see the scarcity of answers given by students. The scarcity in question is the comparison of student answers with the number of other students' answers. If the probability of a response is less than 5%, a score of 3 points is awarded. If the probability is 5-10% given a score of 2 points. If the probability of the response > 10% is given 1 point. Only one score for each division method in task 5 (Hu & Adey, 2002).

Question score no. 6 is the sum of the flexibility and novelty scores. Flexibility score has a maximum of 9 points for one correct method (3 points instrument, 3 point principle, 3 point procedure). The recency value is calculated as before. If the occurrence of the method is generally less than 5%, gets 4 points; if the probability is between 5-10%, then it gets 2 points; if the probability is greater than 10%, it

gets 0 points (Hu & Adey, 2002).

Question score no. 7 is determined by the function of the tool. To make it easier to get to the second floor, the machine/tool must be able to connect to the 2nd floor, making it easy and safe. Each function gets 3 points. Newness scoring was obtained with a score of 1 to 5 based on the overall impression of all responses (Hu & Adey, 2002).

Question score no. 8 is given based on the description given by the subject. The criteria assessed are reading the graph correctly (fluency), making an opinion based on explicit data, making an opinion based on implicit data (flexibility), and stating the reason for choosing the length of the board to be used (recentivity). Each criterion gets 1 point.

Interviews were conducted to complete the results of the creative thinking test and to find out more about how students think. The results of interviews conducted with teachers and students were analyzed by reducing the data and then drawing conclusions from the patterns formed. The conclusion is drawn by looking at the results of the students' thinking creativity test and the results of interviews in order to obtain a more correct understanding.

RESULTS AND DISCUSSION

Student Creative Thinking Based on Creativity Indicators

Thinking creativity test is given to 12 students who have different abilities. The classification is based on learning outcomes and suggestions from science teachers. Students A, B, C, D are students with high abilities. Students E, F, G, H are students with moderate ability. Students I, J, K, L are students with low abilities. The total score of the thinking creativity test is the sum of the scores for the indicators of fluency, flexibility, and novelty. The results of the students' thinking creativity test are presented in the diagram in Figure 1.

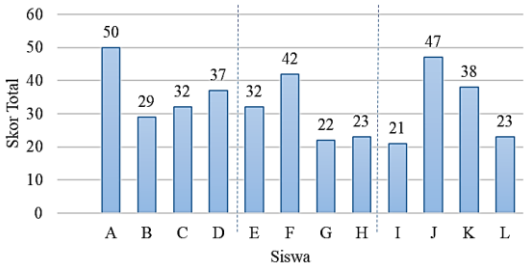

Figure 1. Total Score of Creative Thinking Test

Figure 1 shows the creativity of thinking differently for each student. The scores obtained indicate that higher scores on creativity indicators are not only obtained by students with high learning outcomes. Some students from medium and low level get higher scores than students in the high ability category. Student A from the high ability group, student F from the medium ability group, and student J from the low ability group got high scores on the thinking creativity test.

Fluency scores are obtained by counting students' correct answers regardless of the quality of the answers. The students' thinking fluency scores are shown through the diagram in Figure 2.

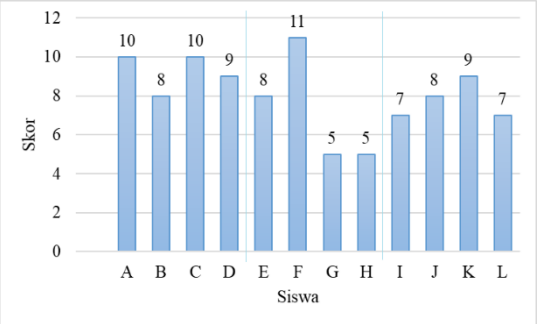

Figure 2. Creative Thinking test scores are indicators of fluency

Based on Figure 2, students with high abilities on average have high scores of fluency in thinking. Some students at moderate and low levels also get high fluency scores. Student F from the medium ability group got the highest score on the fluency indicator and the lowest score was obtained by students G and H from the medium group.

Flexibility scores are obtained by considering the points of view and approaches used by students in answering questions. The flexibility score of the students' thinking creativity test can be seen through the diagram in Figure 3.

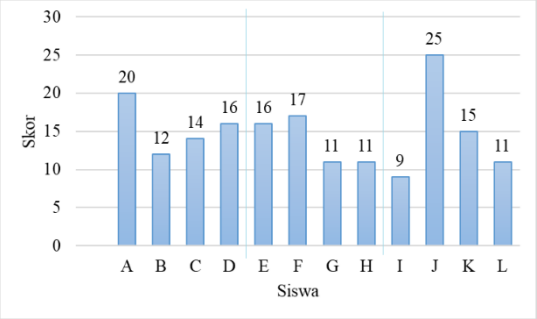

Figure 3. Creative thinking flexibility indicatior test scores

Based on Figure 3, flexibility scores also vary at different levels of student ability. Student A from high ability level and student J from low ability level get higher scores than other students.

An important indicator to measure creativity is novelty. This score is obtained by tabulating all answers and then looking at the level of scarcity of answers given by students. The results of the novelty indicator scores from students' answers are shown through the diagram in Figure 4.

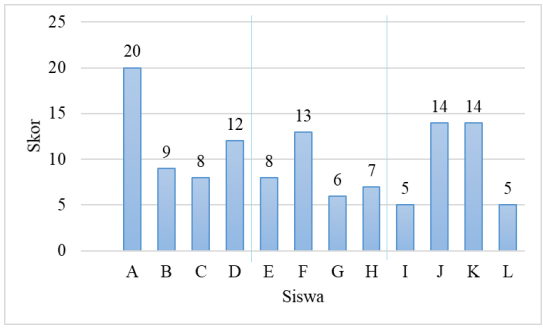

Figure 4. Creative thinking new indicator test scores

Based on Figure 4, the novelty scores also varied among high, medium, and low ability students. Student A got the highest score of all students. Students D, F, J, and K also get better scores than other students. This novelty indicator score also shows that high scores are not only obtained by students from the high ability group, but also by students from the medium and low ability groups.

Students with high thinking creativity scores are not only found at high ability levels. Intelligence / intelligence is one of the factors that affect a person's creativity, but not the only factor. Students with high intelligence do not always show high creativity, as well as students who have high creativity do not always have a high level of intelligence. Creativity is a combination of many attributes. Hu and Adey (2002) also found in their research that scientific creativity is not only based on scientific ability. The theory of creativity

investment developed by Sternberg and Lubart in 1996 suggests 6 attributes of creativity, namely the process of intelligence, intellectual style, knowledge, personality, motivation, and environment (Sternberg, 2006).

Student Thinking Creativity in Problem Solving Stages

The initial stage in problem solving is the identification of information to find problems (Heller & Heller, 2010). This process is important because if students fail to understand the information, it will be difficult to find the topic of the problem and the data used to support the solution. Student J is a student with a low level of ability according to the science subject teacher, but gets a high creativity score in this study. Based on the data obtained during the research, student J sometimes has a different picture in understanding the meaning of the questions posed. As in question number 4 which asks about the possibilities that can occur if the bicycle wheel is replaced with a wheel with a smaller circle. All students have the same view in interpreting the circle on a bicycle wheel, namely the diameter of the wheel. Student J has another interpretation, the "circle" on the wheel is translated as the diameter of the tire (the rubber part). This can be the reason students get low grades during learning because they misrecognize the meaning of the information presented.

All students scored low on graph reading fluency. Students have not been able to read the graph correctly and express their opinion regarding the data presented in the graph. Some students do not even understand the meaning of the graph. This can hinder the process of solving the problem because it cannot recognize the information.

The problem representation stage is the most important stage in solving a problem according to Solso (2008). Students must be able to find the focus of the problem to be solved and describe it in their minds. Because if students find the wrong goal to be completed, then the expected answer will also be wrong. In the problem-solving stage by Heller & Heller (2010), there are stages to explain the problem in the description of physics.

In a question that asked students to arrange 2 dolls with different masses playing on a seesaw with balanced conditions on a 50 cm board, students E, K, and L were able to describe the expected conditions, namely a snowman and a dinosaur playing on a seesaw. However, they did not show an answer that took into account the difference in the mass of the dolls to make the two of them unbalanced. So the solution they provide does not provide the right solution. There are four students A, C, D, and J who are able to name more than one possible solution to the problem. However, all students could not determine the right size and position to make the doll's condition balanced.

The next stage of problem solving is planning solutions by building ideas. At this stage students analyze the knowledge that is in their minds both obtained from learning and experience and choose the appropriate ones to be used to solve problems (Siswono, 2011). Flexibility is required in this case. Fluency in thinking can help the problem solving process, but sometimes the solution to a problem

cannot be found just by thinking smoothly or using the usual way. Thinking flexibility is needed in problem solving to bring up possible solutions from various points of view (Solso et al., 2008).

As revealed by Sambada (2012), Physics involves creative activities and imagination. Problem solving in physics is also closely related to mathematical operations. As in question number 5, the solution requires imagination and mathematical operations. Problem number 5 asks students to arrange 2 dolls with different weights on a seesaw 50 cm long.

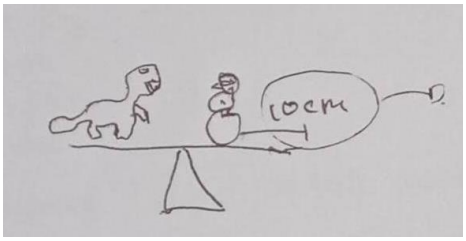

Figure 5. Student D's answer on question number 5

Based on Figure 5, student D wrote 10 cm in the answer. Students are only able to mention possible solutions that might work but cannot determine the right size. When interviewed, student D explained about his answers as quoted from the interview below.

Student D : (pointing to one end of the board) "That's the dinosaur right here."
"Because the snowman is heavier, if you put it here [the other end of the board], the snowman will fall more. So, I advance [snowman] but don't know how many inches. So, only (the length of the board) is fifty divided by two, then the intention is further divided, but I give more, ah."
Interviewer : "So, 10 cm is an assumption, huh?"
Student D : "Yes, not sure yet."

From the results of interviews with other students, all students do not remember the equations that can be used to solve problems. When told the equation, students also had difficulty solving it. Based on the explanation from the teacher, students still have difficulty in mathematical operational abilities and reasoning. This is often a difficulty for students when students have to carry out the plans they have prepared in solving problems.

From the results of interviews, some students who get high creativity scores do not only use the method taught by the teacher at school in solving a problem. These students also use other methods that they get from friends and tutors if they think it's easier. Student J also revealed that if he forgot a formula during an exam, he usually looked for equations from other questions that might be used. This can be done if students have understood the concept of learning material so that they are able to develop ways to solve a problem. Understanding the concept is something that is very important in learning physics (Putranta & Supahar, 2019).

Regarding testing or experimentation, students have not been able to design their own research. Based on information from the science teaching teacher, students were still given instructions to be able to carry out an experimental activity. Only a few students are able to do activities without direct direction. So it is necessary to combine students with different ability categories so that the group can run well. However, students have been able to mention the

quality they want in choosing something, in question number 6 is the better quality of nail cutters according to students. Students have not been able to find methods and procedures that are structured and clear. The procedure described is mostly simple, i.e. directly try to use it to cut nails. This is in line with the statement from the science subject teacher for class VIII-J,

Science teacher: "To design it yourself, only part of it will work later."

In questions that test the ability to design tools, almost all students describe simple designs. The designs they describe are designs that are usually visible to the eye, such as stairs with handrails. The students' answers for elevators and escalators only describe the shape. There was a student who described the passages more completely. Student J describes an elevator as equipped with vents, doors, pulleys, and glass walls. Student J has an interest in technical matters. The experiences of student J have an influence on the way he acts and thinks.

Creativity is a combination of several factors. Solso et al. (2008) in his book mentions the theory of creativity developed by Sternberg and Lubart (1996) mentions six attributes of creativity, including: process intelligence, intellectual style, knowledge, personality, motivation, and environmental context. These attributes form a complex network. Creativity scores obtained in this study were not only high in the high group but also in the medium and low ability groups. This can happen because of other factors that can affect a person's level of creativity. Like students who translate "bike" in question number 3 as a motorcycle, so the answer also refers to a motorcycle. Student A explained the reason for his answer was because he had seen his brother's motorbike. Students' experiences influence the way things are understood. The ability of students to connect concepts with life can help students understand things more easily and not be fixated on certain answers.

CONCLUSION

Based on the results of research that has been done, the creativity of thinking in solving physics problems is different for each individual. Creativity in thinking gets a high score not only on students with high learning outcomes, but also on students with moderate and low learning outcomes. Students' knowledge and experience have a role in the differences in students' creativity in thinking fluently, flexibly, and novelly.

Based on the research that has been done, the researchers provide the following suggestions: 1) Teachers can use learning methods that provide direct experience to students to make it easier for students to understand a material and also improve students' mathematical operational abilities to make it easier for them to solve a problem that requires mathematical calculations and 2) For further research, it is expected to be able to describe more clearly other factors that influence students' creative thinking in solving a problem.

REFERENCES

Almeida, L. S., Prieto, L. P., Ferrando, M., Oliveira, E., & Ferrándiz, C. (2008). Torrance Test of Creative

Thinking: The question of its construct validity. *Thinking Skills and Creativity*, *3*(1), 53–58. https://doi.org/10.1016/j.tsc.2008.03.003

Azizah, R., Yuliati, L. dan Latifah, E. (2015). Kesulitan pemecahan masalah fisika pada siswa SMA. *Jurnal Penelitian Fisika dan Aplikasinya*, 5(2), 44–50. https://doi: 10.26740/Jpfa.V5n2.P44-50.

Ekasari, R. R., Gunawan, G., & Sahidu, H. (2017). Pengaruh Model Pembelajaran Langsung Berbantuan Media Laboratorium Terhadap Kreatifitas Fisika Siswa SMA. *Jurnal Pendidikan Fisika Dan Teknologi*, *2*(3), 106. https://doi.org/10.29303/jpft.v2i3.296

Gunawan, G., Harjono, A., & Sahidu, H. (2017). Studi Pendahuluan Pada Upaya Pengembangan Laboratorium Virtual bagi Calon Guru Fisika. *Jurnal Pendidikan Fisika Dan Teknologi*, *1*(2), 140. https://doi.org/10.29303/jpft.v1i2.250

Hayes, J. C., & Kraemer, D. J. M. (2017). Grounded understanding of abstract concepts: The case of STEM learning. *Cognitive Research: Principles and Implications*, *2*(1). https://doi.org/10.1186/s41235-016-0046-z

Heller, K., & Heller, P. (2010). Cooperative Problem Solving in Physics A User ' s Manual Can this be true ? *University of Minnesota*, 310.

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, *24*(4), 389–403. https://doi.org/10.1080/09500690110098912

Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia. Tanpa Tahun. Kreativitas. Dalam *KBBI Daring*. Diakses 08 Juli 2021 dari https://kbbi.kemdikbud.go.id/entri/kreativitas.

Madyani, I., Yamtinah, S., & Utomo, S. B. (2019). The implementation of PBL integrated with STEM in the material of Temperature and Its Changes to the Improvement of Students' Creative Thinking Skills and Learning Results. *Journal of Educational Science and Technology (EST)*, *5*(3), 260. https://doi.org/10.26858/est.v5i3.10899

Nursalim, M., Satiningsih, Hariastuti, R. T., Savira, S. I., & Budiani, M. S. (2016). *Psikologi pendidikan*. Unesa University Press

Putranta, H., & Supahar. (2019). Development of physics-tier tests (PysTT) to measure students' conceptual understanding and creative thinking skills: A qualitative synthesis. *Journal for the Education of Gifted Young Scientists*, *7*(3), 747–775. https://doi.org/10.17478/jegys.587203

Runco, M. A., & Jaeger, G. J. (2012). The Standard Definition of Creativity. *Creativity Research Journal*, *24*(1), 92–96. https://doi.org/10.1080/10400419.2012.650092

Sambada, Dwi. (2012). Peranan kreativitas siswa terhadap kemampuan memecahkan masalah fisika dalam pembelajaran kontekstual. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*, *2*(2), 37–47.

Siswono, T. Y. E. (2010). Leveling Students ' Creative Thinking in Solving. *IndoMs JME*, *1*(1), 17–40.

Siswono, T. Y. E. (2011). Level of student's creative thinking in classroom mathematics. *Educational Research and Reviews*, *6*(7), 548–553.

Solso, R. L., Maclin, O. H., & Maclin, M. K. (2008). *Psikologi kognitif* (edisi ke-8). Penerbit Erlangga.

Sternberg, R. J. (2006). The nature of creativity. *Creativity Research Journal*, *18*(1), 87–98. https://doi.org/10.1207/s15326934crj1801_10

Suseno, N. (2014). Pemetaan Analogi Pada Konsep Abstrak Fisika. *Jurnal Pendidikan Fisika*, *2*(2). https://doi.org/10.24127/jpf.v2i2.118

Yuliani, H. (2017). Keterampilan Berpikir Kreatif Pada Siswa Sekolah Menengah Di Palangka Raya Menggunakan Pendekatan Saintifik. *Jurnal Pendidikan Fisika Dan Keilmuan (JPFK)*, *3*(1), 48. https://doi.org/10.25273/jpfk.v3i1.1134