

An Analysis of Students' Creative Thinking Ability in Terms of Understanding the Concepts of Direct Current Electricity

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Abstract— The purpose of this study was to analyze students' creative thinking abilities on the subject of direct current electricity. Given the ability to think creatively is very necessary for the learning process, because it allows humans to be more flexible, open, and easy to adapt to various situations and problems in life. The research method used in this study is a descriptive method, which was conducted at one of the senior high schools in Jember. The subjects involved in this study were 30 students, and the instruments used were two-tier tests on the subject of direct current electricity. Students' creative thinking abilities are viewed from a cognitive aspect, based on four categories of conceptual understanding. The results showed that in the aspect of fluency 65.83%, flexibility 63.61%, originality 58.06%, and elaboration 44.72%. In general, students' creative thinking skills are in a low category. The low ability to think creatively is because students do not understand the concept well, so there are errors in expressing reasons and arguments in solving problems. The ability to think creatively can be improved through the application of learning models that can empower the ability to think creatively.

Keywords: *analysis, creative thinking, ability, direct current electricity*

I. INTRODUCTION

The purpose of developing the revised 2013 curriculum is to produce productive, creative, innovative, and human resources through the development of attitudes, skills, and knowledge [1]. So the teacher has an important role, namely, to empower students to have 21st-century thinking skills.

One of the 21st-century thinking abilities is the ability to think creatively [2], [3] which can bring up creative and innovative ideas in the form of works or arguments [4], [5]. In the current context, one's creative thinking ability can stimulate him to issue opinions or argue based on his understanding of the subject matter [5], [6]. Therefore, this complex process is included in the category of higher-order thinking skills (HOTS).

The ability to think creatively has an influence on understanding students' concepts, especially in Physics. Physics is a branch of science based on experimental observations [7]. Experimental observation is an attempt to find patterns and principles that connect natural phenomena, to be able to solve the problems that exist in Physics students are required to be able to understand the basic principles of Physics and use the ability to think creatively.

Understanding concepts that require a high level of understanding on the subject of Physics. One of which is direct current electricity. Direct electric current (Direct Current or DC) is the flow of electrons from a point with high potential energy to another point with lower potential energy [7], [8]. More recent observations have found that direct current is a negative current (electron) flowing from the negative pole to the positive pole. This electron flow causes positively charged holes, which "seem" to flow from the positive pole to the negative pole.

Characteristics of the subject of direct current electricity are very complex, and it is necessary to have a good understanding of the material. Research that is relevant to our study shows that there is an influence between student experience and understanding the concepts of electricity and electricity [9]. The study has not yet analyzed the students' creative thinking abilities in terms of understanding their concepts.

The purpose of this study was to analyze students' creative thinking abilities on the subject of direct current electricity. Considering the ability to think creatively is needed in the learning process because it allows humans to be more flexible, open, and easy to adapt to various situations and problems in life.

II. METHODS

A. Research Design

The research method used in this research is descriptive. This research was conducted by Madrasah Aliyah Wahid Hasyim Jember, while the subjects involved in this study were 30 students. The descriptive method was chosen because it is a research method used to describe or analyze a phenomenon contained in a research subject [10].

B. Research instrument

The instrument used was in the form of a two-tier test on the subject of direct current electricity; the distribution of the items used is presented in Table 1. Students' creative thinking abilities are viewed from a cognitive aspect, based on four categories of conceptual understanding. The instrument used is the result of adaptation based on basic physics reference at the university level. This is so that research emphasizes more on understanding the concepts of physics, so students do not just count. Thus, it is expected that the results of the analysis of creative thinking skills can be measured properly.

TABLE I. DISTRIBUTION OF TEST ITEMS FOR CREATIVE THINKING ABILITY

No	Aspect	Item Question
1	Fluency	1,3,5
2	Flexibility	2,4,7
3	Originality	6,8,9
4	Elaboration	10,11,12

The analysis of the quality of the research instruments was carried out on the reliability of the test, aided by the application of QUEST. Reliability estimates using the QUEST program are calculated based on items called the item separation index and based on testees and are called person separations [11]. The reliability estimation results for the instrument used obtained the value of person reliability (*testee*) of 0.89 and item reliability of 0.74. It can be concluded that the consistency of the answers both from the testee or from the items in the B test instrument has high reliability.

The level of difficulty of the item gives information about the difference in the level of students' ability to answer questions, items that are too easy or too difficult cannot provide sufficient information about the test so that the items need to be discarded or revised. Difficulty level analysis uses the QUEST program based on the results of the estimated difficulty, which is the average of the difficulty indexes for each category on each item. Difficulty value on each item is still in the range of values $-2 < b < +2$; it means the level of difficulty of the items used in both categories based on modern test theory.

C. Data Analysis

The test instrument used in this study is in the form of an open-minded multiple-choice, or what is commonly called a two-tier test. So we need a rubric to categorize students' understanding of concepts. The categorization of conceptual understanding is based on four categories; in test theory, it is commonly called the four categories politomus scale [5], [12], [13].

III. RESULTS AND DISCUSSION

The results of the analysis of students' creative thinking abilities are presented in Table 2.

TABLE II. THE RESULTS OF ANALYSIS STUDENTS' CREATIVE THINKING ABILITY

No	Aspect	Item Question	Achievement (%)
1	Fluency	1,3,5	65,83
2	Flexibility	2,4,7	63,61
3	Originality	6,8,9	58,06
4	Elaboration	10,11,12	44,72

Based on the results of the analysis showed that the minimum completeness criteria had not been achieved, namely in physics subjects by 75 both in the aspects of fluency, flexibility, originality, and elaboration. These

results are consistent with the low student physics learning outcomes on each daily test. This is because certain approaches, methods, or strategies used by teachers in the learning process are still traditional and do not provide opportunities for students to develop their mindsets according to their abilities. As a result, the ability to think creatively can not develop optimally.

The ability to think creatively is a type of thinking that leads to new insights, new approaches, new perspectives, new ways to understand, think and produce new ideas or ideas [14], [15]. The development of creativity is also the development of cognitive processes [16]. The cognitive process in creating is the process of gathering many specific elements into a coherent and functional whole [3], [15].

The purpose of teaching the cognitive process of creating is to teach students to be able to make a new product by organizing a number of mental elements into a pattern or structure that has never existed or was never predicted before [17], [18]. Learning that can empower the cognitive process of creating can use the inquiry approach. The inquiry is the process of gaining and gaining knowledge by conducting observations and experiments to find answers or solve problems to questions or formulate problems using critical and logical thinking skills.

This approach gives birth to an interaction between what the child believed before on new evidence to achieve a better understanding, through exploratory methods to derive and test new ideas. It involves the attitude to seek explanations, and live the ideas of others, open new ideas, think critically, honestly, and creatively.

A. Analysis of Students' Creative Thinking Abilities on the Fluency Aspect

Fluency is understood as the ability to produce many ideas [16]. The fluency aspect used in this study consists of three items, namely items 1, 3, and 5. The results of data analysis on the fluency aspect are presented in Figure 1.

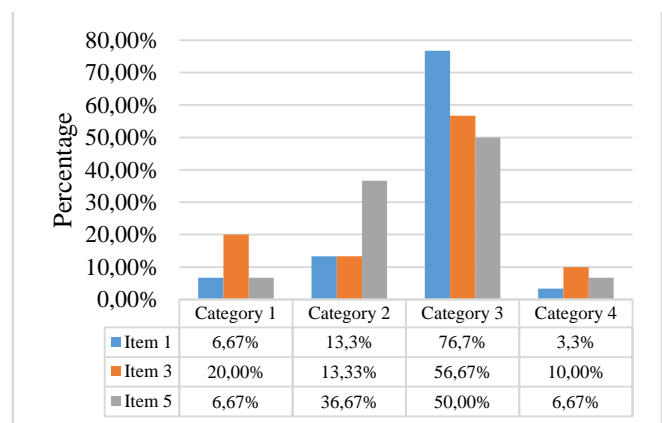


Fig. 1. Percentage of Results of Students' Creative Thinking Abilities on the Fluency Aspect

Based on the results of the study showed that in the aspect of fluency, the highest category is in category three. These results indicate that an average of 61.12% of students in category 3 was able to produce many ideas in solving the problems presented. The arguments presented by students support this; in other words, students have been able to

master a good understanding of concepts in aspects of fluency.

This result also proves that most students have been able to think creatively to formulate new ideas. New ideas can be applied in problem-solving, or as the ability to see new relationships between pre-existing elements [16], [19]. Nevertheless, there are 11.11% of students in category one understanding concepts in the aspect of creative thinking abilities. Item items that are considered difficult to be solved by students in the fluency aspect are item 3. Item 3 aspects of fluency are presented in Figure 2.

Is it possible if there are situations where the voltage is high without being accompanied by a large current....

A. Maybe, because electrons are always moving
 B. Not necessarily, because it depends on the open or closed circuit
 C. Maybe, because of the greater the voltage, the greater the current
 D. Not necessarily, because a high voltage will further increase the current flowing

Your reason:

Fig. 2. Item Number 3 Aspects of Fluency

Item 3 indicator is generating ideas based on the concept of direct current electricity. Examples of student answers are presented in Figure 3.

A. Karena jika tidak bergerak, maka tidak ada arus yang mengalir

English (EH): A. Because if it moves then no current flows

Fig. 3. Example results of students' answers A1 in item 1

The answers given by students A1 can be said not based on clear arguments, and show a limited understanding. Based on Ohm's law, voltage is proportional to current, so most students think that the greater the voltage, the greater the current that flows. But most students forget that Ohm's law occurs in a closed circuit. In an open circuit such as a capacitor, it can have a high voltage capacitor without the slightest current flowing.

B. Analysis of Students' Creative Thinking Ability on the Aspect of Flexibility

Flexibility is the ability not to get stuck in the approaches that are often used [16]. The flexibility aspect used in this study consists of three items, namely items 2, 4, and 7. The results of data analysis on the flexibility aspect are presented in Figure 4.

Based on the results of the study showed that in the aspect of flexibility, the highest category is in the third category. These results indicate there are 52.22% of students have been able to produce many ideas in solving the problems presented. In other words, most students already have the ability not to stick to the approaches that are often used. This is supported by the arguments presented by students, in this case, most students have been able to master a good understanding of concepts in the aspect of flexibility.

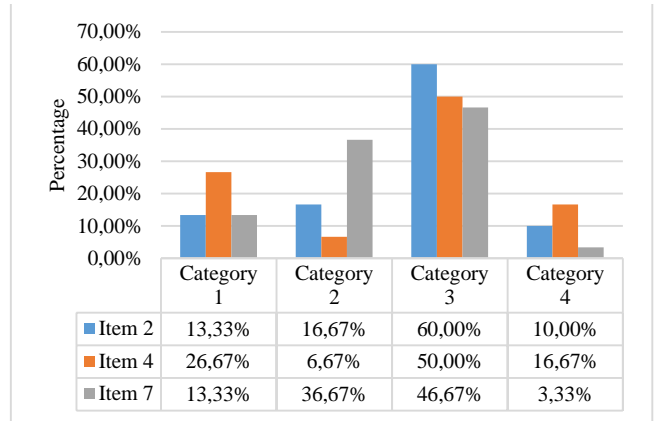


Fig. 4. Percentage of Results of Students' Creative Thinking Ability on the Aspect of Flexibility

This result also proves that most students have been able to think creatively to formulate new ideas. Nevertheless, there are 17.77% of students in category one, understanding concepts in the aspect of creative thinking abilities. The items that are considered difficult to be solved by students in the fluency aspect are item 4. Item 4 of the fluency aspect is presented in Figure 5.

A lamp is connected to the battery. Then the lamp is a series circuit with other lights, then the ratio of lights in the event is....

A. The resistance that the lamp receives is getting bigger, causing the lamp to be brighter
 B. The resistance that the lamp receives is getting smaller, causing the lamp to become dimmer
 C. The resistance of the lights is the same, but the lights become brighter
 D. The lamp resistance is equal, but the light is dim

Your reason:

Fig. 5. Item 4 Aspects of Flexibility

Item 4 indicator is designing different points of view based on the concept of direct current electricity. Bright lights are closely related to the power received by the lamp, which is:

$$P = I^2 R \quad (1)$$

The magnitude of the resistance of the lights is the same, so the power only depends on the electric current. So that when the lights are arranged in series, the current flowing will be smaller. As a result, bright lights are lights arranged in parallel. Examples of student answers are presented in Figure 6.

B. Karena besar kecilnya jumlah hambatan yang diterima lampu, dapat menyebabkan Lampu Samalain redup.

EH: B. Because of the size of the number of obstacles received by the lamp, can cause the lights to dim

Fig. 6. Example results of students' answers A2 in item 4

The answers given by A2 students can be said not based on clear arguments, and show a limited understanding. This is based on the arguments given, namely "the size of the number of obstacles received by the lamp". While the resistance received by the lamp is equal, the power depends only on the electric current.

The inability of A2 students to produce good ideas, because they do not have a good initial conceptual understanding. The ability to think creatively can also be interpreted as the ability of individuals to think about what everyone has thought so that the individual is able to do what has not been done by everyone. Sometimes creative thinking lies in innovation that helps oneself to do old things in new ways.

Based on this, it can be understood that to improve students' creative thinking abilities, interaction between individuals is needed. Interactions that occur allow students to see new relationships offered by other students, and this can only be done through group discussions.

C. Analysis of Students' Creative Thinking Abilities on the Aspect of Originality

Originality or originality is interpreted to the extent to which the context or results of thought show originality, compared to the content that is often used [16]. The aspect of originality used in this study consists of three items, namely items 6, 8, and 9. The results of data analysis on the aspect of originality are presented in Figure 7.

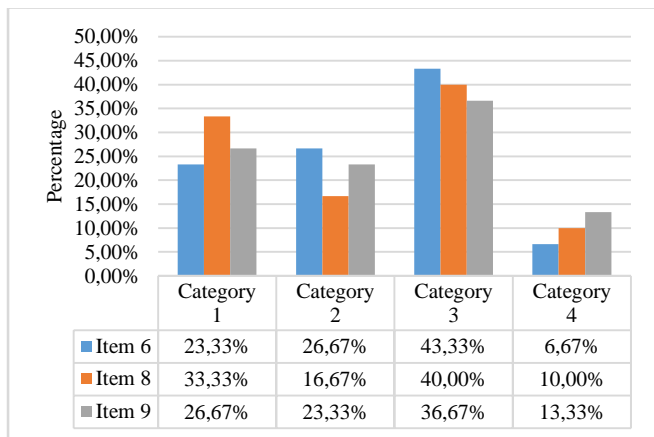


Fig. 7. Percentage of Students' Creative Thinking Ability Results in the Originality Aspect

Based on the results of the study showed that in the aspect of originality the highest category is in the third category. These results indicate that there is an average of 40% of category 3 students, who have the ability not to get hung up on the approaches that are often used.

However, in category 2, the average was 22.22% students and in category 1, the average was 27.77% of students. These findings indicate that overall, students have not been able to provide originality of the results of their thinking, in completing and giving a new perspective. Students in category 1 are mostly on item 8; these items are presented in Figure 8.

Two charged objects $+q_1$ and $+q_2$, x distance from each other. If the x distance is changed, the graph that states the relationship between the interaction force F of the two charges with respect to x is....

A		B	
C		D	

Your reason:

Fig. 8. Item 8 Aspects of Originality

Indicator item 8 is thinking about ways to solve new problems based on understanding the concept of direct current electricity. Examples of student answers are presented in Figure 9.

D. Karena semakin jauh jaraknya, membutuhkan gaya yang semakin besar.

EH: D. Because the farther the distance, requires greater force

Fig. 9. Examples of the results of A3 students' answers in item 8

The answers given by A3 students can be said not based on clear arguments, and show a limited understanding. The students' lack of understanding in this matter does not understand the concept of interaction style between charges. The interaction force between charges can be understood based on Coulomb's law, where the magnitude of this force is proportional to the square of its distance. If the distance approaches infinity, then the magnitude of the force becomes 0, whereas if the distance is close to zero, then the magnitude of the force becomes infinite. So the correct graph depicting this event is in option B.

The ability to think creatively is an expression of the uniqueness of the individual in his interactions with his environment [16]. This creative expression reflects the originality of the individual [20], which is a unique personal expression that can be expected by the emergence of new ideas and innovative products [21]. Based on observations, the characteristics of students who have the ability to think creatively include: (1) able to orient themselves on certain objects, (2) able to specify an idea, (3) able to analyze ideas and the quality of personal work, (4) able creating a new idea in problem-solving.

D. Analysis of Students' Creative Thinking Abilities on the Elaboration Aspect

Elaboration is interpreted as the ability to develop ideas and add or detail ideas [16]. The elaboration aspect used in this study consists of three items, namely items 10, 11, and 12. The results of data analysis on the elaboration aspect are presented in Figure 4.

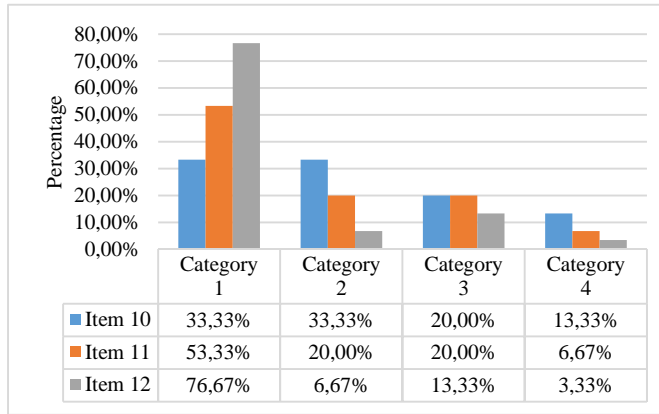


Fig. 10. Percentage of Students' Creative Thinking Ability Results in the Elaboration Aspect

Based on the results of the study showed that in the aspect of elaboration, the highest category is in category one. These results indicate that most of the research samples have not been able to elaborate on ideas. In other words, most students have not been able to give ideas in detail or specifically and clearly.

The resulting argument is only in the form of ideas that have not been arranged properly. So it can be said that students' understanding of concepts in the elaboration aspect is still low. The item that is considered difficult to be solved by students in the elaboration aspect is item 12. Item 12 of the aspects of elaboration presented in Figure 11.

You have certainly seen birds perched on electric wires stretched between electric poles. Although these wires pass through the current, the bird is not electrocuted. This is because.....

A. The skin of a bird's foot has layers like an insulator
 B. The foot of a bird only steps on one of the wires
 C. Bird's feet have space
 D. The bird's feet have an electric antidote

Your reason:

Fig. 11. Item 12 aspects of elaboration

Indicator item 12 is looking for a deeper meaning to a problem that is presented based on understanding the concept of direct current electricity. Examples of student answers are presented in Figure 12.

A. Sepati halnya jakman kabel listrik, yang memiliki lapisan pelindung seperti bahan isolator.

EH: A. Like an electric cable has a protective layer such as made of insulating material

Fig. 12. Examples of the results of A4 student answers in item 12

The answers given by A4 students can be said not based on clear arguments, and show a limited understanding. In the case provided, the bird only steps on one of the wires from the electric wire and does not cause a potential difference in the power cable. So that no electricity electrocutes birds. If the bird's foot accidentally stepped on two cables, the voltage cable with a neutral cable, the bird will also be electrocuted. Besides, birds do not touch the ground, so electricity from high-voltage cables does not flow to low-earthed earth.

The findings of the research show that the ability of students to think creatively on the subject of direct current electricity is still relatively low in the aspects of originality and elaboration. To develop the ability to think creatively, students need to be given the opportunity to be involved creatively by helping to develop the necessary infrastructure. In this case, what is important is to give freedom to students to express themselves creatively, of course, with the condition that it does not harm others or the environment.

Students' creative thinking will be realized if there is support from the environment, or if there is a strong urge in themselves (internal motivation) to produce something creative thinking can develop in a supportive environment. In the family, at school, in the work environment as well as in the community there must be appreciation and support for the attitudes and creative behavior of individuals or groups of individuals. Therefore education should be able to appreciate the personal uniqueness and talents of its students (do not expect all to do or produce the same things, or have the same interests).

Educators should appreciate the creativity of children and communicate it to others, for example, by displaying or displaying the work of children; this will further arouse children's interest to be creative. Most creative students use analogical ways of thinking because they can see relationships that are not visible to other students. Ordinary students also often think analogically, but analogical thinking done by creative students is characterized by their extraordinary, strange, and sometimes irrational nature.

IV. CONCLUSION

Based on the results of research and discussion, the ability to think creatively is the ability to create new and original ideas. Even people who feel unable to create new ideas can actually think creatively, provided they are trained. The results of the study, in general, showed that the minimum completeness criteria had not been achieved, namely in physics subjects by 75 both in the aspects of fluency, flexibility, originality, and elaboration. Some of the arguments produced are only ideas that are not well-organized. This shows that students' understanding of concepts at the highest aspect is still low. To develop creative thinking skills, students need to be allowed to be actively involved during the learning process.

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