Analysis of critical thinking ability in direct current electrical problems solving

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Abstract. This study concern on analyzing the ability of students in critical thinking skills on the subject matter of direct current electricity. Samples were taken using purposive random sampling consisted of 32 students of grade XI, Multimedia 1, SMK Negeri 3 Surakarta in academic year 2016/2017. This study used descriptive quantitative method. The data were collected using tests and interviews regarding the subject matter of direct current electricity. Based on the results, students are getting some difficulties in solving problem in indicator 4. The average of students’ correct answer is 62.8%.

1. Pendahuluan
Critical thinking is reasonable and reflective thinking with an emphasis on making decisions about what to believe or do. Based on Ennis (1993) critical thinking indicators can be derived from the critical activity, they are: (1) ability to formulate the problem issues; (2) ability to uncover the facts needed to solve a problem; (3) ability in selecting a logical argument, relevant, and accurate; (4) ability in detecting bias is based on a different angle or point of view; and (5) ability to determine the effect of a statement taken as a decision. Critical thinking is needed by everyone to solve problems in real life [1]. Elder, et al. says that there are six levels of critical thinking, namely unreflective thinking, challenged thinking, beginning thinking, practicing thinking, advanced thinking, accomplished thinking [2]. Yildirim, et al. defines critical thinking as the process of searching, obtaining, evaluating, analyzing, synthesizing and conceptualizing information as a guide for developing one's thinking with self-awareness, and the ability to use this information by adding creativity and taking risks [3].

The characteristics of the direct current electric material are derived from the current, resistance, and voltage. This material tends to be abstract. Direct current electric material is given to the science curriculum in the vocational high school. Learners have difficulty with the concept of electrical resistance, electric current and voltage, energy and electrical power, electrical measuring devices. Learners have a misconception about direct current electricity. The concepts developed by learners derive from interpretations that are evoked from everyday experience [4]. To understand the concepts of physics, learners must be skilled in expressing these concepts in various ways or forms (multiple representations). Representation skills are a must-have ability to interpret and apply concepts to solve problems appropriately. Some representations are representations of concepts in various ways such as verbs, graphs, diagrams, mathematics equations, and so on.
The ability of learners to succeed in learning is determined, among others, with the ability to think [5]. This is a key point in solving problems during the learning process [6]. With the thinking skills of applying learners can train and develop their cognitive intelligence as well as relate the facts or knowledge information acquired earlier to make predictions about the outcome or outcome that was later formulated by Ariska [7]. Teaching and learning activities should involve explicit thinking skills, thus facilitating the ability to categorize thinking based on the available framework [8]. In this study, we concern on investigating the critical thinking ability of learners on the concept of direct current electricity.

2. Method
The research method used in this research is descriptive method to identify the critical thinking ability of learners about direct current electricity. The sample was taken using purposive random sampling consisting of 32 students of class XI Multimedia 1 SMK Negeri 3 Surakarta Lesson Year 2016/2017. The data were collected by using test and interview. The test items consist of 20 multiple choice tests based on the indicator presented by Ennis, et al [1]. Every critical thinking indicator presented with 3 question. The test is including of 2 items about electrical resistance, 8 items about current and voltage, 8 items about energy and electrical power, and 2 items about electrical measuring instruments. After the test, student were interviewed to confirm the student answer and to get the data about their reasons for the answer.

3. Results and Discussion
The data are the percentage of students’ answer and the profile of students’ answer. The percentage of students answer is presented in table 1.

| Critical Thinking Skills Indicator | Correct Answer (%) |
|-----------------------------------|--------------------|
| 1                                 | 72                 |
| 2                                 | 42                 |
| 3                                 | 64                 |
| 4                                 | 62                 |
| 5                                 | 74                 |

Overall of the result, the average of students’ correct answer is 62.8%. The smallest correct answer is in indicator 2 and the most correct answer is about indicator 5. In indicator number 3 the learners have difficulty understanding the problems presented in various representations. A more understanding is achieved when a learner is consistent about what he or she deems to be true [9]. A representation of the problem of various forms of representation demands a scientific perception of the passage. Factors that influence critical thinking processes in solving problem solving problems are as follows: (a) learners are not accustomed to working on multiple choice questions with additional reasons so that learners take longer; (b) learners are less ability to change the story into a mathematical model so that learners difficulties in solving problems; (c) learners tend to often solve problems only by using one rare way to check the results of their work [10].

3.1. Indicator of critical thinking ability in uncovering facts needed to solve a problem on the subject matter of electric current
The electric current is the flow of electric charge or electric charge flowing per unit time. The direction of electric current is from high potential to low potential, so opposite to the direction of electron flow. In order for the electric current to flow from A to B, the positive charge arriving at B must be moved back to A [11]. Thus the potential A is always higher than B. In order for electric current to flow in the wire, then between the two ends of the wire there must be a potential difference. This concept can be seen in Figure 1 below:
Number 5.
Notice the image below:

Will the lights turn on when the circuit is grounded as in the illustration?

a. On
b. Die
c. Dim
d. Blinking
e. Anything wrong

Reason:

a. Grounding a circuit in one place has no effect on the circuits. The electronics move from the – to the + side of the battery. Going into the earth will only sidetrack them, so they don’t do it.

Figure 1. Example of students’ answer in electrical resistance material

Based on the answers as in Figure 1, learners already understand the problem by representing the problem in the form of images according to the indicator of critical thinking abilities to choose the argument logical, relevant, and accurate. Learners illustrate a lamp connected to a battery voltage source. One of the connecting cables is connected to a water line (ground). The concept of electron flow from pole - (negative) to pole + (positive). Instead the current flow from the + (positive) pole to the pole - (negative). With ordinary observations, the lamp should not be lit. In fact, the lights are still on. So between the electrons flow with the current flow direction is different. The level of critical thinking of learners at the level is able to uncover the facts needed in solving a problem. Learners are able to think abstract in electricity. So this answer is relevant to the problem.

3.2. The indicator of critical thinking ability in being able to choose logical, relevant, and accurate arguments to solve a problem on the subject matter of current and voltage.

The electric current is the amount of charge flowing through the conductor in each time unit denoted by I. While the electric potential is the sum of the effort each unit of charge is denoted by V. This quantity measures the potential energy of an electric field resulting in the flow of electricity in an electrical conductor. Depending on the difference in electrical potential, an electric voltage may be regarded as extra low, low, high or extra high [12]. By definition, the electric voltage causes a negatively charged electrically attracted object from a low-voltage place to a higher-voltage place. This can be seen in Figure 2 below:
High Voltage and Birds

Suppose a bird stands with its feet clamped a light bulb in the following series:

In this case, the bird will likely ....

a. experiencing a shock if the switch is opened
b. experiencing a shock if the switch is closed
c. experiencing a shock if the switch is open or closed
d. no surprises at all in this case
e. not all

Reason:
b. When the switch is open the cable on one side of the switch is showing 12 volts, and the wires on the other side are at 0 volts. The bird is on one side so there is no difference in the tension at the foot of the bird. Now close the switch. The current flows through the light bulb. Some currents take a detour and flow through the birds. The bird got a surprise.

Figure 2. Example of students’ answer in electric current and potential difference

Based on the indicator of critical thinking ability learners have not been able to reveal the facts needed in solving a problem of concepts lowering current and voltage electricity. In the circuit, the voltage difference is always in the part of the circuit whose current does not flow. When the switch has opened the cause of the non-flow current is the switch. When closed, the current does not flow because there are obstacles. Could be more clear if it is described there are 2 birds, the first bird parallel with lights, and the second step on the cable only. Then the first bird gets hit by a shock and the second does not have any surprises at all. The electric shock experience explains the second answer because there is a voltage flowing through the lamp.

3.3. Indicator of critical thinking ability in determining the effect of a statement taken as a decision to solve the problem of energy and electrical power.

Electricity is the amount of effort in moving charge per unit of time, denoted by P and expressed in watts. Learners complete by stating that the power delivered can be doubled by doubling the current or voltage to the electrical device. It can be seen in Figure 3 below:
A unit of power called a watt, delivered to an electrical device (electric saw machine, for example) can be amplified by increasing the....

d. A flowing current (amperage) but no potential difference (voltage);
b. Voltage applied to it but no current;
c. Both are currents or voltages;
d. Loads enlarged

e. Nothing is true;

Reason:
c. When the saw is mounted, the applied voltage is 220 volts. That is the highest voltage available for that tool.

How to increase output power when a large piece of wood gets into the machine? By increasing the ampere it needs. If you are weighing on the saw and slowing it will draw the surplus current that can be proven by blinking the lights elsewhere in the circuit. It's like dropping home water pressure when someone opens a large tap.

Can you think of a case where the voltage increases without changing the current? Think of a battery set up in series with a light bulb. Then think of two batteries arranged in series with two series bulbs. Voltage and power output multiply but because the load resistance also multiplies, the current in the circuit does not change. So the concept of power = watt = voltage × current, can be applied.

3.4. Indicator of the ability to think critically in the ability to detect bias based on different viewpoints on the material of electrical measuring instrument.

Amperemeter is a tool to measure electric current, either direct current or back and forth in a closed circuit. The most important part of the amperemeter is the galvanometer. Galvanometer works with the principle of the magnetic force between the magnetic field and the coil, the greater the current passing through the coil, the greater the magnetic force generated so that the analog needle deviation increases. There is a limitation of the measurement limit of an amperemeter. This can be seen in Figure 3 below:
Consider the following circuit images (a):

![Circuit Diagram](image)

Given $R_{sh} = 500 \, \Omega$ and $R_1 = 1,000 \, \Omega$. Measurement of current with amperemeter is available. It turns out that the measurements exceed the amperemeter limit value (50 mA). To solve the problem, by adding a constraint arranged in parallel with $R_1$, called the shunt resistance ($R_{sh}$) as in figure (b).

The current measurement results at $I_2$, showing the designated scale of 20 mA, the maximum scale of 50 mA, as well as the selected 25 mA measurement limit as shown below:

![Amperimeter](image)

Determine the large main current ($I$) flowing in the circuit (b)!

- a. 0.015 A
- b. 0.150 A
- c. 1.500 A
- d. 5.000 A
- e. Not all

Reason:

b. The function of the shunt resistance is to divide the electric current so that it partially flows on the shunt resistance and partly flows to the constraints that are paralleled with the shunt resistance.

And for a solution measuring an electric current that exceeds the measurement limit we can shift the measuring limit if still possible. If not possible we should install shunt resistance in parallel to the amperemeter.

**Figure 4.** Example of students answer in electrical measuring instrument material

Based on the answer as in figure 4, according to the indicator of critical thinking has not been able to determine a statement taken as its decision on the concept of electrical measuring instrument. The existing problem of learners has not been able to define the concept of shunt resistance. The existence of the measurement of the current value exceeds the measurement limit of an amperemeter. To
overcome this problem, we can increase the value of the measurement limits on the amperemeter by adding a parallel-mounted resistance.

4. Conclusion

Based on the results of the discussion, it can be concluded that students are getting some difficulties in solving problem in indicator 4. The average of students’ correct answer is 62.8%. Some factor in the school is students prefers studying physics by memorizing without understanding the concept of the materials. Moreover, in physics learning, activities are done by students to solve problems without a deep understanding.

Bibliography

[1] Ennis, R. H. 1993. Critical Thinking Assessment. Theory into Practice. Vol 32, No 3, Hal 179-186
[2] Elder, L & Paul, R. 2008. Critical Thinking development : A Stage Theory with Implications for Instruction. [Online]. http://www.criticalthinking.org
[3] Yildirim, B & Ozkahraman, S. 2011. Critical Thinking in Nursing Process and Education. International Journal of Humanities and Social Science. Vol 1, No 13, Hal 257-262
[4] Budiarti, I.S., Suparmi, Sarwanto, Harjana. 2017. Student's Conceptual Understanding Consistency of Heat and Temperature. J. Phys.: Conf. Ser. 795 012051
[5] Fatmawati, H., Mardiyana, Triyanto. 2014. Jurnal Elektronik Pembelajaran Matematika, Volume 2, Nomor 9, 2014. Jurnal 899-910
[6] Liliawati, W. and Ramalis, T.R. 2009. Semnas IPA UNY. Prociding 790 121
[7] Ariska, M. 2015. Jurnal Inovasi dan Pembelajaran Fisika, Volume 2, Nomor 2, 2015. Jurnal 147-154
[8] Fahim, M & Pezeshki, M. 2012. Manipulating Critical Thinking Skills in Test Taking. International Journal of Education. Vol 4, No 1, Hal 153-160
[9] Stipple, EJN. 2016. Development of the Critical Thinking Toolkit (CriTT): a measure of student attitudes and beliefs about critical thinking. doi:10.1016/j.tsc.2016.11.007
[10] Demirhan, FSUG. 2017. The effect of creative drama on critical thinking in preservice physical education teachers. doi:10.1016/j.tsc.2017.02.018
[11] Forawi, S.A. 2016. Standard-based science education and critical thinking. doi:10.1016/j.tsc.2016.02.005
[12] Demirhan, E., Koklukaya, A.N. 2014. The Critical Thinking Dispositions of Prospective Science Teachers. Procedia-Social and Behavioral Sciences 116 (2014) 1551 – 1555