ASSESSING ELEMENTARY SCHOOL STUDENTS' UNDERSTANDING OF ELECTRIC CURRENT AND ITS CONSERVATION

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Abstract

A qualitative research approach was chosen to assess the elementary school students' understanding of electrical current and its conservation. To this end, a written questionnaire was presented to 108 participants.

Keywords: Assessing, understanding, electric current, elementary school, student

The context and purpose of the framework

The works of numerous researchers demonstrate that among the students of the elementary school, their conceptions of the light, magnetism, time, distance, speed and force, matter and its physical transformations and heat and temperature are naïve (Allen, 2010; Métioui & Baulu MacWillie, 2013, 2015). The present research is related to this problem and aims to uncover the conceptions of 108 students from Canada, aged between 10 and 12 years, about the electrical circuit.

Methodology

To assess their understanding of electric current, we proceeded with classical methods such as paper and pencil questionnaire of one-hour duration. Note that the five questions asked (see appendix) were based on researches done worldwide in elementary and secondary schools (Jabot & Henry, 2007). The first and the second questions were about the distribution of current and its conservation in a simple circuit constituted by a battery, a bulb, and two wires. The third question was about the notions of ″open″ and ″close″ circuits, and the fourth and the five questions were about the meaning of the electricity and the composition of a battery. The questionnaire of one hour duration was presented to 108 students aged 10 to 12 years old. The subject volunteered, and they collaborated fully and actively.

Analysis of the data of the experimentation

Analysis of the first question

This question served to know how the students explain to light the bulb we must connect the (+) and (-) terminals of the battery to its poles. The analyses of the answer can be classified in three categories described below:

Category 1 (14%): Unipolar model - (1) currents flows from the battery to the bulb or (2) currents flows from the positive to the negative poles. The typical answers are:

"*The choice I have made will work because the positive end has the most energy.* " (E82)

"*The reason that I picked (c) is because that is the only one that is right for me.* " (E94)

Category 2 (32%): Clashing current model - Currents flowing towards the light bulb from each battery terminal collide and produce the observed phenomenon:

"*Because the two wires touch each other and when they meet at the light bulb, the bulb comes on.* " (E102)

Category 3 (54%): Scientific model - Current moves from the positive (+) end of the battery to the bulb and then moves back to the negative (-) end of the battery, and continues to circulate. The explanations (illustrated below) to justify their choice of answer do not seem to show that they understood the scientific model:

"*Because that is how I thought it would light up before I read it.* " (E85)

"*I think it will light up because the energy continues to circulate through the battery and causes the energy to go to the light.* " (E91)

"*Because it continues to circulate.* " (E95)

"*I picked (d) because I think that is the answer to it and it seems like it would work that way.* " (E98)

Analysis of the second question

The relative data to this question relates to the principle conservation of the total charge revealed two categories of answers as illustrated below. According to this principle, in each moment the intensity of the current is the same at all points of the wires.

Category 1 (38%): The currents in the A wire is stronger than the B wire (or the opposite):

"*Because B is touching the bottom and that is where the bulb works.* " (E3)

"*The B wire is weaker because electricity goes up and the A wire happens to be at the top*. " (E25)

"*The current in the B wire is weaker because B wire is shorted than A wire.* " *(E36)*

"*The current B wire is weaker because it is on the (-) side.* " (E39)

"*The current in the B wire is weaker because it is on the negative (-) and the current A wire is stronger because it is on the positive (+).*" (E41)

"*The bulb lights up with the A wire and the B gives it strength.* " (E87)

"*Because the B wire has to be stronger than the A wire.* " (E89)

Category 2: The current in the B wire is the same as the one in the A wire:

"*With the choice, I have made the bulb will light up because the B wire is the same as the A wire.* » (E27)

"*It will light up because the bulb has a source of DC energy*. " (E33)

"*It takes twice ends of a battery and a wire to light up the bulb.* " (E50)

"Because the wires look the same. They just connected to different ends. " (E79)

"*The current B and A has to be the same or the light won't work. If the B side was stronger than the A side it wouldn't work, the same if it was switched.* " (E105)

Analysis of the third question

The objective of the present question is to verify if the students are aware that if we touch the (+) and the (-) poles simultaneously we ″close″ the circuit then it would be deadly. For 21%, it would be deadly to touch the positive pole because:

"*It would be deadly to touch the (+) side of the battery because that is where the power comes out.* " *(E15)*

"The positive side would be deadlier to touch because it has more voltage in it. " *(E42)*

"*I think is the positive side would be deadlier to touch because positive side is stronger than negative side.* " *(E45)*

"*If you touched the (+) it would be deadly because it has more power than the side (-).* " *(E91)*

For only 7% gave a correct answer it's would be deadly if we touch the two poles at the same time:

"*Neither, you would have to touch both poles to make a complete circuit to be shocked.* " *(E43)*

Analysis of the fourth question

The relative data to the question on what is electricity revealed three categories of answers:

Category 1: Associated electricity to light.

Category 2: Evokes the utilitarian aspect of electricity.

Category 3: Evokes the notion either of energy, either of electrical current, either of force, either of power.

Analysis of the fifth question

Finally, question 5 was used to find out the students points of view on what is in a battery which is a technical object that is familiar to them. The relative data to this question revealed five categories of answers described below:

Category 1 - There is electricity and wires in a battery:

"*I think that there are small wires and electricity in the batteries*. " (E20)

Category 2 - There is either liquid acid, mercury, oil, a gas, or a chemical that releases or retains electricity in a battery:

"*Gas to create light*."(EXX);

"*Mercury, a source of energy.*";

"*Inside a battery there is a liquid (poison) that can make electricity for a little while.*" (E12)

Category 3 - There either energy, a force or volts in a battery:

"*Inside a battery, a part is formed of energy and another part of metal so that electricity can pass.* "*(E9)*

Category 4 - There are only some wires in a battery:

"*Wires that operate the battery and that could operate electric things.* " (E60)

Conclusions and implications

The findings are consistent with several studies which indicated that the students' understanding of electric current is naïves compared to scientists' understanding. A practical implication of these results is that teachers may consider the student understanding of electric current and its conservation to develop pedagogical activities to help them move to more accurate explanatory models.

References

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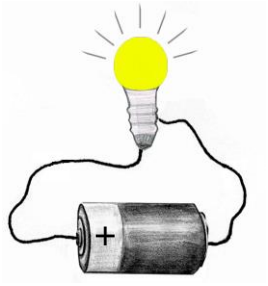
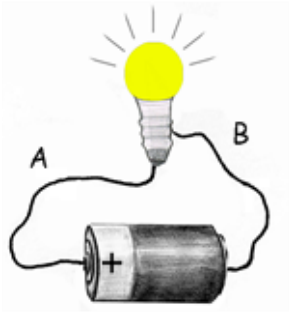
Appendix
Paper-pencil questionnaire

Question 1
Put a circle around the letter corresponding to the sentence that appears to you the most correct explanation of why the bulb linked to the positive and negative ends of a battery lights up.



a. Current moves from the positive (+) end of the battery to the bulb and stops there.
b. Two currents move by leaving the positive (+) end of the battery and the negative (-) end of the battery, and meet in the bulb.
c. Current moves from the positive (+) end of the battery to the bulb, then moves back to the negative (-) end of the battery and then stops there.
d. Current moves from the positive (+) end of the battery to the bulb and then moves back to the negative (-) end of the battery, and continues to circulate.
e. None of the above.

Question 2
In the following sketch the two wires which link the battery to the bulb are identified by the letters A and B, and the bulbs is lighted:



Put a circle around the letter which corresponds best to the currents in the circuit:
a. The current in the B wire is weaker than the current in the A wire.
b. The current in the B wire is stronger than the current in the A wire.
c. The current in the B wire is the same as the one in the A wire.
d. None of the above.

Question 3
If we had a battery of 1 000 volts, which pole (+ or -) would it be deadly to touch or would neither pole be deadly to touch. Explain your answer.

Question 4
What is the meaning of electricity for you?

Question 5: Consider the following battery.

According to you, what is inside?