University Students´s Causal Reasoning Dealing With Electric Current in Transitory situations

Ane LENIZ EREÑO, Kristina ZUZA, Jenaro GUISASOLA

Donostia Physics Education Research Group, Department of Applied Physics, University of the Basque Country (UPV/EHU), Plaza Europa 1, 2008 Donostia-San Sebastian, Spain

Abstract. This study examines university students causal reasoning when tackling electric current in transitory situations. A questionnaire with emphasis on explanations was used to analyse students' reasoning. The results obtained show that a significant percentage of students cannot correctly interpret simple transitory state current phenomena. Their explanations fall into two general categories: one based on potential difference and one that excludes current flow in processes of transitory state. We look at a number of aspects that have been little mentioned in previous research, for example, the reasoning university students use when establishing macro-micro relationships and some difficulties with complex reasoning.

1 Introduction and aims

Despite the fact that there are many studies that identify which concepts and representations students learn well and with which of them students struggle within the context of DC circuits in the steady state, few studies have been made of students' ideas on transient states of movement of charges in a conductor [1, 2]. In this research, we present two of the questions that have been used to investigate the representations of students about the movement of charges of transients in direct current, which focus on the transition between electrostatics and electrodynamics in first year at university. This study adds to prior research the examination of student´reasoning on explanations of electric current in transitory situations in introductory physics courses for science and engineering. We are particularly interested in the causal models students use relating potential difference quantities and macroscopic-microscopic explanations.

2 Method

The current research involved about 200 students at the University of the Basque Country (UPV/EHU) in the first year Introductory Physics course for engineers. The data were collected in written questions. All the questions were answered as post-test after receiving instruction. The students' answers to the questions were subjected to rigorous analysis [3]. The analysis does not focus on correct or incorrect answers but on identifying students' understanding and reasoning. We are aiming at a nuanced understanding of what aspects of explanatory model on currents transient state students understand reasonably well and what aspects are problematic for them.

2.1 Experimental design

Two questions were given to students over the course to investigate their understanding on the mechanism of how current works in transitory movement of charges. The questions were administered in different formats, but all of them were done post-test after receiving instruction. The question Q1 is a multiple-choice question, which also asked for a reasoned explanation of the answer. The Q1 shows an open circuit between two points A and B, made up of a battery and a switch, which is very familiar to students in the academic context. Students have to decide the value of the potential difference between the point A and B after the switch is closed. The second question is exactly the same as the previous one, but

designed as an open-ended question in which students are asked to explain in depth the phenomenon presented, where they had to reason and calculate the potential in points A and B. What this study seeks to identify is the students' main thinking patterns when interpreting contexts of current in transitory state.

3 Results

Although the 79% of students chose the correct option in question Q1, we found that only 23% of them justified their response. The results indicate an improvement over other studies showing that secondary students confuse the concepts of current and potential difference [4]. In the same way, in question Q2, the 38% of students answered correctly that there is a transitory movement of charges through the switch until the potential between A and B becomes the same as the potential difference of the battery. Another 12% of students explained that, after very a small period of time, the potential difference between A and B will be the same as that of the battery, but they did not reason about the flux of charge.

In question Q1, the option "potential difference zero between A and B" was chosen by a significant percentage of students (18.0%). A third of the subjects that chose this option explained that the potential difference is zero because the circuit is open. This mistake is consistent with previous studies that show that High School students tend to confuse the concepts of current and potential difference [5]. The 20% of students´answers had the same reasoning in question Q2.

4 Conclusions

The results obtained show that a significant percentage of students cannot properly interpret simple transitory state current phenomena. Moreover, the percentages of the types of answer are similar in both questions Q1 and Q2, which indicates the consistency of the types of responses. According to our findings and the explanatory model of current in a wire, the key idea that will be necessary to emphasize would be the microscopic mechanism of production of potential difference between two points within the circuit wire, in both transitory current and steady situations. In particular, this involves the relationship between the concept of electric potential studied in Electrostatics (capacitors, charging bodies …) with those analysed in DC circuits. The results show that omitting an explanation of a microscopic mechanism of charge movement makes it harder for students to interpret transitory states in DC circuits.

References

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