

Development of two-tier instrument on simple electric circuits

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Abstract. As a part of a bigger project on student understanding of electric circuits, the new two-tier instrument on simple electric circuits with 30 items has been developed. The instrument probes student understanding of closed electric circuit, serial and parallel circuits, electric current, resistance and voltage. The test was administered to 1900 middle-school students at age of 13-14 in Austria and Germany. Data was analyzed with the WINSTEPS software for Rasch analysis. The test provides the insight in student difficulties with electric circuits and their underlying reasoning. The test analysis and the most common student difficulties will be presented.

1 Context and Background

Students are introduced to simple electric circuits early in their education. In Austria and Germany, they are typically part of physics curriculum for 10 weeks in the middle school, when the pupils are at the age of 13-14. There is an extensive body of the research on this topic that has shown that students have many difficulties with simple electric circuits at all levels [1-5]. Summarized, the findings from the previous research show that students use current as a primary concept, that they think of a current as it is a substance and that they do not distinguish between the concept of current and concept of voltage. Furthermore, they consider the battery as a source of constant current, they seem to believe that current is used up and that the current through the light bulb in the electric circuit depends on the position of that element in the circuit.

Physics education groups at University of Vienna, Austria, University of Graz, Austria, University of Frankfurt, Germany and Technical University Darmstadt, Germany have started a joined research project in order to detect student difficulties in middle school and to test how different teaching approaches help middle-school students to develop the functional understanding of simple electric circuits.

Although there are some existing inventories on electric circuits, they either do not cover all the topics thought in middle school, or are far too demanding for that level. In order to close that research gap and also to be able to test different teaching approaches, the new two-tier instrument on electric circuits has been developed.

2 Research goals

The main goal of this research is to develop a two-tier instrument on simple electric circuits that will be easy to administer in middle schools and that will at the same time enable the insights into students' reasoning. The main questions are: Can new two-tier instrument trace the known student difficulties with electric circuits and do the developed questions build a stable construct?

3 Research Design and Methods

In the first stage of the project, nine semi-structured interviews have been conducted with students at age of 14-15 in two different public schools in Vienna, Austria. The interviews were transcribed and analyzed and the common student difficulties were categorized.

Based on the results of the existing instruments on electric circuits [1-3] and on the results from the interviews the new two-tier instrument on simple electric circuits with 30 items was developed. The first tier of each item consists of a content question, while the second tier offers explanations for the first tier answer in a multiple choice format. The second tier has a purpose to replace students' written explanation, but still to provide insight into students' reasoning. While the first tier was often based on the known questions from the previous research [1-4] with some new questions added, distractors in the second tier are based on the typical student answers and difficulties found during the interviews.

The test was administered to 1900 middle-school students in Austria and Germany at age of 13-14. All students have been thought by their own physics teacher and were exposed to standard physics curriculum. Because the 30 two-tier items are too much at once for the children at that age, the test was divided into two tests with 21 items each, which were anchored through 12 mutual questions.

Data was analyzed with the WINSTEPS software for Rasch analysis to obtain linear measures for item difficulties. The functioning of the test as a whole was satisfactory.

4 Results and conclusion

As a result, some known student difficulties were confirmed, while also some new arose. Beside known difficulties, students at middle school level did not distinguish between serial and parallel circuits and their reasoning on voltage was based on the physical distance from the battery.

The Rasch analysis showed that the functioning of the test as whole was satisfactory and that it can be used with middle school students. The frequency of different distractor combinations in both tiers of one question reflect most common student difficulties with simple electric circuits.

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