Student Model of Engagement in DC circuits

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Abstract

This is the culmination of a long and systematics study on contextual variation of student responses in the context of dc circuit. We published the contextual variation from their Forced Choice Responses of eight electrically identical questions with fine grained variations that are trivial to a physicist, the productive and unproductive foothold ideas, then narrated six micro-episodes from interviews that sketches the complex cognitive terrain of sense-making path that links complex everyday experience, mathematical reasoning and language connotations with the idealised physics model. We reflect on how the overall findings might be used in order to develop a student model which will help to develop a curriculum for simple DC circuits.

Purpose of the study

Within the broader context of a DC circuit (open) we developed Aspects of Circuit Questionnaire (ACQ), to investigate the following:

1. To what extent does the student response **will affect** by (i) changing a resistor for a light bulb or a heating element (ii) drawing the same circuit vertically or horizontally (iii) changing the phrase "charge flow" to "current"? Eur. J. Phys. 38 (2017) 015701
2. Explores the **reasons** behind the contextual variations in student responses at a fine-grained level. Eur. J. Phys. 38 (2017) 015702
3. Based on six micro-episodes from four follow-up interviews, sketches the complex cognitive terrain that students must negotiate in order to create a sense-making path that links complex everyday experience, mathematical reasoning and language connotations with the idealised physics model.

Student cohort

The cohort of students in this study is first time entering university students, 18+ years old, who were admitted to a special access program, who failed to obtain admission in main-stream due to poor grades in high school. High school students in South Africa study physical science which is a combination of physics and chemistry during grades 10, 11 and 12; electricity, in particular DC circuits, form part of a national curriculum.

Methodology

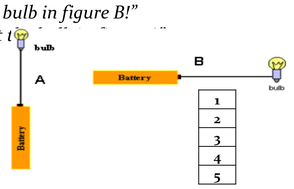
A series of questions based on an open circuit was developed in which three circuit elements were interchanged with each other, namely, a resistor, a light bulb and a heater. These circuit elements were connected with a single wire to one end of a battery in either a horizontal or vertical configuration. In addition the terms "charge flow", "current" and "heat up" (or "light up") were also interchanged in the text for identical circuits. For the purpose of this study we chose 8 questions. We studied the contextual variation of student response in three phases. First phase was analysis of numerical choices while the second phase was free response writing and lastly the personal interview. A Cognitive Medel is presented.

Sample Question (ACQ)

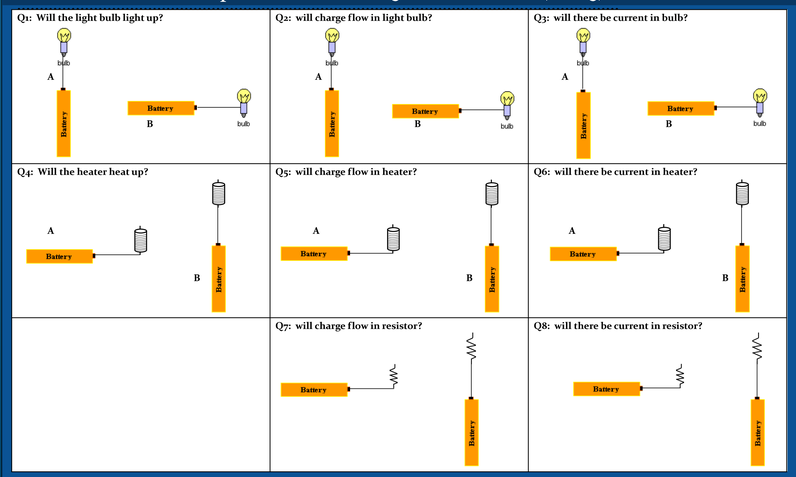
One student connects a light bulb to a battery as shown in figure A. Another student connects the light bulb to a battery as shown in the figure B. The following discussion takes place among the students.
Student 1 says "The bulb in figure A will light up but not the bulb in figure B!"
Student 2 says "No! The bulb in figure B will light up but not t…
Student 3 says "I disagree! Both bulbs will light up!"
Student 4 says "No! None of the bulbs will light up!"
Student 5 says "I have another idea which I will explain!"
With whom do you most closely agree?

Circle only one of 1, 2, 3, 4 or 5.

Explain the reasons for your option in detail below.



Aspects of Circuit Questionnaire (ACQ)



Result from composite sample

The summary of student answers obtained from the investigation is provided in table 2. The eight columns for the 8 answers. Each row represents eight answer of each student against 8 questions. The four Choices,(1) "only circuit A will activate"; (2)"only circuit B will activate"; (3) "both the circuits A & B will activate"; (4) "none will activate" (correct choice) are represented by different colours. **BLACK** cells represents the correct answer.

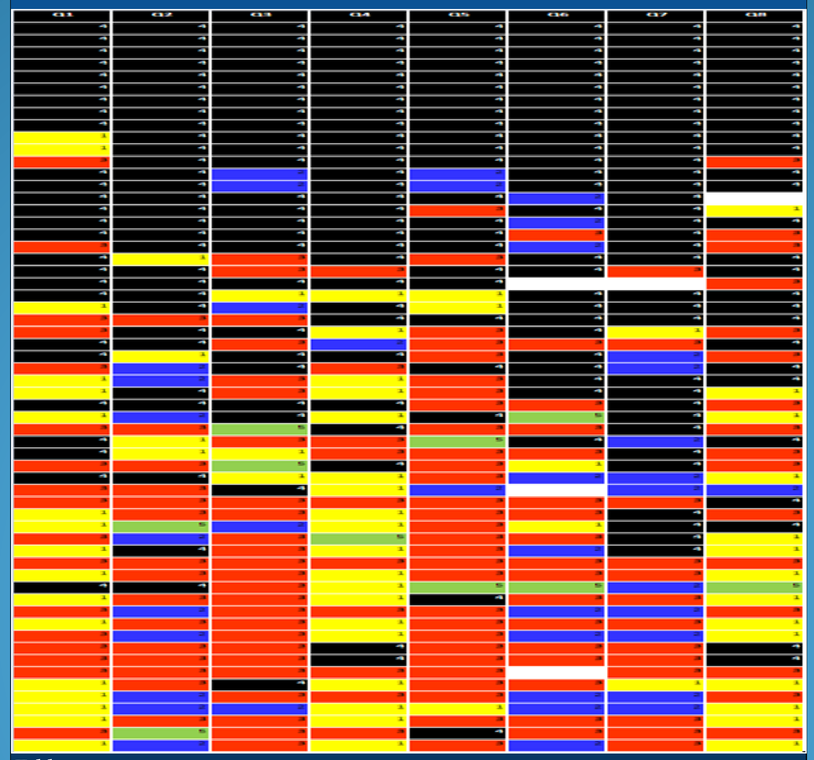
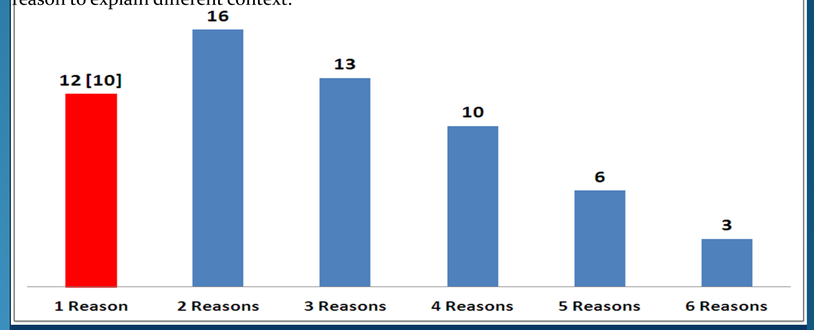


Table 2:
The **Black** cells represents the correct answer, "none of the circuits will activate"
Yellow: "Only Vertical circuit will activate"; **Blue**: "Only Horizontal circuit will activate"; **Red**: "Both the circuits will activate"

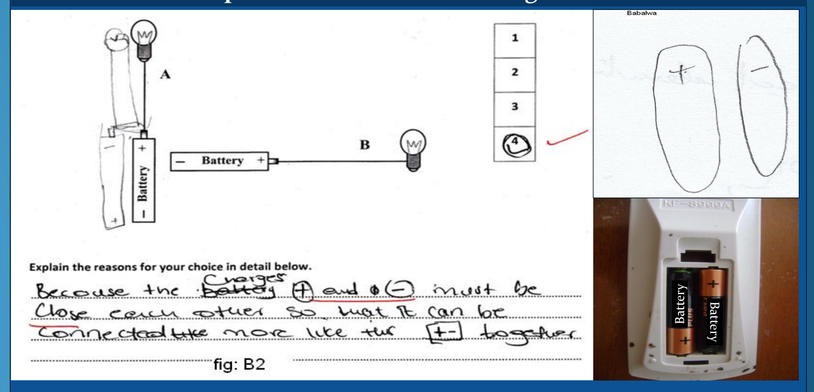
Examples of written explanation

Number of students vs number of reasons/student

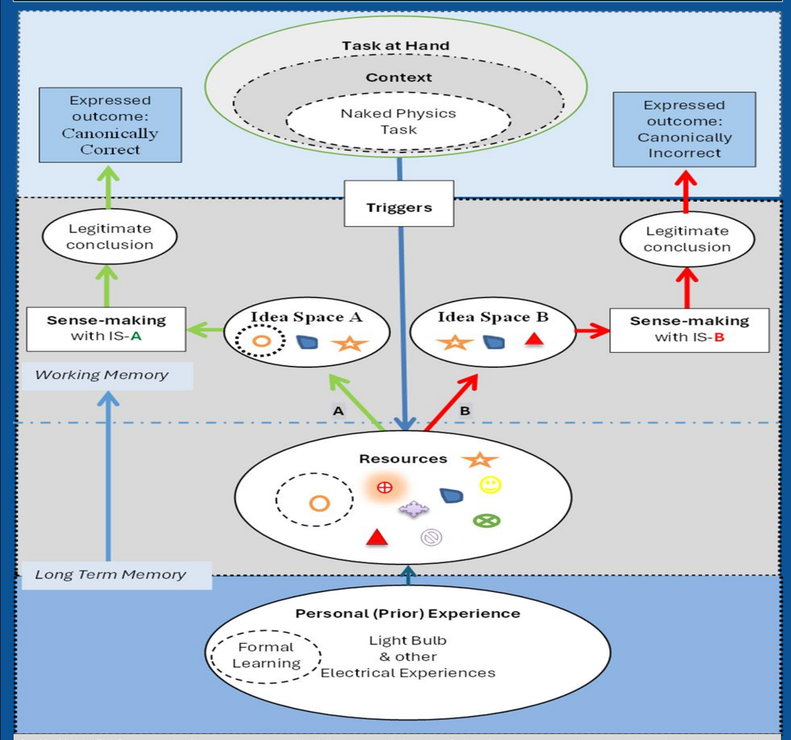
Students were grouped according to the number of reasons they used in 8 answers. 12 students used only one reason in all 8 answers , represented by **RED** bar. Others used more than one reason to explain different context.



Foothold experiences and sense making from interviews



Simplified Cognitive Model



Cognitive Model of Task Engagement showing two pathways that could be followed by a particular student. Pathway **A** shows a sequence of events when the student has the resource of "loop continuity" available (circle enclosed within dotted circle), while Pathway **B** shows the sequence when the resource is absent. In both cases sense-making is applied.

References: 1. John, I., & Allie, S. (2017). DC circuits: I . Evidence for fine grained contextual dependence. European Journal of Physics, 38(38), 22.,
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3. Allie, S., & Demaree, D. (2010). Toward Meaning and Scientific Thinking in the Traditional Freshman Laboratory : Opening the " Idea Space ." American Institute Physics Conference Proceedings, 1289(1), 1–4.