Using Apps for Teaching Circuits in Introductory Physics

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- Investigate the use of a circuit building application (iCircuit) for teaching basic DC resistor circuits
- The Course:
  - Second semester of introductory, calculus based physics class (Physics 2140)
  - Taught Fall 2017
- The Students:
  - Average age of 19
  - STEM majors
  - 76% male

- Two sections of Physics 2140.
  - Both used a semi-flipped format for lectures
  - Similar weekly schedule
    - Three days of lecture with pre-lecture readings/videos and Peer Instruction questions/discussion
    - Two days of recitation where students work in groups to complete conceptual tutorials and practice problems
  - Similar exams

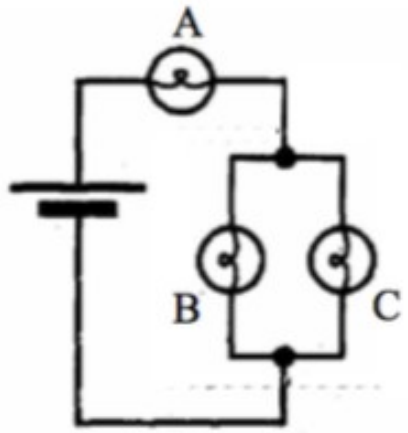
- Section 010
  - MWF lecture
  - Practice problems and quizzes/exams during Tuesday recitation
  - Written tutorials during Thursday recitation
  - Standard end-of-chapter type homework problems
- Section 091
  - MWF lecture
  - Practice problems and quizzes/exams during Tuesday recitation
  - Written tutorials modified for use with the iCircuits app during Thursday recitation.
  - Homework a mix of end-of-chapter type problems and problems requiring the circuit simulation apps
- Both sections were given a sub-set of 30 resistor circuit questions from the Electric Circuits Concept Evaluation in a pre/post test format

Tutorials and other class activities

- Examples from Section 010's written tutorials

More Complex Circuits

A. The circuit at right contains three identical bulbs and an ideal battery.
   1. Predict the relative brightness of the bulbs in the circuit. Explain.



   2. Predict how the brightness of bulb A would change if you unscrewed bulb C. Explain.

B. Explain why you can't predict how the brightness of bulb B would change if you unscrewed bulb C just by thinking about what happens to the current.

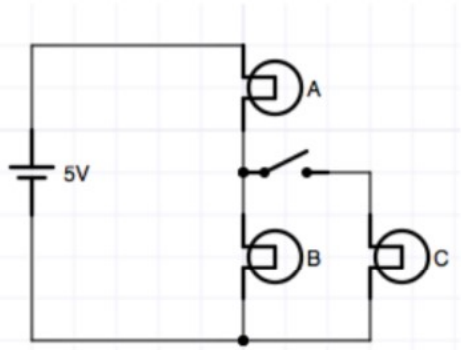
Tutorials and other class activities

- Examples from Section 091's written tutorials for use with the circuit simulator apps

Set up a two-bulb circuit w
switches so that the termin
battery are connected toget
connected together in this
connected in parallel.

A. Close all the switches a
currents of the bulbs in
1. What can you conc
observation about t
through each bulb?

A. The circuit shown contains three identical bulbs and an ideal battery. Assume that the resistance of the switch, when closed, is negligible. Without building the circuit on the app, use the model we have developed to
   - predict the relative brightness of the bulbs in the circuit with the switch closed. Explain.



   - predict how the brightness of bulb A changes when the switch is opened. Explain.

B. Show that a simple application of the model for current that we have developed so far is inadequate for determining how the brightness of bulb B changes when the switch is opened.

Tutorials and other class activities

- Example from Section 091's homework questions for use with the circuit simulator apps

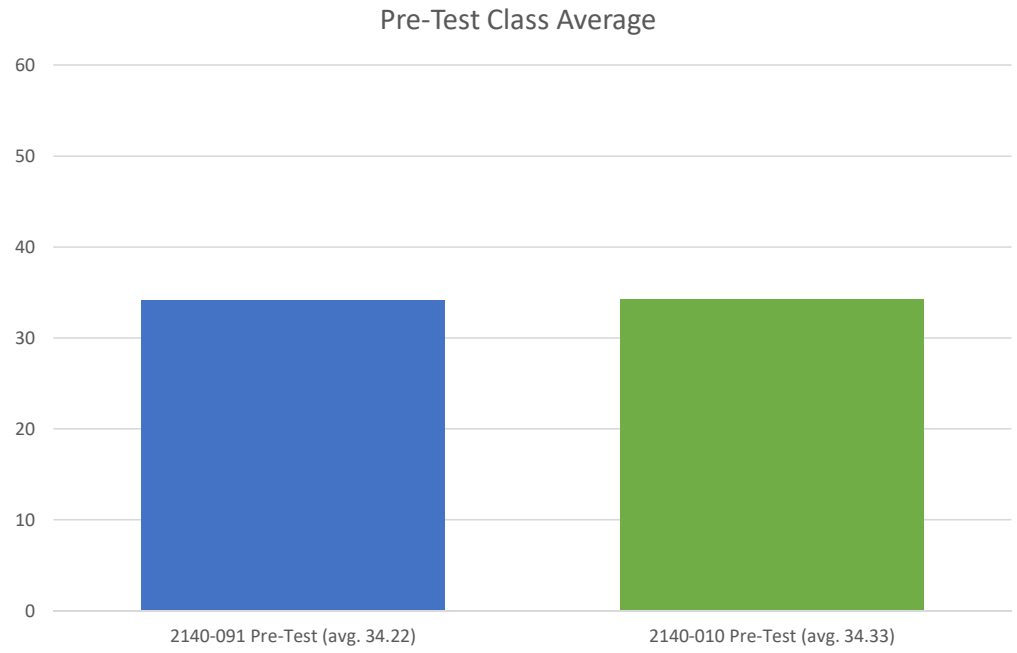
For each of the following situations, use the app to design a circuit that will light 12 identical bulbs (12V/12W), all to the same intensity, from a 48V battery. This assignment requires four completely different circuits.

1. When any one bulb goes out, all other bulbs stay lit with the same intensity (power) as before.
2. When any one bulb goes out, not all bulbs must remain lit, but those that do should have the same intensity (power) as before.
3. When any one bulb goes out, only one other bulb will also go out. The rest will remain at the same intensity (power) as before.
4. When any one bulb goes out, either only two more will also go out or none will go out (your circuit must fulfill both conditions). All other bulbs will remain at the same intensity (power) as before.

For each of these circuits, build the circuit using the circuit simulator and show that it meets the requirements. Calculate the total resistance of the circuit, the total current through the battery, and the total power dissipated in the circuit. Show your work in this process. Submit a pdf file showing a screen shot of each circuit and your written work for each circuit (all in one file—you may write your work by hand and then scan/take a picture before converting to pdf). Submit this file via Blackboard.

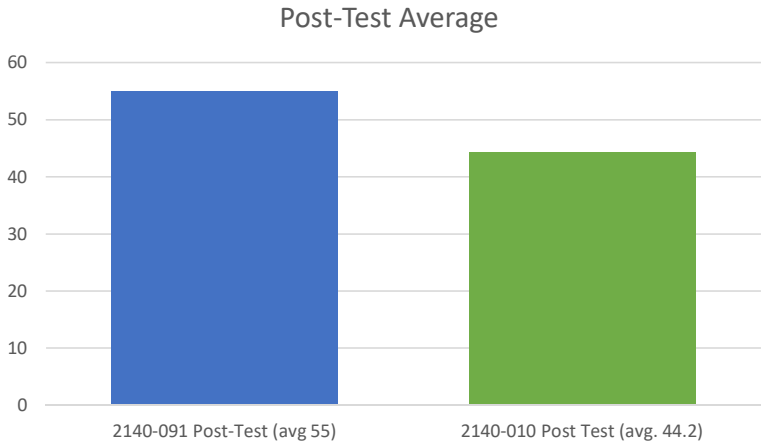
Findings

- The two sections had no significant difference in their pre-test averages

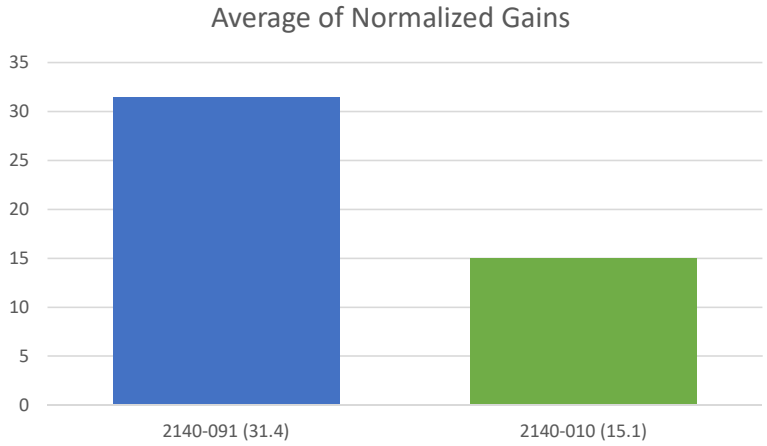


Findings

- Differences in post-test scores and normalized gains were significant



$p < 0.05$



$p < 0.05$

Preliminary findings suggest that use of circuit simulation applications contributes to greater student understanding of DC resistor circuits compared to written tutorials and standard homework.

The **Electric Circuits Concept Evaluation** (ECCE), R. Thornton, D. R. Sokoloff - Unpublished test

Tutorials in Introductory Physics, L. C. McDermott and P. S. Shaffer, (Pearson, Boston, 2010).

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