Qualitative, Tiered, iClicker Recitation Introductions and an Open Ended Laboratory

David Blasing, Andrew Hirsch, and Rebecca Lindell

Purdue University, Department of Physics and Astronomy, West Lafayette, IN

THE PROJECT OBJECTIVE is to create a robust learning environment that enhances the ability of both novice and expert students to build:

I. the qualitative understanding of the physical principles necessary to set up physically meaningful mathematical expressions
II. the quantitative ability to manipulate those mathematical expressions into practical, physical predictions

Implemented in PHYS 272, "Electric and Magnetic Interactions" (Textbook Matter and Interactions)

MOTIVATION: PHYS 272 HAS BROAD IMACT

- PHYS 272 teaches fundamental principles of electricity and magnetism yearly to about 600 students. Permanently refining its pedagogy could benefit thousands of students.

RESEARCH QUESTION: DO QUALITATIVE, TIERED, ICLICKER RECITATION INTRODUCTIONS IMPACT STUDENT LEARNING?

- Using the Brief Electricity and Magnetism Assessment (BEMA, Ding et al. 2006) and the final exam, we measure the impact on the learning gain of students when a graduate TA seeds quantitative, collaborative group work with qualitative, tiered iClicker introductions.

PROGRESS REPORT: ICLICKER RECITATION INTRODUCTIONS

- Fall 2013 through Summer 2014:
  - 17 iClicker series tailored to PHYS 272's recitations (about 100 questions total, majority of which were newly created but following Lin Ding and Bill Raey's pedagogy)
  - These iClicker series take about 15 minutes per week; about 5% of the total time that the students spend combined across in recitation, lab, and lecture
  - Each question has been vetted across 175 student answers across 8 recitations led by 5 teaching assistants
- Future Directions:
  - Understand statistical variations due to different instructors and exams
  - Consider incorporating alpha-numeric questions and/or demographic analysis
  - Refine the quantitative problems to enhance the connection to the recitation introductions

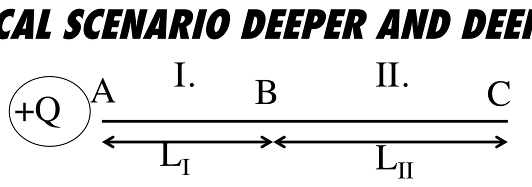
PRELIMINARY SPRING 2014 RESULTS

Two TAs did recitations each with and without the iClicker introductions forming two groups below

- Matched BEMA normalized change (Marx and Cummings, 2007)
  - iClicker Intros (N 70) = .40 +/- .03
  - No-iClicker Intros (N 67) = .36 +/- .03
- Final exam percentage correct, P level = .001
  - iClicker Intros (N 78) = 68.6 +/- 2.1
  - No-iClicker Intros (N 82) = 57.9 +/- 2.3
  - Exam written by a professor not involved in project

TIERED SERIES EXAMPLE, SAME TA LEADING THREE RECITATIONS (FALL 2013):

FOUR DIFFERENT QUESTIONS PROBE THE STUDENT'S CONCEPTUAL UNDERSTANDING OF THE SAME PHYSICAL SCENARIO DEEPER AND DEEPER



PHYSICAL SCENARIO:
There are electric fields in region I and II shown in the figure, but their magnitudes (E_I and E_{II}) are unknown. We introduce a sphere carrying charge +Q at rest at location A. Its velocity is observed to increase at a constant rate until point B. After point B, its velocity decreases at a constant rate until stopping at location C. Ignore any effect from non-electric forces.

QUESTION 1: ELECTRIC FIELD'S DIRECTION

What is the direction of the electric field in region I. (II.)?

a. Right (Left)
b. Left (Right)
c. Right (Right)
d. Left (Left)
e. I am never taking another physics class again

QUESTION 2: ELECTRIC FIELD'S MAGNITUDE

Which of following is true?

a. The electric field is uniform throughout the whole space
b. E_I increases at a uniform rate in region I and E_{II} decreases at a uniform rate in region II
c. E_I is constant in region I and E_{II} is constant in region II
d. Nothing quantitative can be deduced about E_I and E_{II}
e. None of the above statements are true

QUESTION 3: RELATING ELECTRIC FIELD AND ENERGY CONSERVATION

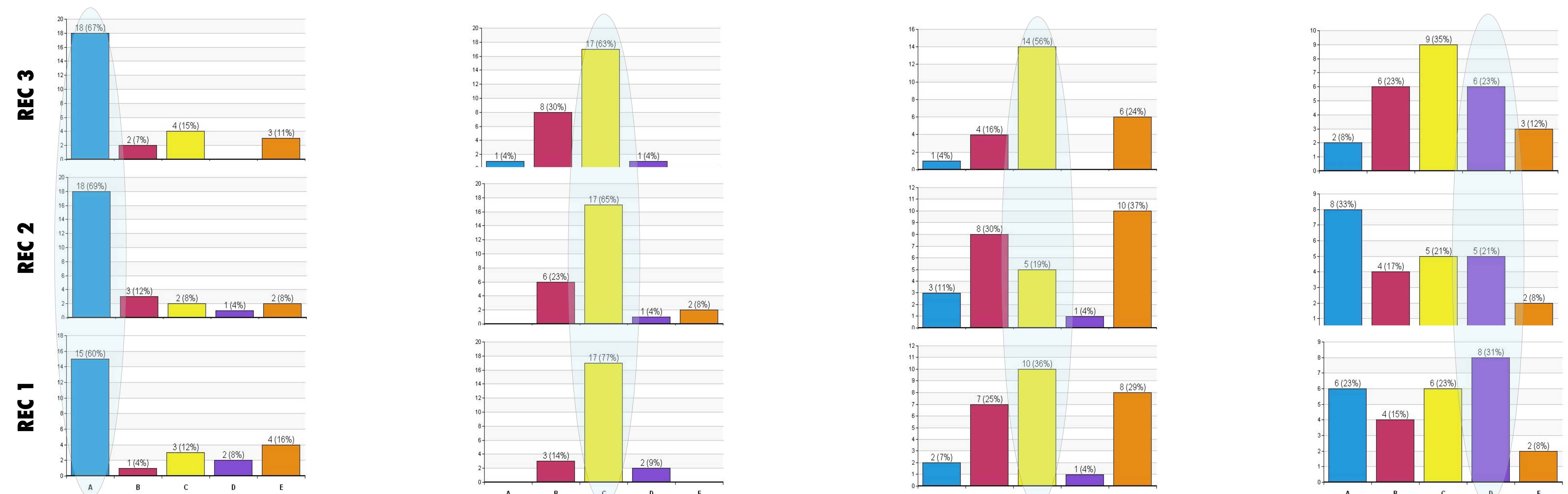
If the initial point is at A, for how many final points do you know $\Delta V = -\int_{r_i}^{r_f} \vec{E} \cdot d\vec{l}$ exactly?

a. 0
b. 1
c. 2
d. 4
e. An uncountably infinite number of points

QUESTION 4: USE CONCEPTS OF QUESTION 1/3 TO FLUSH OUT 2

With initial location A and final location C, can you use $\Delta V = -\int_{r_i}^{r_f} \vec{E} \cdot d\vec{l} = 0$ to deduce any of the following about the magnitudes of the electric fields in region I and II?

a. No
b. $E_I = E_{II}$
c. $E_I/E_{II} = L_I/L_{II}$
d. $E_{II}/E_I = L_I/L_{II}$
e. $E_I/E_{II} = (L_I/L_{II})^2$



EASY – STRONG CONSENSUS → **DIFFICULT - WEAK CONSENSUS**

TIERED AND QUALITATIVE:

- Tiered: questions build off one another, increase in difficulty, and can require synthesizing the principles behind previous correct answers
- Qualitative: most series focus qualitatively on conceptual content while attempting to minimize mathematical stumbling blocks
- Along the way, the teaching assistant engages the students in a guided discussion about the validity and/or shortcomings of each option
  - Explaining the right answer's validity helps engender correct reasoning
  - Addressing wrong answer's shortcomings helps rectify misconceptions
- Changes of representation guard against false positives

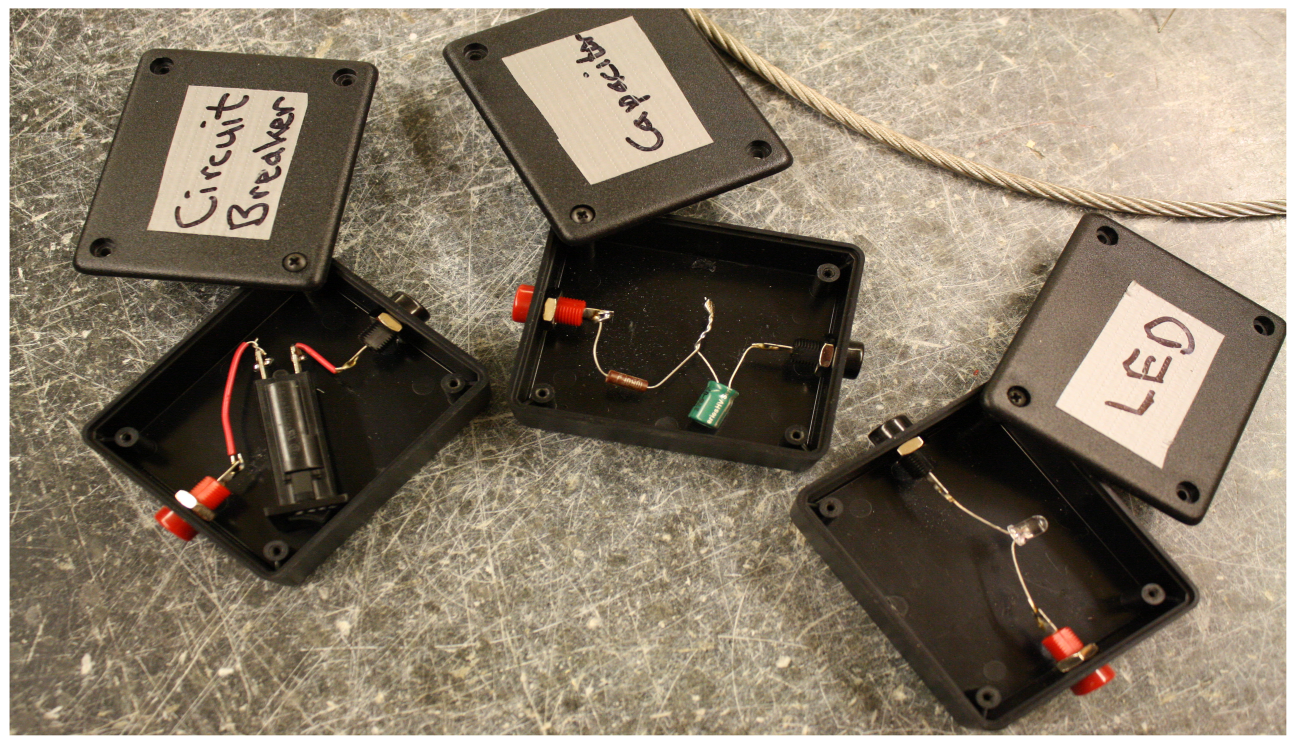
YOUTUBE EXPLANATION | POSTER PDF | CONTACT INFO

OPEN ENDED LABORATORY

MOST PHYS 272 labs transfer knowledge to students through a pre-thought out and working experiment. The primary goal is to convey knowledge about a physical system, the experiment is the tool. This open ended lab reverses that general structure. The goal now is to help students learn how set up experiments; the tool is the knowledge they already gained about circuit components in previous laboratories. Their task is to uncover the identity of ten common circuit components concealed in black boxes but electrically accessible from the outside by two banana clips. *The students decide which experiments will best reveal the identity of the circuit elements.*

The laboratory has three stages where the students progressively have access to better equipment to refine their measurements:
Stage 1: build any circuit
Stage 2: stage 1 plus volt-meter and internet
Stage 3: stage 2/1 plus PASCO power supply and PASCO measuring probes

Three black boxes with their contents labeled:



ACKNOWLEDGEMENTS

I explicitly thank many people who played a hand in this project:

- Professors Lin Ding and Bill Reay for sparking this project by providing some series, which are available at: http://www.physics.ohio-state.edu/~physedu/clicker/
- Mark Palenik and Jason Boomsma for field testing iClicker series in their recitations
- Prof. Darren Craig at Wheaton College for an outstanding course, PHYS 342, in which my abilities to teach Electricity and Magnetism were formed
- Andrew Lewicki for being considerate in scheduling TAs with recitations back to back
- David Sederberg and Gary Hudson for contributing to the black box lab
- Purdue University Department of Physics and Astronomy and Andrew Hirsch for funding this project

References

- Ding, L et al. (2006), Evaluating an electricity and magnetism assessment tool: Brief electricity and magnetism assessment. Physical Review Special Topics - Physics Education Research, 2(1), 010105.
- Marx, J. D., & Cummings, K. (2007). Normalized change. American Journal of Physics, 75(1), 87. doi:10.1119/1.2372468

PURDUE UNIVERSITY