To Click or not To Click

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The Question:

Do clickers show an improvement over cards in students learning the following concepts:
1. Coulomb's force law
2. Magnetic fields caused by currents

Background

PHY 133 is a required course of all physical sciences and engineering majors so the importance of this class cannot be overemphasized. Electricity and magnetism are two most important areas in all sciences and engineering. This course lays the foundation of electricity and magnetism in physics and engineering studies. The materials covered in this course will form the basis for later more advanced courses by covering basic concepts such as static charge, moving charge, voltage, resistance, and current, magnetism and how it relates to electricity.

Physics Education Research has shown that students in introductory physics courses, similar to PHY 133, lack a deep understanding of physics principles and concepts [1]. Students often have difficulty connecting related physics concepts. Through research-based curricula such as peer instruction, and group problem solving conceptual understanding can be improved. Peer instruction techniques involve students in their own learning during lecture and focus their attention on underlying concepts. Lectures are interspersed with conceptual questions called *Concept Tests*, designed to expose common difficulties in understanding the material. The students are given one to two minutes to think about the question and formulate their own answers; they then spend two to three minutes discussing their answers in groups of three to four, attempting to reach consensus on the correct answer. To answer the questions students have a wireless handset, like a TV remote control ("clicker"), which allows them to vote in response to a multiple choice type question posed by their lecturer. The possible answers and a summary of the responses are displayed graphically on a PC screen. Alternately, students can display their answers on cards. **The goal of this project was to evaluate whether clickers have advantage over cards or whether they are an overkill technology.**

Methods

Compare 2 classes:

Class 1, cards are used PHY 133 48 students Fall 06 quarter.

Class 2, clickers are used PHY 133 48 students Winter 07 quarter

Are students using clickers more open towards concept questions and peer instruction method compared to students using cards?

A questionnaire was given to each class to evaluate students' opinions about the benefits of concept based lectures/tests and results are compared between the two classes.

Are the students using clickers learning the concepts better?

A few multiple choice questions from a standard exam used in physics education were included in the final exams research [2] of both class#1 and class#2. The performance of the 2 classes on this portion of the exam is compared.

Conclusions

The survey that was designed to test the student's attitudes towards conceptual questions showed that students using card rather then clickers are showed somewhat more openness towards conceptual questions

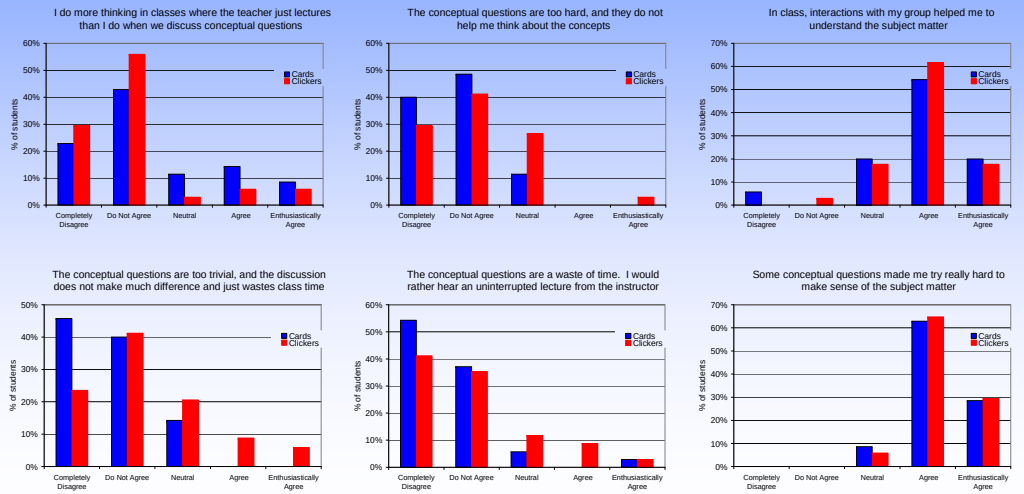
In understanding Coulomb's force law the class that used clickers clearly demonstrated a better grasp of the concept.
The two classes were approximately equal in their understanding of the concept of Magnetic fields caused by currents

It appears that students with clickers learn the concepts better even though they are less amenable to the approach of using concept questions.

References

[1] L. Ding, R. Chabay, B. Sherwood, and R. Beichner Evaluating an electricity and magnetism assessment tool: Brief electricity and magnetism assessment Phys. Rev. ST Phys. Educ. Res. 2, 010105 (2006
[2] D. Maloney, T. O'Kuma, C. Hieggelke, and A. Van Heuvelen, "Surveying students' conceptual knowledge of electricity and magnetism," Am. J. Phys. 69, S12 2001.

Results



Sample questions from the final exam

Coulomb's force law:

Two small objects each with a net charge of +Q exert a force of magnitude F on each other.

We replace one of the objects with another whose net charge is +4Q:

Question 1: The original magnitude of the force on the +Q charge was F; what is the magnitude of the force on the +Q now?
(a) 16F (b) 4F (c) F (d) F/4 (e) other

Question 2: What is the magnitude of the force on the +4Q charge?
(a) 16F (b) 4F (c) F (d) F/4 (e) other

Question 3: Next we move the +Q and +4Q charges to be 3 times as far apart as they were, now what is the magnitude of the force on the +4Q?
(a) F/9 (b) F/3 (c) 4F/9 (d) 4F/3 (e) other

Question 1	A	B	C	D	E
Cards	0%	79%	13%	6%	2%
Clickers	0%	88%	7%	5%	0%

Question 2	A	B	C	D	E
Cards	0%	53%	43%	4%	0%
Clickers	0%	80%	12%	7%	0%

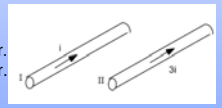
Question 3	A	B	C	D	E
Cards	21%	19%	36%	23%	0%
Clickers	5%	5%	68%	15%	7%

Magnetic fields caused by currents:

Question 8: Wire 1 has a large current i flowing out of the page as shown in the diagram. Wire 2 has a large current i flowing into the page. In what direction does the magnetic field point at position P?
(a) ↑ (b) ← (c) → (d) ↓ (e) none of the above

Question 8	A	B	C	D	E
Cards	68%	6%	11%	11%	4%
Clickers	59%	10%	17%	10%	5%

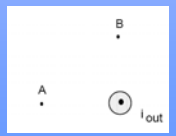
Question 9: Two parallel wires I and II that are near each other carry currents i and 3i both in the same direction. Compare the forces that the two wires exert on each other.
(a) Wire I exerts a stronger force on wire II than II exerts on I.
(b) Wire II exerts a stronger force on wire I than I exerts on II.
(c) The wires exert equal magnitude attractive forces on each other.
(d) The wires exert equal magnitude repulsive forces on each other.
(e) The wires exert no forces on each other.



Question 9	A	B	C	D	E
Cards	0%	38%	32%	19%	11%
Clickers	2%	29%	59%	10%	0%

Question 10	A	B	C	D	E
Cards	72%	0%	2%	19%	6%
Clickers	56%	7%	12%	20%	5%

Question 10: The diagram shows a wire with a large electric current I coming out of the paper. In what direction would the magnetic field be at positions A and B?



	A	B
(a)	↓	←
(b)	→	↓
(c)	↑	→
(d)	←	↑
(e)	None of these	

Acknowledgements

A project from the Investigating Teaching and Learning Faculty Learning Community sponsored by the Faculty Center for Professional Development .