Clickers or Flashcards: Is there really a difference?

N. Lasry, John Abbott College, Montreal, Qc

A growing number of physics teachers are currently turning to instructional technologies such as wireless handheld response systems - colloquially called *clickers*. Two possible rationales may explain the growing interest in these devices. The first is the presumption that clickers are more effective instructional instruments. The second rational is somewhat reminiscent of Martin Davis' declaration when purchasing the Oakland Athletics: *"As men get older, the toys get more expensive"*. Although personally motivated by both of these rationales, the effectiveness of clickers over inexpensive low-tech flashcards remains questionable. Thus, the first half of this paper presents findings of a classroom study comparing the differences in student learning between a Peer Instruction group using clickers and a Peer Instruction group using flashcards. Having assessed student *learning* differences, the second half of the paper describes differences in *teaching* effectiveness between clickers and flashcards.

About Peer Instruction

Peer Instruction (PI) is a student-centered instructional approach developed at Harvard by Eric Mazur[1]. The method has been welcomed by the science community and adopted by a large number of colleges and universities, due among other reasons to its common sense approach and its documented effectiveness[1,2]. A schematic description of the PI method used in this study is shown below (Fig.1).
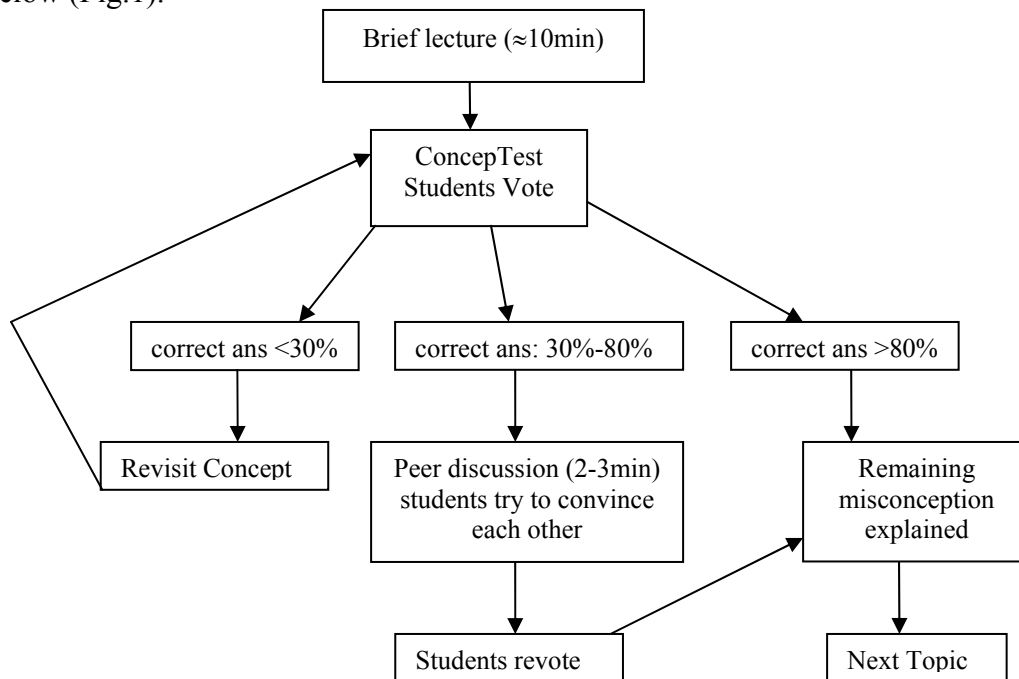

Figure 1 A *Peer Instruction* Implementation Algorithm

In PI, the progression of any given class depends on the outcome of real-time student feedback to ConcepTests: multiple-choice conceptual questions. In the early 1990s, students displayed their answer to ConcepTests using a show of hands and later flashcards. Instructors would then count or estimate the number of students holding each alternative conception. Due to the tediousness of counting flashcards in large enrolment courses, flashcards were replaced with wired classroom communication systems[3] and later with wireless clickers.

Study Description

First-semester students in a two-year Canadian public community college were randomly assigned by the registrar to one of two sections of an algebra-based mechanics course. Instruction in the fist section consisted of PI with clickers (n=41) while the other followed PI with flashcards (n=42) to respond to in-class ConcepTests. Both sections were taught by the author, followed the same course structure and content (using 3-4 ConcepTests with peer discussion in each class) and had the same laboratory component.

Conceptual understanding was measured in both groups during the first and last week of the semester with the Force Concept Inventory[5]. Also assessed were students' final exam scores on the college's very traditional final examination. This exam was constructed by a committee of physics instructors (none of which were involved with this study) and had to be approved unanimously by all those teaching the course (10-12 instructors). Note that the other ten groups of this cohort did not use PI and a comparison with these groups will be the topic of a separate paper. Each instructor marked a single exam question for the entire cohort (n ≈ 500; not just for his or her students n ≈ 40). This insured that no group had an exam of a differing difficulty, or a corrector of different generosity. Furthermore, the correctors of the exam questions were unaware of which students belonged to which treatment condition.

Results: comparing clickers to flashcards

To determine the difference in learning between clickers and flashcards, the FCI pre-test, FCI post-test, FCI normalized gain[6] and exam data are compared for both PI groups below:

Table 1
The effect of clickers: difference in learning data between flashcard and clicker groups

	PreFCI /30	PostFCI /30	g	Exam (%)
Clickers (n= 35)	**11.9**	**19.9**	**0.486**	69.8
Flashcards (n=34)	**13.6**	**21.3**	**0.520**	71.6
t-test (2-tailed) p	0.209	0.351	0.745	0.630

Both groups do not differ significantly in FCI score at the beginning of the semester (p=0.209) or at its end (0.351). These results show that the use of clickers does not add to the amount of conceptual learning or to exam performance. Indeed, although clickers have been reported to have a motivating influence, over the course of a semester no significant differences were found in conceptual learning gains (p = 0.745) nor in traditional examinations (0.630). This implies that PI is an effective instructional approach that is independent of the use of technology such as clickers.

Lack of difference in learning

These data show that clickers do not provide any additional learning benefit to students. Previous users of clickers in university classrooms have reported benefits such as increased rates of attendance and decreased rates of attrition[4]. However, no data was found in this study to support the claim that clickers increase conceptual learning or exam performance. PI is a pedagogical approach that emphasizes basic concepts, has students commit to a conception, provides a setting for peer discussion and has instructors explicitly address misconceptions. The technology by itself is not the pedagogy. But if clickers don't add to learning, what is their contribution?

Description of teaching differences

The contribution of clickers is more on the teaching side than on the learning side of the educational equation. For instance, whereas flashcards require taking class-time to tabulate responses or estimate answer distributions, clickers allow instructors to automatically get precise real-time student feedback. A few other differences can be identified between clickers and flashcards such as: archivability of student responses, the appeal of technology, and institutional expense.

Archiving student response data

Using clickers also allows instructors to archive all the data relative to students' answers of in-class ConcepTest. Beyond data analyses and research questions that can be later addressed, these data can be used instructionally to sort out useful ConcepTests from those that work poorly. Furthermore, ConcepTests of questionable effectiveness could be reformulated and a core set of questions can evolve from one semester to another. Flashcards do not enable the instructor to automatically archive any ConcepTest related data. Thus, reusing the same flashcard questions from semester to semester may differ in effectiveness from using clicker questions that have been modified from one semester to the next.

The appeal of technology

Clickers have contributed to the spread of the PI approach[7]. Many instructors, including myself, have adopted the PI approach due to the appeal of using this technology in their classrooms. Using PI with clickers however forces instructors to reconsider their teaching, focus on concepts and thus fundamentally reshape their instruction. Therefore, the presumption that using clickers is more effective turns out to be true if one moves from traditional instruction to PI with clickers.

Institutional expense

Some instructors may be aware of PI methodology and willing to reshape their instruction to provide greater focus on basic concepts. Yet, the capital expense for the purchase of clickers and related hardware may not be available and passing the expense onto the students may not possible or desirable. As PI is effective regardless of the method used to obtain feedback from students, in this instance PI should be implemented with flashcards.

Conclusion

Clickers are usually used in the classroom to enhance *teaching* and *learning*. From a *teaching* perspective, clickers have a number of very practical advantages: they allow instructors to get precise real-time feedback and store students' responses to ConcepTests. Furthermore, using clickers draws attention to PI and requires instructors to shift their focus towards conceptual instruction. From a *learning* perspective, using PI with clickers does not provided any significant learning advantage over low-tech flashcards. PI is an approach that engages students and challenges them to commit to a point of view which they can defend. The pedagogy is not the technology by itself.

References

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