USING CLICKERS: EXPERIENCES IN INTRODUCTORY STATISTICS COURSES

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Clickers. Classroom response system technology enables immediate feedback to students and instructors about student understanding. The technology includes a handset (a.k.a., a *clicker*) that allows each student to respond, anonymously, to a multiple choice question. Software records the student's response and offers a bar graph display of the entire class' response distribution. According to the literature (Caldwell, 2007; Cline, Zullo, & Parker, 2007; EDUCAUSE Learning Initiative, 2005), instructors use clickers in their classes

- to assess student preparation and ensure accountability;
- as diagnostic assessment;
- to incite discussion and debate;
- to lead students through multi-step processes;
- as a review tool.

While no instructional strategy is perfect, clickers can

- be used for almost any class size (Liu, Liang, Wang, & Chan, 2003);
- lead to cognitive gains through increased student engagement in active learning and affective gains including increased student attendance and enthusiasm (Duncan, 2005; Mazur, 1997); and
- allow students to become aware of their own misconceptions (EDUCAUSE Learning Initiative, 2005) and to feel more comfortable knowing that they are not alone with those misconceptions (Caldwell, 2007).

An extensive body of literature and other resources about clickers has been gathered by Derek Bruff and is available at http://www.vanderbilt.edu/cft/crs.htm.

Our project. We have assembled a multi-disciplinary team of faculty to develop and pilot a starter set of annotated multiple choice questions for use with clickers in introductory statistics courses. Based on a decade of experience in physics education, Crouch and

> The five-number summary for all student scores on an exam is 29, 42, 70, 75, 79. Suppose 200 students took the test. How many students had scores between 42 and 70?
>
> (A) 25 (B) 28 (C) 50 (D) 100

Explanations

Note: The five-number summary represents the min, 25th percentile, median, 75th percentile, and max, respectively and in order. Since 42 is the 25th percentile score and 70 is the median score, then 25% must have had scores between 42 and 70.

(A) 25 is the percentage of the sample of scores that is between 42 and 70, but the question asks for the number (not percentage).

(B) 28 is the difference between 42 and 70, which does not give the number of students.

(C)* correct – 25% of n = 200 students is 50.

(D) As 70 is the median, there are 100 students whose scores are below 70.

Field-Testing

[Spring 2007] In a calculus-based, upper division class that serves engineering/natural science, the instructor gave this question twice, with student-student discussion in between. The two response distributions were

Take 1				Take 2		
(A)	15	56%	Student-Student Discussion	(A)	0	0%
(B)	1	4%		(B)	0	0%
(C)*	11	41%		(C)*	25	93%
(D)	0	0%		(D)	2	7%

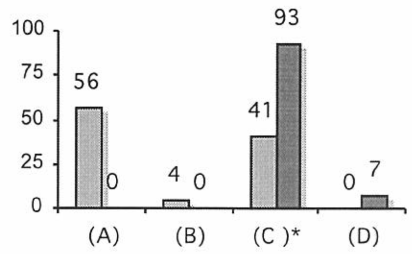


Figure 1: An example of an item and its annotation.

Mazur (2001) assert that

> appropriate [clicker questions] are essential for success. They should be designed to give students a chance to explore important concepts, rather than testing cleverness or memory, and to expose common difficulties with the material. For this reason, incorrect answer choices should be plausible, and, when possible, based on typical student misunderstandings. (p. 974)

Our team has generated some items from scratch and adapted others from existing sets (e.g., http://data.gen.umn.edu/artist/). Statistics topics covered by our project include: confidence intervals and hypothesis testing, correlation and regression, descriptive statistics, measurement, probability, probability distributions, sampling, and tables. To date, most of our items emphasize conceptual understanding, but some emphasize computation. Our questions emphasize formative assessment (rather than summative assessment such as quizzes/tests, which clickers can also be used for) that instructors can use to make decisions about how to proceed with instruction.

We have piloted items in algebra-based (housed in Psychology) and calculus-based (housed in Mathematics and Meteorology) introductory statistics courses. We have also been constructing annotations that include explanations for the correct and incorrect responses, experiences with field-testing, suggestions for instructional decisions, and other results as appropriate and informative. Figure 1 above shows an example of an item and its annotation. We have used the following process for vetting items and annotations:

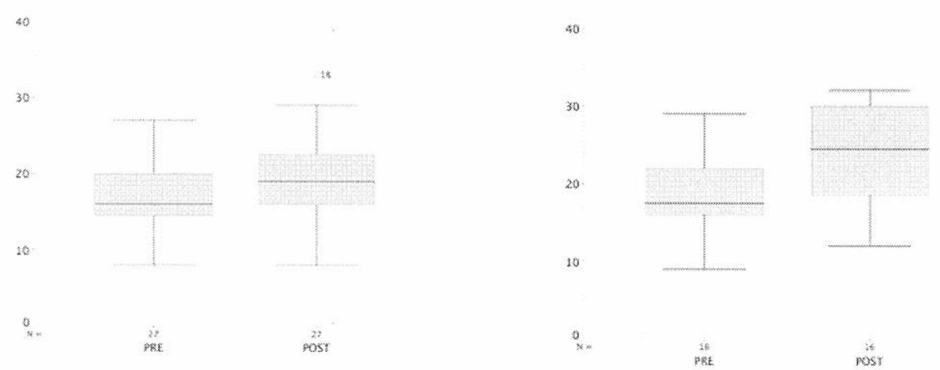
1. Discuss draft of item and its annotation during a group meeting.
2. Edit the item and its annotation.
3. Assign an ID number to the item (e.g., 0022v01), add it to PPT and Word files.
4. Use the item (as appropriate) in class.
5. Debrief class use during a group meeting.
6. Revise the item.

We have used clicker questions to introduce a topic; to assess mastery of a topic before moving on to new topics; to review a topic -- the next class session or before a test; and to generate discussion -- some questions may not have a best answer.

Technology issues. At OU, faculty in a number of departments (Botany & Microbiology, Chemistry, Mathematics, Meteorology, Physics & Astronomy, Psychology, Zoology) have been engaged in conversations about adopting only one system so that students do not need to purchase multiple clickers. Such attempts to coordinate technology use lead to constraints such as the need for a system that accommodate 350 students in a Physics lecture (which rules out TI-Navigator) but that allows more than five responses in multiple-choice questions for our statistics project (which rules out iClicker). Even with a system selected (to date, H-iTT), we have had considerable trouble making sure that interested instructors are assigned to rooms with the equipment. That problem makes

Radio Frequency technology very attractive, but a change in the technology goes back to the question of coordinating across courses with different instructors. We have also had software complications ranging from the need for adapters and drivers for those adapters (e.g., KeySpan) to cross-platform issues (some instructors use Windows, others use Mac OS X) to the inability to figure out how to extract relevant student-level data from the records stored in the proprietary software.

Student learning. With any instructional technology come questions of impact on student learning. As one gauge of student learning, we have administered the Statistics Concept Inventory (https://engineering.purdue.edu/SCI) as a pre- and post-test, a 38-item multiple choice test developed under a grant from the National Science Foundation (NSF 0206977). Figure 2 shows SCI data for two classes (only students who signed an OU-NC IRB-approved informed consent form). We have been happy to see overall gains from



Left boxplot

n=27	$\bar{x}$	s	min	Q1	median	Q3	max
pre	16.7	4.4	8	14	16	20	27
post	19.5	5.5	8	16	19	23	33

Right boxplot

n=16	$\bar{x}$	s	min	Q1	median	Q3	max
pre	18.6	5.7	9	16	18	23	29
post	23.9	6.9	12	17	25	30	32

Figure 2: Pre-/Post-Test Summary Statistics in Two Classes (Fall 2007)

pre- to post-test. Unfortunately, however, we can not attribute these gains to the use of clicker questions. Examples of confounding variables include use by some instructors of small group work on non-clicker questions and use of real data and computer software (see the recommendations in Garfield et al., 2005).

Next steps. As we finish the second year of the grant and enter a no-cost extension year, we will continue to develop items and annotations, including more informative instructional notes. We hope in the future to involve additional instructors and to conduct additional research that will specify the impact that various uses of clicker questions have on student learning.

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