

**Understanding the Components of the iClicker System that Promote Learning,  
Retention, and Generalization of Knowledge  
Chancellor's Fellowship for Excellence in STEM Education Progress Summary**

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**Project Summary**

The objective of this project was to systematically evaluate which components of the *iclicker* system influence the cognitive mechanisms that support learning. In the original proposal, both teaching-relevant and student-relevant mechanisms and the components each were outlined. The primary teaching-relevant mechanism was *assessment* of students' knowledge. The components of assessment that were outlined included a) appropriate spacing of clicker questions relative to the original presentation of lecture material and b) a consideration of the type of information being taught, such as factual knowledge, which is declarative, or skill-related knowledge, which is procedural, because different types of information react differently in terms of how it is retained over time and applied to novel situations (Healy, 2007; Healy & Bourne, 1995). The primary student-relevant mechanisms were *testing* and the utilization of *desirable cognitive processes*, both of which encourage deeper learning. The components of testing that were outlined included a) the type and timing of feedback following clicker questions and b) the level of abstraction of tested material, both of which have been shown to be mediators of learning. (For a discussion on the effects of testing with *iclickers*, please see Anderson, Healy, Kole, & Bourne, 2010). The component that was proposed to encourage the utilization of desirable cognitive processes with the *iclicker* was generation of question answers, as opposed to the current recognition-based format of multiple-choice clicker questions.

The work undertaken during the funding period thoroughly addressed the core mechanism of **assessment**, which has important implications for both instructors and students. Specifically, the learning effects of feedback delivered following clicker questions were examined. The *iclicker* system offers a unique feature that allows the distribution of students' selections to each multiple-choice alternative to be immediately displayed following clicker questions. The work conducted during the funding period examined whether or not displaying student response distributions during feedback helped or hindered learning, specifically in cases where the majority of the class selects a particular incorrect alternative. In such cases it was predicted that displaying distributions might help learning if the distributions served an awareness function, through increasing awareness of misconceptions, in turn avoiding future errors due to those misconceptions (e.g., Lilienfeld, 2010). Alternatively, the distributions might serve as a salient distractor by drawing focus to an incorrect alternative, in turn hurting learning, perhaps through social influence (Asch, 1955), by highlighting incorrect lure alternatives (e.g., Butler & Roediger, 2008), or purely through visual attentional capture (e.g., Yantis & Jonides, 1990).

**Experimental Design**

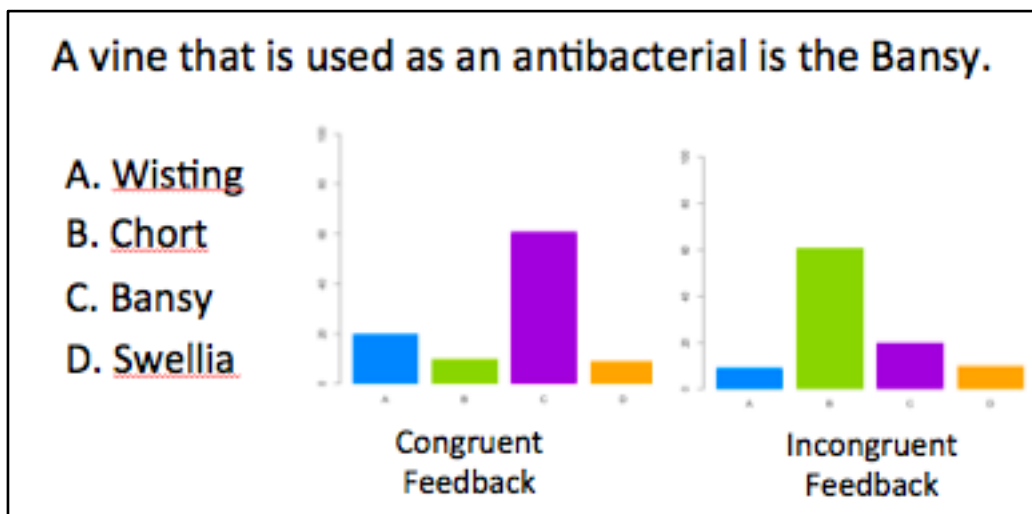
To empirically test the latter two predictions, we conducted three laboratory experiments, which varied the type of response distributions delivered during feedback. The overall design was a 3(feedback distribution condition) x 2(train vs. test) x 8(block)

repeated measures factorial. Three primary feedback distribution conditions were compared: (a) congruent distribution, (b) incongruent distribution, and (c) no distribution. In the congruent distribution condition, corrective feedback was paired with a distribution depicting that the correct answer was the popular choice. In the incongruent distribution condition, corrective feedback was paired with a distribution depicting that an incorrect answer choice was the popular choice. The no distribution condition served as a control, which provided corrective feedback, as in the other 2 conditions, but without displaying any distribution.

### General Procedure

Participants learned several sets of 8 facts about plants from 8 different categories and were tested on their ability to remember those facts. All participants were tested individually, however, multiple participants were tested simultaneously, and participants were aware of this upon entry to the experiment. Before starting the experiment, participants were informed that they may see graphs, and that these graphs reflected the number of other participants that selected each answer choice on a given question. During training, there were 8 study-quiz rounds. After each study block, participants were given a multiple-choice test over the facts presented within the most recent study block. Participants were given the fact stem (i.e. the whole fact minus the target name of the plant) followed by a blank, and were to select the appropriate answer among 4 alternative answer choices. Participants were given 9 s to make their selection. Immediate feedback was provided for 9 s after each quiz question. Participants were always given corrective feedback in the form of the multiple-choice quiz question, but with the plant name filled in. When participants were done with the learning phase, they completed a 10-minute distractor task. Following the distractor task, participants completed a final multiple-choice test of all 64 facts, without the opportunity for prior study and without corrective feedback in order to assess the effects of the feedback delivered during learning.

### Visual of Corrective Feedback and Potential Response Distributions



## Results and Implications

Data were collected from a total of 144 participants in three phases. Data were analyzed using an analysis of variance (ANOVA). Of primary interest was final test performance. Post-hoc pairwise comparisons revealed that test performance was significantly worse for items that were paired with incongruent distributions at feedback than for both items paired with congruent distributions and no distributions at feedback. This result supports our salience hypothesis, which predicted that response distributions would negatively impact learning. No differences in test performance were found between items that were paired with congruent distributions and no distributions at feedback, demonstrating that the distributions do not play a facilitatory role during learning. The implication of these results for instructors is that when delivering the results of iclicker questions, if the majority of the class selects a particular incorrect multiple-choice alternative, it is better to withhold displaying the response distribution because doing so can negatively affect students' memory of the correct answer.

Interestingly, the results revealed an effect of study-quiz block, such that performance improved across the 8 blocks during learning (performance at test reflected a similar pattern). Because each fact was only presented once during each phase, this improvement cannot reflect learning due to repetition. Instead, we propose that this improvement across blocks might reflect an improvement in the learning process itself. Given that feedback was in fact the only aspect of the learning process that was affected by our experimental manipulation, it is possible that participants were learning how to utilize and incorporate feedback. Ongoing analyses are being conducted in order to more finely examine the effects of response distributions on the likelihood of an individual being swayed to the popular incorrect alternative as a function of their performance accuracy during learning.

## References

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