

FINAL REPORT

to the University of Massachusetts Information Technology Council

Subcommittee on Academic Technology

PROJECT TITLE: Using Remote Response Technology to Enhance and Understand Learning in a Large Classroom: An Empirical Investigation

PROJECT CATEGORY: Scholarship of Teaching and Learning

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Original Objectives and Strategies, and Revisions to Same

The goal of this work was to gain a better understanding of the cognitive mechanisms underlying the learning effects of remote response technology (RRT). Specifically, there are two competing explanations for why RRT improves students' test performance. The first possibility is that the RRT questions merely highlight important ideas for students. In other words, the effect may come about by prompting students to direct attentional resources to specific items during class and in subsequent study. The second possibility is that retrieval is acting as a source of memory encoding. Known as the *testing effect*, it has been well documented that the act of recalling a piece of information can strengthen it in memory (Roediger and Karpicke, 2006). As such, it is highly possible that asking students to retrieve a piece of information in the moments just after encoding serves to reinforce that memory for students. If the testing effect is the source of RRT's effect on test performance, it would mean that RRT technology offers a true learning advantage rather than mere flagging or study prompts. Such a result would be important to our understanding of both learning theory and pedagogical practice.

To test the merits of the attentional resource and testing effect hypotheses, I developed 2 types of in-class activities: RRT questions and non-RRT presentations designed to highlight the importance of and draw attention to the target material. These items formed the RRT and Flagging conditions, respectively. Descriptions and/or sample in-class activities for each condition are provided below:

RRT: The information was presented in class and appeared on a Powerpoint slide. A RRT question was presented. (e.g., Information presented in class about punishment was followed with this RRT question: *Which of the following is true about punishment (A) Punishment is most effective if it always immediately follows the behavior; (B) Punishment works by reducing an undesired behavior; (C) Punishment can be ineffective if a big enough reward can be had by producing the behavior in question; (D) All of the above.*)

Flagging: The information was presented in class and appeared on a Powerpoint slide. It was highlighted in red font and pulsed several times. In addition the professor emphasized its importance by saying, “This is important. It is likely to be on the test.” In the punishment example, the relevant information about punishment on the slide pulsed red and the professor told the class the information was important and would be on the test.

Each presentation condition was tested for its effect on targeted test question performance. For the sample material on punishment provided above, the test item was: *Punishment is most effective if (A) it immediately precedes the operant; (B) it consistently follows the operant; (C) it occasionally follows the operant; (D) there is considerable delay between the operant and the punishment.*

Presenting the two activities for each test item in alternate semesters removed potential error stemming from differences between classes or items from the analysis. If the effect of RRT on test performance is due solely to attentional flagging, students should perform better on test items when they are flagged as important. However, if RRT’s effectiveness stems from the testing effect, students should do as well or better on test items when relevant information was

targeted by in-class RRT questions. The important comparison, then, was between performance on test items when the relevant information was targeted by flagging versus RRT questions.

Activities Carried Out

The work described in the previous section was the same as that proposed in the funded application and was all conducted in the 2008-2009 academic year. However, I did add two additional components to the work after it was funded. The first was a replication of prior work showing the effectiveness of RRT. In that study, a series of RRT questions were introduced for a group of targeted test questions. Half the RRT questions were presented in each semester. No special presentations or manipulations were included for the material relevant to each test question in the semester the RRT item was not presented for a given test item. In other words, performance on each test item was compared when students were presented with content-relevant RRT questions versus a “do nothing” control condition. I included this for two reasons. First, it was important to show that I could demonstrate RRT learning effects in my classroom in order to validate the proposed work. Second, the methodology of controlling for item differences by alternating RRT and control conditions between semesters for single test items is new. It was important to establish its efficacy.

The second addition to the project was a survey of class opinions about their learning experience. Unconscious cognitive processes drive the testing effect. As such, if the testing effect is at work with RRT, students should have no conscious awareness of its role.

Alternatively, directing students’ attention to material identified as important in the course and targeted on a test should result in fully conscious decisions to study that material. Therefore, it was informative to ask students their impressions of what helped them perform well on the test

and what guided their decisions about what to study. Moreover, if the RRT questions work because they alert students to important information to study, they should report a high incidence of directing their study efforts based on RRT question content. The questions relevant to this issue were the following:

- *How much did using the iClicker help you learn and remember the class material?*
- *How much did the highlighted facts on the slides indicating important material help you learn and remember the class material?*
- *How much did the professor's spoken emphasis indicating important material help you learn and remember the class material?*
- *How much did using the iClicker guide your decisions about what to study for the tests?*
- *How much did the highlighted facts on the slides indicating important material guide your decisions about what to study for the tests?*
- *How much did the professor's spoken emphasis indicating important material guide your decisions about what to study for the tests?*

Deliverables

No material product was generated from this work, as it was always intended as basic research. However, it did produce some exciting and very interesting results that I believe will make an important contribution to the field both theoretically and in terms of practical application.

Assessment

Experiment 1: RRT Learning Effect Replication

Prior studies demonstrating the learning effects of RRT were replicated by the present results. The average percent correct on each item targeted with RRT questions was 70.7% while the same items, when used in the control condition with no special attention paid to the material had a mean of 63.2% correct. This difference is statistically significant, $t(15) = 5.83, p < .01$. In real terms, performance on these test items rose by just under 12% when RRT questions were offered in class.

Experiment 2: Testing Effect versus Attentional Flagging

The role of the testing effect was strongly supported by the results. When students were told a fact was important and would be included on the test, they scored an average of 64.7% on the test items targeting that material. When they were not told the material was of particular importance but were given RRT questions to answer in class about the material, they scored 68.8% correct on the same items. This is a performance improvement of 6.3% over the flagging condition on the same test items. The difference was statistically significant, $t(15) = 2.49, p < .05$. In other words, telling students that a specific piece of information would be on the test was

significantly less effective in raising test performance on the material than was asking them to retrieve the information from memory in class with a RRT system.

Class Survey Results

Students reported that answering the RRT questions was slightly less than moderately helpful in learning the material, as the average rating was 2.85 on a 1-5 scale for how effective they were in helping learn the material. The slides' emphasis and professor's verbal emphasis were rated as having significantly more impact on learning than the RRT questions. The means were 3.38 and 3.69 for slide and professor emphasis, respectively. The differences between RRT ratings and both forms of emphasis ratings were statistically significant, $t(274) = 7.18, p < .01$ and $t(274) = 10.41, p < .01$, respectively.

Survey questions also probed students for information about what guided their decisions about what to study. If RRT questions were effective due to flagging, one would expect that students would have been using that information to direct their efforts during study. Student responses, however, indicate this is not what happened. Students rated the highlighted information on the slides and the professor's verbal remarks higher (3.85 and 4.25, respectively) than the RRT questions (3.04). Again, the differences between RRT ratings and both emphasis ratings were statistically significant, $t(274) = 11.34, p < .01$ and $t(274) = 17.73, p < .01$, respectively.

In summary, the present work has demonstrated that (1) RRT is an effective classroom learning tool, (2) RRT produces real learning effects rather than mere hints at study strategies and (3) the learning effects are largely unconscious, as students are not highly aware of their role in enhancing learning.

Issues and Further Questions

A number of issues based on the present results are ripe for further work. It would be interesting to know if there is an upper limit to the number of RRT questions that can be offered in a class before their effectiveness wanes. Also, the present work was conducted using simple, factual material. A number of published studies indicate that RRT questions can be used to foster deep comprehension and problem solving ability. Because the testing effect targets factual memory, it isn't likely that the effect on "deeper" learning and skills is due to the testing effect. Thus, it would appear other cognitive processes underlying those skills are also tapped by RRT. The identity of those processes is still a mystery, as yet, and are important to bring to light.

Disposition of funds.

All funds were paid out in summer 2008, as scheduled.