

# When Talking Is Better Than Staying Quiet

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**Abstract.** The effectiveness of Peer Instruction is often associated to the importance of in-class discussions between peers. Typically, a greater number of students have correct answers after peer discussions. However, other cognitive and metacognitive processes such as reflection or time-on-task may also explain this increase because students answering conceptual questions reflect more and spend more time thinking about their understanding. An identical sequence of conceptual questions was given to three groups of students. All groups were polled twice on each question. Between polls, students were asked either to discuss their choice with a peer, or to reflect for a minute (no discussion), or were given a distraction task (sequence of cartoons: no discussion and no reflection). Increases in the rates of correct answers between the first and the second poll were found across all conditions. The 'Distract' condition had a small but positive increase (3.4%). The 'Reflect' condition had a greater increase (9.7%) while the 'Discuss' condition had the greatest (21.0%). All conditions showed gains, possibly because of 'testing effects', though peer-discussions clearly yield greatest increases. Our findings show that learning gains through peer discussions cannot be explained only by additional time-on-task or self-reflection.

**Keywords:** Peer Instruction, discussion, reflection, distraction, poll.

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## INTRODUCTION

Peer Instruction (PI) is an instructional strategy developed by Eric Mazur at Harvard in the early 1990s [1,2]. In PI, the instructor lectures briefly and then presents students with a multiple-choice conceptual question [2]. Having committed to an answer, students are typically asked to turn to their neighbor and try to convince them of their answer: the *peer instruction per se*. Previous work has shown that instructors implement PI in various ways [3] with some instructors polling students on conceptual questions but without asking students to discuss between peers after the initial poll [4]. One may argue that peer discussions are useful because rates of correct answers typically increase after discussions. Although this learning gain is implicitly ascribed to peer discussions, it is possible that students arrive more frequently at a correct answer after discussion because they are given more time to work on the concept or because of their own individual reflective process, independently of the peer with whom they discuss. Furthermore, it has been shown that testing is not a 'read-only' procedure. Repeated testing increases learning and retention, a

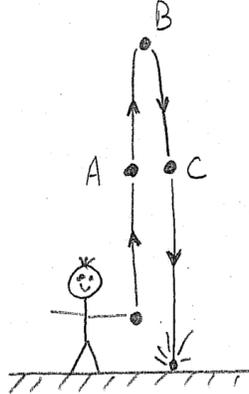
process that has been termed the 'testing-effect' [5]. Through the 'testing-effect', one would expect students tested twice to migrate towards the correct answer. We investigate whether instructions requesting different cognitive tasks between polls on a conceptual question might influence learning and determine the effectiveness of peer discussions in PI.

## STUDY DESIGN

The participants were three sections ( $n=24$ ,  $n=30$ ,  $n=32$ ) of a college-level algebra-based introductory physics course [6]. Each group was made up of science majors between the ages of 17-19 with similar distributions of male and female students. Pretest results using the Force Concept Inventory (FCI) [12] showed no statistical difference between the three groups' understanding of Newtonian concepts ( $M=9.8$ ,  $M=9.1$ ,  $M=11.5$ ;  $p>0.1$ ).

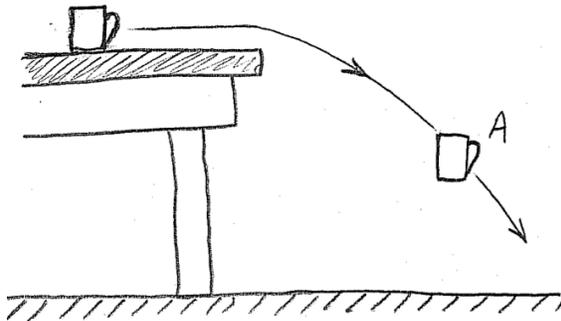
An identical sequence of nine multi-choice questions was given to each of the three groups during a 90-minute class in the first week of the school year.

The activity was framed as part of an introduction to using clickers. All nine questions were conceptual in nature (see Figures 1 and 2). Six questions polled students about the magnitude and direction of a ball tossed upwards when at its maximal height (point B) and at midpoints on the way up or down (points A, C).



**FIGURE 1.** All students were shown this drawing of a ball thrown upwards. Six conceptual questions were posed: Three on the magnitude of the ball's acceleration at point A, B and C and another three on its direction at those points.

Another three questions polled students using the drawing in Figure 2 below. Students once again were asked about the magnitude and direction of the acceleration of the mug falling off the table. The final question asked students if an empty mug would fall closer, farther or the same distance from the table.



**FIGURE 2.** All students were shown this drawing of mug sliding off a table. Three conceptual questions were posed: 1) the magnitude of the ball's acceleration at point A; 2) its direction 3) how close to the table would an empty mug would fall in comparison to a full mug.

All students were polled twice on each of the nine questions. However, different tasks were assigned to the respective groups between the first and second polling - students were either asked to discuss, reflect or were distracted (e.g., distracted by the display of a sequence of science-inspired cartoons).

In all conditions, no polling results were shown until the end of sequence of nine questions because students could have changed to the correct answer by looking at polling results. This would have prevented us from isolating the change due to peer-discussions, self-reflection or distraction.

### Group 1: Peer Instruction

In the first treatment group students were asked to record their answer, for each of the nine multiple-choice conceptual questions, using individually assigned clickers. Once the vote was recorded, students were asked to turn to their neighbor and discuss their answers to the question, (i.e., peer-to-peer discussion between polls). In each case, the discussion was allotted approximately a minute and students were given 60 seconds to re-enter a vote. This treatment followed the traditional Peer Instruction format with an initial poll followed by a peer discussion and then another poll [1,2]. Polling results were shown (and discussed) only after the full nine-question sequence.

### Group 2: Reflection-Distraction

In the second treatment group, students were given the same sequence of 9 multiple-choice questions as the first group with no polling results shown until the end of the sequence. On 5 of these 9 questions, after students were asked to vote, they were instructed to reflect individually on their answer for 60 seconds (i.e., not turn and discuss). At the end of the minute, students were given 60 seconds to re-enter a vote on the same question. For the remaining 4 questions, these students were asked to choose their answer, however, instead of reflecting on their answer during the 60-second interval between votes, they were given a distraction task (e.g., sequence of 'funny' science cartoons). Students were then re-polled on the same question and had 60 seconds to re-enter a choice. The possibility of reflecting on the concepts was reduced by the distraction task given to students between polls although students were given the same amount of time as when they had been asked to reflect.

### Group 3: Distraction-Reflection

Students in the third treatment group were given the same set of 9 conceptual questions as the two other groups with no polling results shown until the end of the sequence. The treatment was identical to group 2 except for the fact that the order of reflect and distract were reversed - i.e., students were distracted on the first 5 questions and reflected on the last 4. In doing

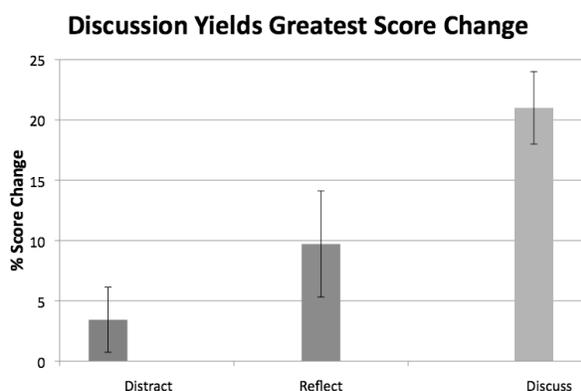
so, this group was asked to reflect on the half of questions that treatment group 2 was distracted on.

Note that the Peer Instruction group and was not distracted or asked to reflect on a portion of the questions. This methodological gap is due to the fact that in classroom settings, when students are given the possibility to discuss, it is excessively difficult to prevent them from discussing afterwards. Hence, no distraction or reflection tasks were assigned to this group that was initially asked to discuss.

A cross design was used so that both reflection and distraction conditions would be used with every question in different groups. Using reflection and distraction on every question enabled us to control for individual question difficulty. Asking one group to reflect on the first half of questions while the other group was asked to reflect on a second half, allowed us to isolate the change due to reflection (or distraction) while controlling for individual student differences.

## RESULTS

In figure 3 below, the average change in score between both polls is shown. We find increases in correct answers in 'Distract', 'Reflect' and 'Discuss' conditions. The 'Distract' condition had a small but positive increase (3.4%). The 'Reflect' condition had a greater increase (9.7%) while the 'Discuss' condition had the greatest (21.0%). The error bars shown represent the standard error.



**FIGURE 3.** Average change in percent of correct answers between consecutive polls on the same conceptual questions. Error bars represent standard error [7]. Between polls, students were either asked to 'Discuss' their choice of answer with their peers or were asked to 'Reflect' individually (no discussion) or were given a 'Distraction' task (no discussion and no reflection). All conditions increased in rates of correct answers when re-pollled on the same question with 'Discuss' condition increasing the most.

## DISCUSSION

All conditions had increases in rates of correct answers, including increased rates of correct answers on questions where students had been distracted between polls. Such increases may be due to the 'testing-effect' recently published in Science [5]. Tests are conventionally used to 'read' students' knowledge. Yet, testing is not a read-only procedure because testing itself can aid learning; an effect that could be attributed to neural mechanisms such as memory reconsolidation [8] and the impact of reconsolidation on providing multiple traces into memory to maximize retrieval [9]. Testing effects suggest that instructors should rethink the use of tests in general and concept tests in particular so as to view these as important pedagogical tools, not just passive assessments of students' knowledge. Although simply re-polling students in-class on conceptual questions yields increases, peer-discussions provides the greatest increases in rates of correct answers.

The greatest increases in rates of correct answers found with peer discussions can be linked to previous work showing that peer discussions matter, even if no student in the group knows the correct answer [10]. Indeed, in a recent study published in Science, Smith *et al.* have shown that peer discussions result in increased performance even if no one student in the group knows the correct answer at the beginning of a discussion. Our results confirm the notion that peer discussions are important and play a central role in Peer Instruction.

This finding is of interest in light of the recent survey by Melissa Dancy and Charles Henderson of physics instructors' use of research-based instruction. This survey showed the wide variability of ways that PER-based approaches such as Peer Instruction are used. In fact, they report that less than 15% of the physics teachers using Peer Instruction do so as it was designed to be implemented [11].

The results of this current study confirm that the strength of Peer Instruction lies in the discussions between peers and not only in other metacognitive processes that may occur along the way, specifically self-reflection. As such, future efforts to improve the implementation of Peer Instruction should note that peer discussion must continue to be a principled part of this approach.

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