

Why peer discussion improves student performance on in-class concept questions

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Abstract

When students answer an in-class conceptual question individually using clickers, discuss it with their neighbors, and then re-vote on the same question, the percentage of correct answers typically increases. This outcome could result from gains in understanding during discussion, or simply from peer influence of knowledgeable students on their neighbors. To distinguish between these alternatives in an undergraduate genetics course, we followed the above exercise with a second, similar (isomorphic) question on the same concept that students answered individually. Our results indicate that peer discussion enhances understanding, even when none of the students in a discussion group originally knows the correct answer.

In undergraduate science courses, conceptual questions that students answer using "clickers" are promoted as a means to increase student learning (e.g. 1, 2), often through Peer Instruction (PI) (3). Students are first asked to answer a question individually; a histogram of their responses may be displayed to the class, and then they are invited to discuss with their neighbors and then re-vote before the correct answer is revealed. Most instructors report that the percentage of correct answers, as well as students' confidence in their answers, almost always increase after peer discussion (2-4).

Our question: does active engagement of students during discussion with peers lead to increased conceptual understanding, resulting in improved performance following PI? OR, alternatively, do students in fact not learn from the discussion, but simply choose the answer promoted by neighbors they perceive to be knowledgeable?

Our experiment: After students answered a question individually (Q1) and then answered the same question again after discussion (Q1_{AD}), they individually answered an additional, similar (isomorphic) question (Q2), to test for gains in understanding.

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Experimental design using isomorphic questions, Q1 and Q2:

Q1 $\xrightarrow{\text{Peer discussion}}$ Q1_{AD} \rightarrow Q2

Students vote individually, correct answer and distribution not revealed.

Students re-vote, correct answer and distribution still not revealed.

Isomorphic question: students vote individually, correct answers and distributions revealed.

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The results shown in Figure 1 suggest that students are indeed gaining conceptual understanding from the discussion of Q1 that allows them to improve their performance on Q2.

This suggestion is confirmed by the results in Figure 2, in which the answers of individual students on Q1, Q1_{AD}, and Q2 were analyzed. Among students who answered Q1 incorrectly, those who answered Q1_{AD} correctly performed much better on Q2 (77% correct) than those who answered Q1_{AD} incorrectly (44% correct).

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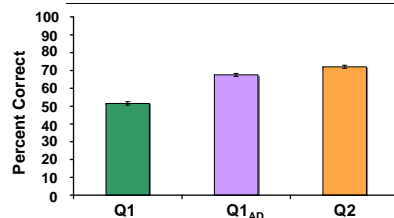


Figure 1. Mean individual improvement from Q1 to Q2 for 16 isomorphic question pairs. Data from one of the U. of Colorado majors genetics courses; n = 350 students. Mean Q2 score is significantly higher than mean Q1 score (16% \pm 1%SE), suggesting that on average, students gained conceptual understanding during the discussion of Q1.

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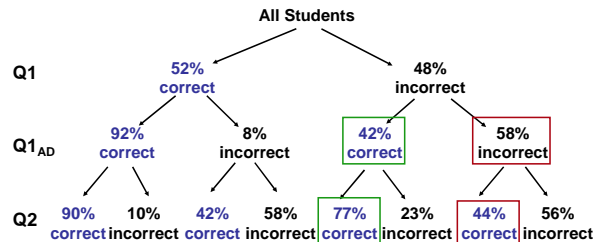


Figure 2. Distribution of answers on all 16 isomorphic question pairs. On average, students who corrected their initial response to Q1 on Q1_{AD} did much better on Q2 than students who did not correct their initial response (compare green and red boxed entries), confirming that students gain conceptual understanding during the discussion

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The gains from discussion differed according to question difficulty, based on percent correct answers on Q1, as shown in Figure 3. Gains were more pronounced from Q1_{AD} to Q2 on the most difficult questions.

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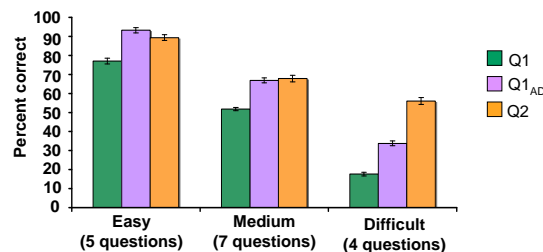


Figure 3. Mean individual improvement from Q1 to Q2 for question pairs of different difficulty. Note significant gain from Q1_{AD} to Q2 for difficult questions.

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The foregoing results indicate that students are gaining conceptual understanding from group discussion. But how?

"Transmissionist" view: peer instruction is taking place; the stronger students explain the correct reasoning to the weaker students, who therefore now understand it.

Constructivist view: in the process of actively discussing and defending different points of view, students arrive at a correct understanding by themselves.

Our data from the most difficult questions supports the constructivist view at least as a contributing factor to the results, since for these questions, where only a small percentage of students answered Q1 correctly, the majority of the discussion groups (3 students on average) included no one who knew the correct answer to Q1 (naïve groups). The statistical analysis in Table 1 shows that a significant fraction of the students who answered Q2 correctly must have been in naïve groups.

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Table 1. Chi-square analysis of responses to each of the four difficult question pairs

Observed correct on Q1	Predicted* correct on Q2	Observed correct on Q2	Total students participating	p value
24 (12%)	64	102	203	<0.01
44 (16%)	114	147	277	<0.01
50 (18%)	122	141	275	0.02
52 (20%)	125	185	258	<0.01

* Predicted correct answers are based on a model in which students who answer Q1 correctly are randomly distributed among the participating groups of three, and all participants in these groups subsequently choose the correct answer to Q2. Since the number of observed correct answers on each of the four questions was significantly higher than predicted, many of the correct answers to Q2 must have come from groups in which no one knew the correct answer to Q1, supporting a constructivist explanation for the value of group discussion.

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Student survey responses also support a constructivist interpretation.

When asked whether they agreed or disagreed with this statement: "When I discuss clicker questions with my neighbors, having someone in the group who knows the correct answer is necessary in order to make the discussion productive," 47% of students disagreed.

Comments from these students included:

"Often when talking through the questions the group can figure out the questions without originally knowing the answer, and the answer almost sticks better that way because we talked through it instead of just hearing the answer."

"Discussion is productive when people do not know the answers because you explore all the options and eliminate the ones you know can't be correct."

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