The effects of in-class concept questions on learning and retention in genetics

Michelle Smith, Ken Krauter, Bill Wood and Jenny Knight
Department of Molecular, Cellular and Developmental Biology, CU-Boulder
Abstract

To determine best practices for maximizing student learning from in-class concept questions, sets of very similar clicker questions were used to monitor student understanding in two genetics courses, one for majors and another for non-majors. After answering the first question individually, students participated in one of three paradigms: peer discussion, listening to an instructor explanation, or both, before answering a second question individually.

Our results show that the combination of peer discussion followed by instructor explanation significantly improves student understanding when compared to either approach alone.

To determine how much students retain when the combination of peer discussion followed by instructor explanation is used, students in the non-majors course were asked a third (retention) question several days later. Students who answered the second question correctly in class were much more likely to answer the retention question correctly. This result suggests that being able to correctly apply material in class helps students retain concepts.
What is the most effective way for students to learn from in-class concept questions?

**Combination**
- Q1 individual
- Q1 ad (same question as Q1 asked after discussion)

**Instructor Explanation**
- Q1 individual
- Instructor explains answer to Q1
- Q2 individual

**Peer Discussion**
- Q1 individual
- Peer discussion
- Q1 ad
- Answer given without explanation
- Instructor explains answer to Q2; discusses both questions if necessary

*Study conducted in Majors Genetics, Fall 2008 and Non-majors Genetics, Fall 2009*
Mean percentage of correct answers is significantly higher for Q1\textsubscript{ad} and Q2 than for Q1, for all three modes (repeated measures ANOVA, p<0.05 in all cases). Error bars=SEM
The Combination Method Results in the Largest $<g>$ from Q1 to Q2

In both courses, the percent learning gain is significantly higher using the combination method (repeated measures ANOVA, $p<0.05$ in all cases).

For each individual, percent normalized learning gains: $<g> = 100\%(Q2- Q1)/(100 – Q1)$ (Hake, 1998). Individual learning gains were then averaged.

Error bars=SEM
The **combination method** is helpful for all students regardless of performance on Q1 and Q1ad.

**Majors Genetics**
- n=7 questions
- Q1
  - Individual
  - Q1
  - Q1ad
  - Peer discussion
  - Numbers correspond to the percent correct
  - “R”=Right
  - “W”=Wrong

**Non-majors Genetics**
- n=14 questions
- Q2
  - Individual
  - Q2
- Instructor explanation

**Numbers correspond to the percent correct**

- 95%
- 85%
- 83%
- 84%
- 84%
- 81%
- 81%
- 75%
- 81%
- 77%
- 74%
With the **instructor method**, answering individual Q1 correctly has a variable influence on student performance.

**Majors Genetics**
- n=6 question

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>W</th>
<th>% correct</th>
<th>% incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td></td>
<td></td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>76</td>
<td>70</td>
<td></td>
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- For the majors, answering Q1 correctly gives students a small advantage for answering Q2 correctly.

**Non-majors Genetics**
- n=9 questions

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>W</th>
<th>% correct</th>
<th>% incorrect</th>
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</thead>
<tbody>
<tr>
<td>Q1</td>
<td></td>
<td></td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>80</td>
<td>60</td>
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- For the non-majors, answering Q1 correctly gives students a large advantage for answering Q2 correctly.

**Numbers correspond to the percent correct**

- “R”=Right
- “W”=Wrong
The peer discussion method is most beneficial to students who answer $Q_{1_{ad}}$ correctly (repeatable in consecutive semesters with different instructors).

The non-majors genetics course did not test student learning with the peer discussion only method. This data is from Smith et al, 2009.
The combination method may be effective because peer discussion engages students and prepares them to listen to the instructor.

On an end-of-term survey, 64% of the majors genetics students agreed with this statement (n=122 responses): Having a discussion with my neighbors prepares me to listen to instructor’s explanation:

- “Sometimes it is easier to understand the problem solving approach introduced by your peers rather than the one introduced by your professor.”

- “It gets me thinking about the topic before [the instructor’s] lecture, rather than just passively listening to what he has to say, I am already engaged.”
How much do students retain from in-class concept questions?

Study performed in the non-majors genetics course
Retention is happening, but it’s low (61%)

However, performance on previous clicker questions affects retention

*Study performed in the non-majors genetics course*
Students who answer Q2 correctly are more likely to answer Q3 correctly, even though everyone hears an explanation to Q2.

Numbers correspond to the percent correct
“R”=Right
“W”=Wrong

% correct
% incorrect
Performance on the retention question (Q3) does not affect exam performance

12 questions (of the original 14) were followed by very similar questions on exams

<table>
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<tr>
<th>Individual Performance on Q3</th>
<th>% correct on similar exam questions</th>
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<tbody>
<tr>
<td>correct</td>
<td>71 %</td>
</tr>
<tr>
<td>incorrect</td>
<td>74 %</td>
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</table>

Possible interpretation: students who get Q3 incorrect are motivated to study that concept.

Student comments:
- “When I was thinking about a problem later on I could think back and say, ‘oh yeah, like the clicker question in class.’ If I remembered getting a question wrong it would definitely motivate me to look up the answer and see why I wasn't understanding it.”

- “I was really disappointed if I got a review clicker question wrong because we had gone over the answer before. It meant that I obviously needed to read the question more carefully or learn that idea.”
Student attitudes about the clicker question series reflect that they find the review questions useful

<table>
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<tr>
<th>End-year survey question</th>
<th>% students who agreed or strongly agreed</th>
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<tr>
<td>It was useful for my learning to answer the review clicker questions (Q3).</td>
<td>93%</td>
</tr>
<tr>
<td>I was motivated to answer the review clicker questions correctly.</td>
<td>93%</td>
</tr>
<tr>
<td>If I got a review clicker question incorrect, I was disappointed.</td>
<td>62%</td>
</tr>
<tr>
<td>Answering a review clicker question incorrectly motivated me to study that topic more so than if I got that question correct.</td>
<td>64%</td>
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Conclusions

- Using a combination of peer discussion followed by instructor explanation is the most effective way to promote learning during in-class concept questions.

- Students who can successfully apply the concept individually after peer discussion are more likely to retain the concept than those who cannot.