An improved design for in-class review based on collaborative, two-stage testing

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*Carl Wieman Science Education Initiative*
Abstract

We present the theory and implementation of a review strategy based on testing rather than lecturing. We also show the results of a beginning-of-course review using the format of a two-stage examination, in which students complete a set of questions individually, then again as a group. Compared with the typical lecture review: (a) students engage with the review topics much more deeply and more accurately gauge their own preparation; (b) students receive immediate, corrective feedback from their peers and clarify their understanding through discussion during the group stage; and (c) the instructor receives detailed information on students’ background understanding that can be used to tailor instruction. These proposed benefits are supported by the improved performance of groups during the second stage and by student opinions collected by survey several days after the review activity. The two-stage review therefore serves to both diagnose and remediate deficiencies in background understanding, leaving students and instructors better prepared for the course.
# Why may traditional review fail?

<table>
<thead>
<tr>
<th>Goal</th>
<th>Barrier</th>
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<tbody>
<tr>
<td>Clarify understanding of previously learned concepts</td>
<td>Students confuse feeling of <em>familiarity</em> with actual understanding (Willingham, 2003)</td>
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</table>
| Prime students to connect prior knowledge to the new topics | Students tune out if they think they already understand  
Students who haven’t heard about the topic are unlikely to learn much from such a brief review |
| Focus students’ attention                       | **The review lectures take up class time and provide little benefit.**  
Additional time required to re-engage when new material is introduced |
How to improve review effectiveness?

Results from Cognitive Psychology:

• **Testing** benefits retention, self-evaluation, and learning
  – (Bjork, 1994; Karpicke & Roediger, 2008; Roediger & Karpicke, 2006)

• **Collaborative strategies** provide students with immediate, corrective feedback
  – Peer Instruction (Crouch & Mazur, 2001)

• Students remember the answer chosen by their group in during collaborative testing (Gilley & Clarkston, 2014)
## Two-stage review strategy

<table>
<thead>
<tr>
<th>Stage</th>
<th>Student benefits</th>
<th>Instructor benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Individual stage</strong>&lt;br&gt;Students answer questions on Scantron form</td>
<td>Engage deeply with questions&lt;br&gt;Opportunity to gauge their own preparation</td>
<td>Results can be used to tailor future instruction&lt;br&gt;Opportunity to communicate pre-requisite expectations</td>
</tr>
<tr>
<td>2. <strong>Group stage</strong>&lt;br&gt;Students answer the same questions in groups of 4-5</td>
<td>Group discussion provides immediate, corrective feedback &amp; clarification&lt;br&gt;Groups receive feedback from IF-AT card</td>
<td>Group results reveal stickiness of misconceptions, areas of greatest concern</td>
</tr>
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</table>
Developing a two-stage review activity

1. Identify the topics and key concepts from pre-requisite courses
2. Develop a set of multiple-choice questions
   - Target "quiz" level rather than "final exam" level
3. Prepare question sheets, Scantron forms, and IF-AT cards

Immediate Feedback Assessment Technique (IF-AT cards)

- Multiple-choice form covered in scratch-away layer
- Groups scratch selected answer, reveal a star if correct
- If incorrect, groups try again
Example question: Analytical Chemistry

Q7. You shine a green laser pointer through a 1-cm glass cuvette containing 4 mL of cranberry juice, and observe that the beam that comes out the other side.

Which of the following changes would increase the percent of light that passes through the cuvette?

A. Adding 2 mL of water
B. Increasing the width of the cuvette from 1 cm to 2 cm
C. Increasing the intensity of the laser pointer by 10%
D. More than one of the above
E. None of the above
Example question: Genetics

One or more of the cells represented below are diploid. Which one is it/which ones are they?

A. i only  
B. ii only  
C. iii only  
D. i and ii  
E. i and iii

Individual stage: 45% correct  
Group stage: 85% correct
The first day of class

• Students form groups of 4-5 during a 5-minute break
  – Groups may be assigned or self-selected
  – Assigned groups helpful for mixing cohorts or maximizing heterogeneity within groups

• Activity introduced as an opportunity for students to assess their background understanding

• Emphasize that it is NOT graded, but results will be used to tailor instruction

• **Individual review**: Scantron sheets, 15 min

• **Group review**: same questions, “Immediate Feedback Assessment Technology” (IF AT) cards, 15 min
Two stage review results: Analytical Chemistry

Individual and group scores the two-stage review. Group scores were calculated as the percentage of groups choosing the correct response on their first answer attempt (first scratch on the IF-AT card).
Review results provide information on student’s strengths and weaknesses

3 major categories of questions:

<table>
<thead>
<tr>
<th>Category</th>
<th>Action required</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Majority of individuals &amp; groups correct</td>
<td>No further review required</td>
<td>Q1-4, 14, 17, 18</td>
</tr>
<tr>
<td>Majority of individuals incorrect, majority of groups correct</td>
<td>Flag for additional review or provide study resources</td>
<td>Q7-9, 13, 15</td>
</tr>
<tr>
<td>Majority of individuals &amp; groups incorrect</td>
<td>Major target for future instruction to correct misconceptions</td>
<td>Q5, 10, 12</td>
</tr>
</tbody>
</table>
Example of a persistent misconception

Q10. Which feature of the absorption spectrum of an unknown dye could be used to definitively identify the molecular structure of the dye?

A. The height of the absorption peak  
   Individual: 4%  
   Group: 1%

B. The area of the absorption peak  
   Individual: 21%  
   Group: 8%

C. The wavelength of maximum absorption  
   Individual: 63%  
   Group: 57%

D. The number of absorption peaks in the UV-visible spectrum  
   Individual: 38%  
   Group: 19%

E. None of the above  
   Individual: 29%  
   Group: 14%
### Student perspective

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The two-stage review activity helped me become aware of things I didn't understand.</td>
<td>7</td>
<td>19</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussing the questions with my group helped me to better understand the relevant concepts/topics.</td>
<td>10</td>
<td>18</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>The two-stage review activity was more useful than a lecture review.</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

**Responses from genetics students to an online survey completed 4 days post-review (32 of 50 students responding)**
Student perspective

<table>
<thead>
<tr>
<th>What did you like most about the two-stage review activity?</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussing/working with group</td>
<td>20</td>
</tr>
<tr>
<td>Gauge ability/feedback/ review</td>
<td>11</td>
</tr>
<tr>
<td>Clarify/improve/correct understanding</td>
<td>5</td>
</tr>
<tr>
<td>Scratch cards</td>
<td>4</td>
</tr>
<tr>
<td>Doing individual stage first</td>
<td>3</td>
</tr>
</tbody>
</table>

“I liked that the activity was put under test conditions at first, to realize how much I personally know. Then the group portion allowed me to understand the material better by talking in groups and teaching and learning the material to our group members.”
Instructor perspective

• Results of two-stage review allowed the genetics course to **save two full class periods** previously spent on review.

• Student performance on test questions related to this topic (based on pre- and post-tests) were not negatively

• Instructors who have used this method in other courses have been universally enthusiastic.
Summary of benefits

Using two-stage review allows instructors to:

• Capture a snapshot of students’ understanding of key concepts that could be used to tailor lectures and activities

• Provide students with immediate feedback on their level of preparation

• Remediate deficiencies in students’ understanding through peer discussion

• Communicate clear expectations for students’ background understanding

• Engage students in active class from the first day
References


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