Think-Pair-Share

What it is:
A thought-provoking question is posed to students who think about the answer then discuss it with their neighbors.

Implementation:
• Ask a question
• Students think about or write down their answer (usually 1-2 minutes)
• Students pair up
• Students share their thoughts with each other and discuss the answer
• Instructor can ask for responses from some, all, or no pairs

The question:
• Promotes student engagement
• Facilitates informal assessment

Examples include

• Image Interpretation: Interpret the geologic history of the rocks shown in this image.

• Graph Interpretation: From the plot of weathering depth vs. age for limestone in tombstones, estimate the mean weathering rate.

• Open-ended question: How do we know what the climate was like before people started keeping track?

• More examples at: http://serc.carleton.edu/16225

References
• http://serc.carleton.edu/introgeo/interactive/tpshare.html
• King, 1993, From Sage on the Stage to Guide on the Side, College Teaching, 41: 30-35
What it is:
Cooperative learning during which students first become experts in one aspect, then peer-teach and work together to solve a problem or complete a task.

Implementation:
• Instructor divides topic into team assignments
• In teams, students become experts (by completing an assignment) on one aspect
• Students recombine into new groups, with each team represented in the group
• Students in the group, first teach each other their specialties, then work together to solve a problem/complete a task.

The topic/problem should:
• Be easy to divide
• Have related team assignments
• Not require students to be experts in everything
• Be complex enough to result in productive discussions

Example: Google Earth. Each team analyzes different locations that show similar features (e.g., barrier islands, folds, valley glaciers, volcanic cones, etc.), then combine to discuss similarities and differences of the feature.

Example: Plate tectonics. Teams analyze earthquake, volcano, seafloor age, and topography data maps, then combine to draw plate boundaries and interpret processes.

http://serc.carleton.edu/introgeo/jigsaws/index.html

“When efforts are structured cooperatively, there is considerable evidence that students will exert more effort to achieve, learn more, use higher-level reasoning strategies more frequently, build more complete and complex conceptual structures, and retain information learned more accurately” Johnson & Johnson, 1999, Making Cooperative Learning Work.
What it is:
Multiple-choice question that focuses on one key concept of the lesson.

Implementation:
• Present a short lecture (5-10’)
• Post a Concept Test on board/screen
• Students consider question and answer (by hands, lettered cards, clickers…)
• Students discuss reasons for their answers with neighbors
• Students answer question again
• Instructor, or student spokesperson, explains the correct response

The question should:
• Focus on application of a single concept (not recognize a fact or define a term)
• Be of intermediate difficulty (expect 35-70% of student to initially answer correctly)

ConcepTests have been shown to:
• Increase student engagement
• Communicate high expectations
• Promote interaction
• Provide prompt feedback
• Increase student course satisfaction
• Improve student learning

References

Examples
How many plates are present?
- a. 3 (26%; 0%)  c. 5 (44%; 75%)
- b. 4 (19%; 18%)  d. 6 (11%; 7%)

The following diagram illustrates the hydrologic cycle. Arrow 11 best represents what process?
- a. evaporation
- b. precipitation
- c. transpiration
- d. run-off

More examples and information at http://serc.carleton.edu/introgeo/conceptests/index.html
# Minute Paper

## What it is:
Questions that require short responses from students. The “Minute Paper” is sometimes called “Muddiest Point” or “Daily Check-In” depending on how it is used.

## Implementation:
- Pose a question.
- Students respond
  - *May be anonymous.*
  - *May be collected on notecards.*
- Collect responses and review
  - *Read with an open mind. You may learn students are unsure about a concept you believe was explained clearly.*
- Address student responses
  - *You may choose to do this at the start of the next lesson or electronically via email or a class website*

## Advantages:
- Provides immediate feedback
- Students self-assess: they must mentally review before they can respond
- Facilitates student reflection which increases retention
- Allows all students to have a “voice” in the class

## Examples of common questions:
- What was the most important point discussed in today’s class?
- What question do you have about today’s class/reading/discussion?
- What was the muddiest point in today’s class?
- What would you like to learn more about?

## References

[http://serc.carleton.edu/introgeo/interactive/oneminwrite.html](http://serc.carleton.edu/introgeo/interactive/oneminwrite.html)
What it is:
Students get out of their seats and respond in small groups to a prompt, and then respond to other student’s responses as well.

Implementation:
- Instructor posts a series of prompts around room. Prompts should be open-ended, allowing for a variety of responses.
- Provide instructions to students and arrange students into groups.
- Each group responds on paper to one of the prompts.
- Groups rotate through prompts, responding both to the prompt as well as prior groups’ comments. Instructor monitors and spurs discussion when needed.
- Students report out key points. Instructor adds comments and corrects for misconceptions.

Benefits:
- Facilitates student interaction & collaboration
- Allows all students to voice their thoughts
- Promotes debate and consensus building
- May be used to assess students’ prior knowledge or misconceptions
- Wakes up students with movement

Examples of Gallery Walk questions organized by Bloom’s Hierarchy

- **Knowledge:** List the impacts of increased ultraviolet radiation reaching the earth.
- **Comprehension:** What is the difference between weathering and erosion?
- **Application:** Use Darcy’s Law to calculate groundwater flow rates in the marked locations.
- **Analysis:** What inference can you make about the geomorphic history of this region based on the terraces?
- **Synthesis:** Create a coastal zoning plan to better protect from hurricane damage.
- **Evaluation:** Use scientific evidence to defend or criticize the use of Yucca Mountain as a nuclear waste repository.

http://serc.carleton.edu/introgeo/gallerywalk/index.html

**Example prompts:**
- Images
- Graphs
- News headlines
- Opinion statements
- Questions

**Group members may choose roles:**
- Leader
- Reporter
- Monitor
- Recorder

Gallery Walk introducing REE in 30 person, non-majors course. Photo by Kevin Travers, Bowdoin College.
**Worksheets (Lecture Tutorials)**

**What it is:**
Short worksheets aimed at reducing misconceptions or working through difficult concepts that students complete in groups in class.

**Implementation:**
- Give a short, introductory lecture.
- Students pair up and complete a worksheet (instructors can create their own worksheets or use Lecture Tutorials in a published workbook).
- Briefly review select questions. Collecting the worksheets is optional.

**The worksheet should:**
- Address topics with which students have difficulties.
- Require mid- to high-level thinking.

**Lecture Tutorials have been shown to:**
- Increase student learning
- Reduce misconceptions
- Promote interaction
- Provide prompt feedback
- Create a positive response in students

**Directions to create your own:**

**Example**

**References**


Cooperative Exam

What it is: Exams for which students answer some questions independently and some in groups. These type of exams may be called cooperative, two-stage, or pyramid exams.

Implementation:
• Prepare an exam that has an individual component and a cooperative group component.
• Questions may be in any format: multiple choice, short answer, problem-solving… Questions in the 2nd part may build on a questions from the 1st part or ask them in a new way.
• For the 1st part of the exam (often 30-45’), students individually answer questions and turn in their responses.
• For the 2nd part of the exam (often 30-45’), in groups of 3-5, students answer the same questions, new questions, or a combination of both depending on how you choose to format the exam.

Grading:
• Many instructors have the individual component count as 70-80% of the total exam grade, with the cooperative portion counting for the remaining.
• Many instructors do not penalize students if they perform better on the individual portion than on the cooperative portion.

Advantages:
• Exam is a learning experience
• Immediate feedback from peers
• Students achieve a higher level of mastery

Student comments: (from Wieman et al., 2014)
• I was able to instantly learn from my mistakes.
• It was good to compare methods and answers with others, and it allowed us to be more confident.
• Interesting. All had different ways of approaching the question. Very helpful to understand everyone’s response and why they thought their answer was correct.

References


Collaborative Documents

What it is:
Activities that encourage students to work together in or out of the classroom by using on-line collaborative tools. Many possibilities – 3 examples are shown here. May be combined with an on-line peer review tool (e.g. iPeer or PRAZE).

Class Review

Implementation:
Provide a review sheet online through Google Docs or a similar tool. Invite students to share the document and study together virtually.

Presentations

Implementation: Ask students to create a presentation using one of the many on-line presentations apps available. Provide a rubric showing how they will be evaluated. Students work together in small groups to prepare a presentation, and present it to the class.

Wiki Page or Web Page

Implementation:
• Give an assignment with specific instructions and grading rubric. Students work in small groups over course of week.
• Students research and create a wiki or web page that describes topic, includes images, and cites sources.
• Evaluate their creations!

The assignment should:
• Allow students to investigate and learn information that is outside the prescribed coursework that interests them

Pyrope

Mineral formula: MgAl₂Si₃O₁₂
Crystal system: isometric
Crystal Habit: Dodecahedral, often found as granular
Hardness on Mohs scale: 7 - 7.5
Specific gravity: 3.56 g/cc
Color: deep red
Luster: vitreous
Streak: white
Fracture: conchoidal
(Sources: 1, 2)

Interesting Fact:
In 1984, geologist Christian Chopin published a paper describing his sampling of metamorphic core and pure pyrope in the Western Alps. His seemingly minor find went on to change the way scientists understood plate tectonics. Previously, diagrams showing the tectonic movement of continental plates had restricted such movement to the normal thickness of the continental crust. Pyrope has a high pressure stability field, and pyrope-rich garnets had previously only been found in rocks with origins in the mantle. Chopin's findings showed that crustal rocks had generated much deeper into the earth than previously believed, traveling down at least 100km. The discovery of this rare pyrope and its inclusions ultimately brought around a new theory of continental tectonics (Elements: European Journal of Mineralogy).

Chopin's original article: Coesite and pure pyrope in high grade blueschists of the Western Alps: a first record and some consequences.

http://serc.carleton.edu/NAGTWorkshops/undergraduate_research/collaborate.html
What it is: a self-monitoring activity that surrounds another assignment or activity.

3 steps to teach metacognition: (Lovett, 2008)
1. Teach students their ability to learn can change.
2. Teach planning and goal-setting.
3. Provide opportunities for students to monitor and adapt their learning.

Wrapper benefits:
- Students monitor their learning.
- Students get immediate self-feedback.
- Responses to wrapper may provide start to in-class discussion.
- Big impact for a short activity.

Exam Wrapper
(modified from Ambrose et al., 2010)
1. Approximately how much time did you spend preparing for this exam?

2. What percentage of your time was doing the following:
   a. Reading textbook sections for the first time
   b. Rereading textbook sections
   c. Practicing problems
   d. Reviewing notes
   e. Reviewing class materials
   f. Other (specify)

3. After reviewing your graded exam, estimate the percentage of points lost due to the following:
   a. Lack of understanding the concept
   b. Not knowing how to approach the question/problem
   c. Carelessness
   d. Other

4. Based on your responses above, how do you plan to prepare differently for the next exam?

Lecture Wrapper
(from Lovett, 2008)
- Start of lecture: provide tips on active listening
- End of lecture: students list 3 key points of lecture. Instructor collects lists, and reveals 3 most important points for immediate feedback.
- Study: After 3 successive lecture wrappers, student responses increasingly matched the instructor's: 45%, 68%, 75%.

Research Project Wrapper
(from R. Beane)
- What did you learn about research and the topic through this project?
- What did you learn about your own research habits and preferences?
- When were you excited and/or frustrated during the project?
- If you did a similar project in the future, would you approach the project the same or differently?

Reading Reflection
(from K. Wirth)
✧ What is the main point of this reading?
✧ What did you find surprising? Why?
✧ What did you find confusing? Why?

References

http://serc.carleton.edu/NAGTWorkshops/metacognition/index.html