Small in-class activities in a large classroom

Going beyond clicker-only participation in an auditorium-style, intro-level classroom

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Three new in-class activities were introduced in an introductory geology class of ~ 165 students.

Topics/Goals for in-class activities:

• Interpreting time and order in geologic cross-section diagrams

• Creating a phylogenetic tree or cladogram

• Inferring the location of the Ancient Rocky Mountains from rocks exposed today on the plains. (Guest lecturer: Lon Abbot)

Each activity focused on ONE learning goal/idea and was limited in number of images/information that can be used.
How did you figure out what topics to use in small in-class activities? We worked “backwards”!

**Step 1: Identify the learning goals/objectives for the course.**

No matter how appealing an idea was for a potential activity, it had to be in line with the main goals of the course.

**Step 2: Identify ideas/goals that would be presented multiple times throughout the course.**

For all in-class activities, we chose learning objectives/big ideas that are seen in multiple contexts throughout the course. For example, phylogeny and cladograms were presented in many different fossil animal groups to show change through time.

**Step 3: Compare existing course material (e.g. lectures, homeworks, quizzes) with the ideas/goals that ran through the course.**

All of the material used in the in-class activities existed as either homework, quizzes, or on tests from previous versions of the course. The material was then repackaged in a way to limit the amount of direct explanation from the instructor.

**Step 4: Have fun and leave the “need to control the classroom” at home Okay – not sure what this means, especially the ‘at home’ part.**
How were the in-class activities implemented in the classroom?

• Students were shown an image/figure via powerpoint projection, and hard paper copies were passed out in most cases.

• Paper copies were limited to 1-2 pages, if used.

• Time for the activities ranged from 20-30 minutes depending on how much discussion occurred.
  - Most cases it was 15-20 minutes for activity, followed by a 10-minute discussion.

• Instructor and one other person (e.g., STF) walked around the room answering questions.

• Each in-class activity had a follow up/summary in class and related to a homework assigned within a week.

• Relevant clicker review questions in following lecture.
Did students stay on task and work with each other?

• Students did focus when a task was given to them. However, our in-class observations revealed that not all students chose to work with their neighbor. This may be due to fixed, auditorium style seating that did not allow for easy “turn-around” for discussion.

• Therefore, it was important to follow up with clicker or other discussion questions following the in-class activity that would encourage participation (and interaction) by everyone in the class.
How did we follow up the students’ in-class activities?

Immediately:

Use of clicker questions (e.g., Relative Dating exercise)

Faculty asking/answering student questions in class session

Recording student responses on board/PPT slides to emphasize value

“Long-term”:

To make the message ‘stick,’ homeworks build off of the main idea presented in in-class activity.

E.g., Phylogeny and Cladistics activity was followed by a homework that asked students to use a similar approach to determine the relationships of fossil horses (classic case of evolution).
How useful can a short in-class activity actually be? Doesn’t it have to be a long, in-depth process for students to benefit?

No way!

• In-class activities give students an opportunity to “do” something instead of just listening — shift from passive to ‘active’ learning!. As soon as students become active in their learning (such as trying to solve a problem), they care more about their learning, and they discover what they are confused about (Hendelsman et al., 2004).

• THE biggest determinant of an in-class activity’s success is having a clear learning goal or objective as well as the time for students to reflect on the activity (Handelsman et al., 2007).

• Due to time and space limitations imposed by a large auditorium-style classroom, we decided to focus on one idea per activity and we then followed up on that idea with homework.
Did the students actually appreciate the small activities?

**Yes!** In a survey, students were asked about an idea that they learned in the course and what helped them learn that idea. While students still identify “pure lecture” as the main source of information, many students attributed the combination of in-class activities and homework as a way to make sure that they understood lecture information.

**Selected student responses on what they found useful for learning.**

“plate tectonics. the one lecture/activity was very beneficial. It reinstated information from 1010.”.

“I loved learning how to read the different layers of rocks, i.e. the first homework. I enjoyed that. The activity and homework prepared me for the test!”

“I really learned cladistics while doing the in-class activity on the same topic.”
Students viewed in-class activities as being just as helpful as clickers and homework in their learning.
Is having three in-class activities over a 15-week semester enough?

It is a good starting point. Students’ responses suggest they appreciate in-class activities to not only help with their learning, but also to make the class more interesting. About half of students that participated in the survey said they would not change the course (48.2% of responses).

The most common suggestion to change the course was to have MORE in-class activities (8% of students responses) followed by MORE homework (6% of student responses).

The great majority of students taking the survey really liked the in-class activities! A single student out of 78 surveyed responded that he/she did not like the in-class activities. This student also mentioned a general dislike for all science and preferred to do bare minimum to pass the class for his/her science requirement. It is unclear if their low interest in science is connected with dislike of the in-class activities (Jen- I think I’d remove this last sentence; your audience will ‘read’ this message without actually having to state it).
Selected student suggestions for changes to Spring 2009 GEOL 1020 course with in-class activities:

“Maybe make the homework more of an in-class assignment, to not only encourage attendance, but to also have a more interactive learning experience.”

“Make the course kind of a half activity/half lecture type of class”

The instructor does an amazing job helping us understand everything. My problem is that I suck at science and had a very rough semester, so I did not get good grades. But I love the instructor's in-class teaching methods.

“No, the course ran very smoothly and was very interactive which helped to keep my attention.”

“If there were more in class activities it would be more helpful”

“More clickers and interactive stuff”

“More small group activities”
IN-CLASS ACTIVITY: Interpreting Time and Order in Geologic Cross-sections – Here’s what you NEED:

Materials used:
• Powerpoint slides
• Hand outs of cross sectional diagrams
• Clicker (personal response system)

Set up: virtually none

• Many students were introduced to the idea of relative dating (determining order) and Steno’s Laws, the “rules” used in GEOL 1010, but may not have put those ideas into practice.

• Activity was presented to the students before the “rules.” Steno’s laws and relative ordering diagram were re-introduced by the GEOL 1020 instructor.

• Implementation was based on “innovation” approach use by Schwartz (year).

Duration of activity: 15-20 minutes

• Students were instructed to determine the order that rocks appeared in a cross section and to identify “rules” they can use to determine relative ordering (or age).

• Instructor and STF walked around classroom answering and asking questions.
Follow up: ~ 10 minutes using clicker questions

- After 20 minutes, students were asked to describe their observations and guidelines from working through the exercise; these were written on an overhead.

<table>
<thead>
<tr>
<th>Examples of student-derived guidelines for relative geologic dating</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Igneous intrusion came later.</td>
</tr>
<tr>
<td>• Everything horizontal at first.</td>
</tr>
<tr>
<td>• Something cut through another rock, that rock had to be there first.</td>
</tr>
<tr>
<td>• Metamorphism usually comes after with pressure and heat.</td>
</tr>
<tr>
<td>• See one rock type on one side, you should see it on the other side.</td>
</tr>
<tr>
<td>• Erosion comes before another layer is deposited.</td>
</tr>
<tr>
<td>• Inclusions are older than the rocks that they are in.</td>
</tr>
</tbody>
</table>

- The official phrasing of Steno’s laws was introduced and linked with students’ responses.
- Copies of cross-section images were projected and students chose the order of events using clicker responses. Students were asked to explain which rule applied to determine order.
- Followed with homework assignment for students to do same task with more complex example. E.g., The Grand Canyon.
Geologic cross section puzzles:

How can you tell the order of geologic events (e.g. faults, erosion) and rocks from a cross section?

- Work with your neighbors.
- Indicate the sequence by adding numbers in the circles to represent which groups of rocks came first, second, third, etc. **Note the number “1” is used to represent the oldest event.**
- It is **NOT** expected that you will get the sequences correct on the first try.
- Describe the **reasoning** you used in determining the relative order of the events in the various diagrams.
GEOL 1020: Interpreting time and order in geologic cross-section diagrams

Learning goals: By the end of this activity, students should be able to:

1. Determine the relative order of geologic events from a cross-section diagram
2. Describe the reasoning used to determine the relative order of two or more geologic events

Directions: These puzzles intend to probe your thinking, generate discussion about the reasoning behind your answers, and encourage group work in planning how to solve problems. You are NOT expected to know complete answers to all the questions, but should discuss your questions and potential ways to determine answers.

1. Indicate the sequence of geologic events for the following three diagrams by adding numbers in the circles to represented which groups of rocks came first, second, third, etc. Note the number “1” is used to represent the oldest event.
2. Describe the reasoning you used in determining the relative order of the events in the various diagrams.

For example: How were you able to determine the first event in each of the following diagrams?

Key to Rock Symbols

Sedimentary rocks

- mudstone
- sandstone
- conglomerate

Igneous rocks

- diorite
- granite
- rhyolite

Metamorphic rocks

- schist
Instructor directions:

The purpose of this invention activity is to get students prepared to think about Steno’s law and applying them in determining the relative order of rocks, faults, deformations that are visible in geologic cross section. Invention activities when coupled with subsequent learning resources like lectures, led to strong gains in procedural skills, insight into formulas, and abilities to evaluate data from an argument.

Just telling students the expert knowledge seems like an efficient way to teach, but it is efficient because it is a shortcut. The price of the shortcut is that students do not develop integrated knowledge structures which leads to the novice characteristics listed above. Telling students becomes much more effective if they have first had a chance to intellectually engage in investigating the structure of a phenomenon or idea. Instructors need to avoid the blind spot of assuming that what is obvious structure for them exists for the student. Investigating the structure does not mean solving a series of discrete or step-by-step problems, because students will treat each step as a separate exercise. Instead, one proven way to get students to explore structure is to have them complete “invention” activities. Students receive a set of carefully selected cases simultaneously, and their task is to invent a compact description that generalizes across the cases. Students do not need to discover the correct answer. Rather, the invention task helps students notice important structure in the cases and to form an organizational framework that prepares them to understand conventional descriptions. After this task, students can be told the expert knowledge. The added benefits of the invention-then-telling approach do not always show up on routine exercises, of the sort given on most exams (though it doesn’t hurt). However, strong differences are evident when students are given more expert-like tasks that include learning new related ideas and applying their knowledge to new situations (Schwartz, et al. 1998; 1999; 2005).

How to use the invention activity:

1. Review in the class what the different symbols mean regarding different rock types.

2. BEFORE introducing the terms and concepts used for relative ordering diagrams in lecture or class, have students work in groups of 2 or 3 to try and solve the ordering problems and write down their reasoning when determining the order.

3. Make it clear to the students that they are expected to reason through the problems, and they are not expected to get all of the answers correct this first time. The focus of discussion will be on their observations and reasons, not the correct order of event.

4. Have teaching assistants, undergraduate learning assistant or other faculty walk among the students to answer any questions from the students.

5. After ample time (expected 20-30 minutes) refocus the students to start discussion on what reasoning they used in determining the order of events.
6. Write student reasons either on powerpoint or blackboard using their own terms. Using their phrasing, start introducing the proper scientific terms and definitions.

What to expect:

- Students may initially express frustration that they will have to attempt to complete an activity without clear step-by-step instructions. However the majority of students will quickly adapt
- Students will want approval from teaching staff on their choices.
- In most cases students will easily identify the law of superposition and cross-cutting relationships. They will have a little more difficulty with concepts of original horizontality and using inclusion.

Benefits:

- Students will initially be hesitant on their choices and reasoning, yet by the end of the discussion many of them will express confidence in their choices.
- By presenting the concepts before the scientific jargon and terminology, students can focus on the concepts instead of focusing on proper
* Note the number “1” is used to represent the oldest event.

What observations and reasoning were used to figure out the order of when geologic feature appeared in these figures?
Events oldest to youngest

1. Deposition of limestone and mudstone
2. Intrusion of igneous rock
3. Erosion
4. Deposition of sandstone and limestone
5. Faulting
6. Erosion (after the beds below have been tilted)
7. Deposition of conglomerate and mudstone
8. Intrusion of igneous rock (can see it intruding into the top layer of the mudstone)
Events oldest to youngest

1. Igneous rock #1
2. Igneous rock #2, on the left of diagram there is a xenolith of igneous #1 is emplaced in igneous rock #2
3. Erosion of igneous rocks #1 and #2.
4. Deposition of the protolith of metamorphic rock and limestone, then deformation
5. Intrusion of Igneous rock #5
6. Deposition of conglomerate, sandstone, mudstone, and sandstone.
7. Intrusion of igneous rock #7, can see it intruded into the sedimentary rock at top of section.
Example of review clicker question, followed by asking students their reasoning?

Which geologic event is the oldest?

A. Rock group “Z”
B. Rock “Y”
C. Rock “X”
In-class activity: Creating a cladogram

Materials:
• PPT slides
• Clicker optional

Set up: 10-15 minutes
• Introduce the terminology and importance of derived biological traits in previous slides; clicker questions were used to determine level of understanding.
• Students practiced identifying derived traits from comparing related ‘real animal’ examples.
• Students practiced “reading” a cladogram to determine what species are closely related.

During activity (~15 minutes):
• We asked students to copy down the “bare cladogram tree in notes” ; chart slide remained projected for the entire time of the activity.
• Instructor and STF walked around room answering and asking questions.
Follow up: ~ 5-10 minutes.

- Instructor asked class to fill in species on cladogram first, followed by the traits along the side of the cladogram.
- Results from student observations were recorded by instructor on the overhead slide.
- Students were asked to interpret what this could mean for (a) evolution; and (b) fossil record.
- We followed this in-class interactive with a homework assignment for students to do same task with more complex example (fossil horses).

Utilizing the THREE traits labelled by the large black arrows (body size, front foot, and tooth height), complete the cladogram, incorporating all 5 horse genera (Eohippus, Mesoequus, Merychippus, Paleohippus, and Equus).
Cladistics relies on: (intro)

Shared derived characters or *synapomorphies*

*versus*

*Autapomorphy* is a derived trait that is unique to a given clade or group

**Cladogram for Vertebrates**

- **Outgroup**: taxon with primitive characters
  - Fish
  - Amphibians: Moist, breathable skin
  - Reptiles: Claws or nails
  - Mammals: Hair, Mammary glands
    - Synapomorphies
    - Autapomorphy

Cladogram for Vertebrates
Cladistics exercise

Here is a character matrix. You build a cladogram!

<table>
<thead>
<tr>
<th>Traits</th>
<th>Species A</th>
<th>Species B</th>
<th>Species C</th>
<th>Species D</th>
<th>Species E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of toes</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Tooth Height</td>
<td>Short</td>
<td>Short</td>
<td>Tall</td>
<td>Tall</td>
<td>Tall</td>
</tr>
<tr>
<td>Body Size</td>
<td>Small</td>
<td>Small</td>
<td>Large</td>
<td>Medium</td>
<td>Large</td>
</tr>
<tr>
<td>Nasal horns</td>
<td>Absent</td>
<td>Absent</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Nasal horn size</td>
<td>--------</td>
<td>--------</td>
<td>Large</td>
<td>Small</td>
<td>Large</td>
</tr>
</tbody>
</table>

*Hint: Look for shared traits!

*Let’s assume **Species A** is the outgroup (it’s geologically the oldest and most primitive).

J: May want to change Sp A, B, C, to some kind of names
Fill in the Cladogram

- Write in the species across the top
- Write in the derived traits (synapomorphies) along the cladogram
Fill in the Cladogram (follow-up)

- Write in the species across the top
- Write in the derived traits (synapomorphies) along the cladogram

Outgroup

A

B

D

C

E

1 toe

Large body size, large horns

3 (or fewer) toes, tall teeth, incr. body size, horns present

Reduced toes <5

*Whether a trait is considered derived versus primitive is relative. On the above cladogram, 4 toes is derived compared to 5 toes, BUT primitive compared to 1 toe.
Okay, so why would you (the instructor) want to use in-class activities in a large (>150 person) class?

• It changes the learning environment from a passive to an active one! Students participate more in their learning experience, they get more excited about it, AND by actively being involved, they seem to care more about what they’re learning.

• Students have some control over what is learned, and how a class/lecture proceeds.

• Students get to know and interact with their neighbors (this can be an important support network for a student, particularly when he/she misses lectures and needs to borrow notes) AND their instructor(s). I noticed the Geo-club in my GEOL 1020 – the 4 GEOL majors + ENVS major tended to sit together and interact a lot.