Active Lectures in Classrooms of All Sizes

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NAGT

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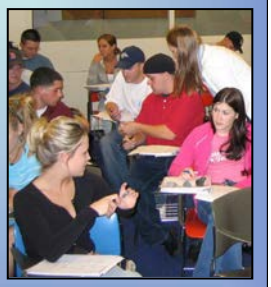
What do you hope to learn from this workshop?

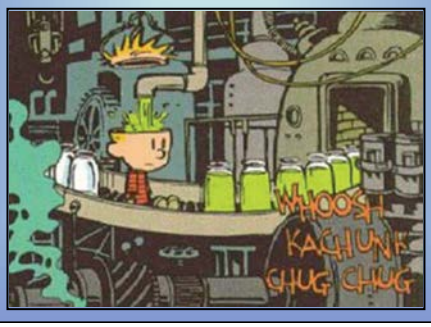
Overview

- Lecture and learning
- Active learning techniques
  - Lecture Tutorials
  - ConcepTests
  - Think-Pair-Share
  - Minute Papers
- Active assessment techniques
  - Pyramid Exams



Learning and Lecture

A Commonly Held Inaccurate Model of Teaching and Learning



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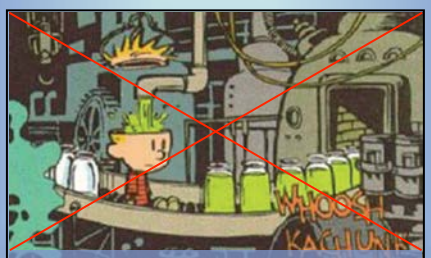

Students link new information to prior knowledge they have about Earth.

Some results from research into education and cognition

- Learning is constructive – it requires mental effort
- Most people require some social interactions in order to learn deeply and effectively
- People can retain approximately the first 10 minutes of a lecture
- Knowing what you do and do not understand (metacognition) is an important part of students' learning process

Benefits of Group Activities

- Capitalize on students who like to socialize
- Revisit complicated concepts in ways besides lecture
- Emphasize learning during class time
- Demonstrate to students that science is about doing stuff, not memorizing lists of facts
- Give students the opportunity to "talk science"

Benefits of Informal Assessments

- Testing students leads to better retention of material
- Students learn what they do and do not know
- Instructors learn what students understand before the first exam
- Breaks lecture into more manageable chunks

Benefits of Interactive Teaching on Students' Attitudes and Motivation

- Courses that are more student-centered have a more positive effect on student attitudes and motivation
- Interactive teaching can increase students' sense of self-belief (e.g. control of learning, self efficacy)
- Builds a sense of community

Memorization is what we resort to when what we are learning makes no sense.

~ Anonymous

The Montillation of Traxoline

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is montilled in Ceristanna. The Ceristannians gristerlate large amounts of fevon and then brachter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future because of our zionter lescelidge.

(attributed to the insight of Judy Lanier)

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Where is traxoline montilled?

a. Lescelidge
b. Ceristanna
c. Fevonville

Problem:

Students do not understand fundamental geologic concepts, and lecture doesn't do a good job teaching them.

So What Can You Do About It?

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- Lecture with more intensity?

So What Can You Do About It?

- ~~Lecture with more intensity?~~
- It's not what the instructor does that matters – it is what the students do that matters
- Create a learner-centered environment that promotes the intellectual engagement of your students
  - Not all active learning strategies are created equal

The best learners … often make the worst teachers. They are, in a very real sense, perceptually challenged. They cannot imagine what it must be like to struggle to learn something that comes so naturally to them.

~ Stephan Brookfield

What is the most important benefit of using interactive methods when you teach?

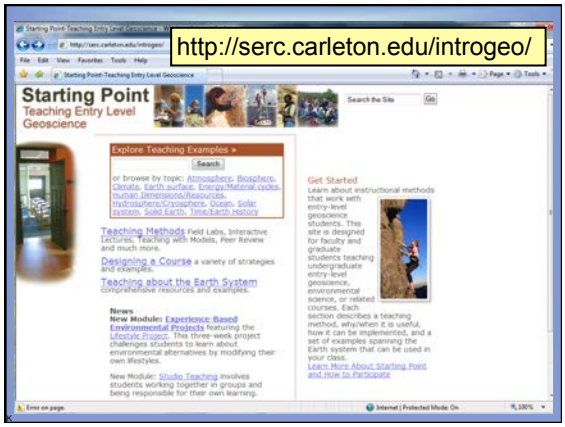
a. Engaging students

b. The immediate feedback it gives us regarding what and how students are learning

c. Taking regular attendance so we know which students need extra attention

Characteristics of Active Learning Techniques We're Presenting

- Can be used in a course that is primarily lecture
- Easy to implement
- Special tools not needed
- Can use in any size classroom



Example Course: Intro Oceanography

Geo 103 - Intro Oceanography

- 300+ students each semester, mostly non-science majors.
- **Engage and challenge students with active learning**: daily in-class exercises, many are collected for credit.
- This is a **General Education course**; I give them the **opportunity to succeed**:

1. Drop lowest exam score
2. In-class exercises; credit for being there and participating
3. 2-step 'pyramid' multiple choice exams
4. Opportunity for 'extra credit' based on attendance

- **Goal: make science accessible and relevant**! *maybe they'll read that science story in the newspaper, or engage in local issues regarding science or the environment*

It all starts with a thorough syllabus (i.e., contract)

- **Purpose of the course**: *what makes this a General Education course, and why should you (the student) care?*
- **Tangible life skills**: there are real world benefits or experiences beyond the content of the course.
- **Learning goals & outcomes**: *what do you want your students to gain from the course?*
- **Details of course**, including the basis of assessment.
- **Expectations**: *what do you expect of your students, what they can expect from you?*

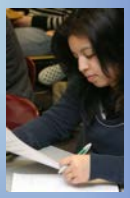
Learning Goals and Outcomes

- To demonstrate that **science is accessible** to a largely non-scientific audience by gaining exposure, familiarity, confidence, and interest in our home planet and our place in it.
- To grasp **fundamental concepts** about how Earth works as an integrated system comprising the geosphere, hydrosphere, atmosphere, cryosphere, and biosphere.
- To relate **common experiences** to our understanding of the world around us and to gain clearer perspective of our collective impact on the Earth system.
- To ask **how we know what we know**.
- To explore **scientific inquiry as a process** that reveals the details and splendor of our natural world.
- To challenge ourselves to become better **stewards** of our home planet.

Lecture Tutorials

Lecture Tutorials

- Worksheet students complete in pairs after a short lecture
- Written to combat misconceptions and difficult topics
- Starts with basic questions and works towards more application-type questions



Development of Lecture Tutorials

- Modeled after Astronomy Lecture Tutorials
- Topics were chosen because they:
  - Are frequently covered in introductory courses
  - Are difficult for students
  - Address common misconceptions
- Designed for easy implementation into existing traditional lecture courses
  - Already tested multiple times

Using Lecture Tutorials

- Professor lectures for a short time
- *Optional*: Students are posed a conceptually challenging question on the lecture material
- The class breaks into teams of two/three and work through the Lecture Tutorial worksheet
- Professor "debriefs" the activity highlighting the common problems
- *Optional*: Students are posed a similar question as before
- Professor returns to lecture mode

Example Student Debate

2. Three students are discussing whether or not lava initially coming out of a volcano contains abundant sediments.

Student 1: *No, hot lava does not contain sediments, since the sediments would melt in the lava. When it cools, the igneous rock is made out of minerals that are cooled and crystallized lava.*

Student 2: *Yes, as it comes out of a volcano, lava picks up sediments, which somehow do not melt. When it cools, the sediments are trapped inside and outside of the igneous rock.*

Student 3: *Yes, magma is made up of other rocks that melted, such as sedimentary rocks. So it can contain sediments.*

With which student do you agree? Why?

Lecture Tutorial exercise in Kortz and Smay (2012)

Lecture Tutorial Example

- Form groups of 2 or 3.
- Complete the Lecture Tutorial titled "Isostacy".
- Think about it as if you are a student…

Isostacy

Predict what will happen to land elevations in Greenland when all the glaciers melt.

a. The land will rise.
b. The land will sink.
c. The land is stable and will not change.

Lecture Tutorial Research Results

- After completing the Lecture Tutorial, student scores increased 18% on multiple choice questions (from 58% to 76%)
- After an extended lecture (in lieu of Lecture Tutorial) student scores increased 5% on multiple choice questions

Kortz, Smay, and Murray, 2008

Lecture Tutorial Questionnaire Results

- 99% (n=209) of students agreed:

  "The worksheets helped with my understanding of the subject"

Kortz, Smay, and Murray, 2008

Do you think the worksheets were a useful part of class?

"Yes, it was a completely new way of getting me to learn a topic through lecture then practicing what I just learned. The material that I had trouble with stood out immediately and gave me a chance right then to ask questions. Overall helped me to do great on tests."

Kortz, Smay, and Murray, 2008

For More Info: Lecture Tutorials

- Kortz and Smay (2012) Lecture Tutorials for Introductory Geoscience, 2e. W.H. Freeman.
- Kortz, Murray, and Smay (2008) Increasing Learning in Introductory Geoscience Courses Using Lecture Tutorials. JGE, v. 56, 280-290.
- Lecture Tutorial module: http://serc.carleton.edu/introgeo/index.html
- Mora (2010) Peer Instruction and Lecture Tutorials Equally Improve Student Learning in Intro Geology Classes. JGE, v. 58, 286-296.

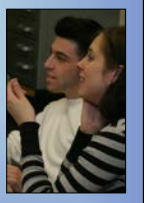
ConcepTests

ConcepTests

- Conceptual multiple-choice questions
  - Focus on a single concept
  - Have good multiple-choice answers
  - Are clearly worded
  - Are of intermediate difficulty (comprehension, application, analysis)
  - Are not terminology-intensive

ConcepTests

- Ask a ConcepTest question
- Students think about it and vote
  - 30-70% should be correct
- Students pair up and discuss, if necessary
- Students vote again
- Can be used with personal response systems ("clickers")



ConcepTest Voting

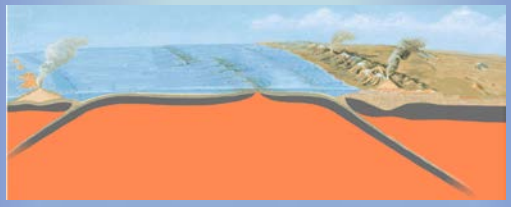
- Show of hands
- Show of fingers

- Colored cards

- Personal response systems ("clickers")

How Many Plates Are Present?

a. 2 b. 3 c. 4 d. 5 e. 6

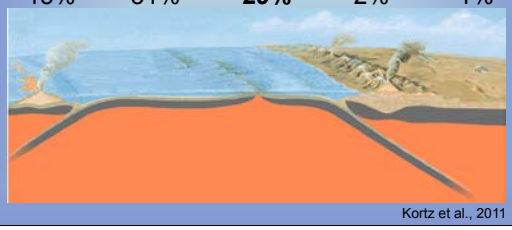


Kortz et al., 2011

How Many Plates Are Present?

Student Responses:

a. 2	b. 3	**c. 4**	d. 5	e. 6
13%	51%	**29%**	2%	1%



Kortz et al., 2011

What percentage of the mantle is liquid (magma)?

A. 0%-25%
B. 26%-50%
C. 51%-75%
D. 76%-100%

Clark et al. (2011)

ConcepTests

- Working in pairs, create a suitable question to use as a ConcepTest question
- Good characteristics:
  - Single concept
  - Multiple choice
  - Not vocabulary-intensive
  - Promotes discussion

For More Info: ConcepTests

- http://serc.carleton.edu/introgeo/interactive/conctest.html
- http://serc.carleton.edu/introgeo/conceptests/index.html
- McConnell et al. (2006) Using ConcepTests to Assess and Improve Student Conceptual Understanding in Intro Geoscience Courses. JGE, 54(1), p. 61-68.
- McConnell et al. (2003) Assessment and Active Learning Strategies for Introductory Geology Courses. JGE, 51(2), 205.
- http://derekbruff.com/site/classroom-response-systems

Think-Pair-Share

Think-Pair-Share Questions

- Open-ended
- Promote student engagement

Think-Pair-Share

- Ask an open-ended question
- Students think about the 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

Think-Pair-Share Example

- What are advantages and disadvantages of using Think-Pair-Share questions instead of asking an open question to the entire class?

Think-Pair-Share Examples

- Explain how you can identify the three plate boundaries on the diagram.
- Why does melting occur at convergent and divergent boundaries?
- From the data provided, what was the rate of plate movement?
- Why do geologists divide rocks into 3 categories?
- Explain the order of events in the outcrop.
- What do you need to do to get a higher grade on the next exam?

Think-Pair-Share **Bad** Examples

- What is the thickness of oceanic lithosphere?
- What is the age of the oldest seafloor?
- What is the definition of intrusive igneous rock?

Examples of short (15-20 minute) activities/exercises - every class we do something

- Interpret a figure from the textbook
- Plot authentic data and interpret the results
- View an image or several images and make a list of observations or questions
- Write a 'minute paper' concerning a particular subject, or a previous class ('low stakes' writing)
- Brainstorm a list related to a particular topic

initially done as individuals or think-pair-share, then followed up with classroom discussion

Tides

Exercise #21 - Tides

1. What are tides?

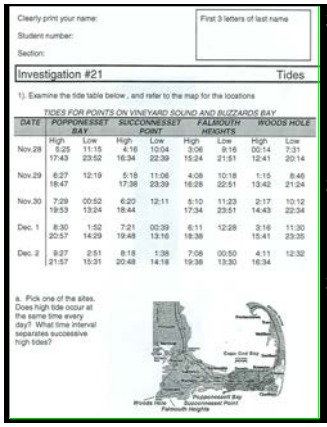
2. What force(s) drive the tides?

What observations can we make in order to test this hypothesis?

Encourage students to think about how they might test their hypothesis that the moon and/or sun causes the tides. For example, **collect daily observational data** at the coast for a number of days (then relate findings to the lunar cycle).

p. 45

Portsmouth, NH
tidal range 2 m



Clearly print your name:
Student number:
Section:
First 3 letters of last name

Investigation #21 Tides

1). Examine the tide table below, and refer to the map for the locations

TIDES FOR POINTS ON VINEYARD SOUND AND BUZZARDS BAY

DATE	POPPONESSET BAY		SUCCONNESSET POINT		FALMOUTH HEIGHTS		WOODS HOLE	
	High	Low	High	Low	High	Low	High	Low
Nov.28	5:25 17:43	11:15 23:52	4:16 16:34	10:04 22:39	3:06 15:24	9:16 21:51	00:14 12:41	7:31 20:14
Nov.29	6:27 18:47	12:19	5:18 17:38	11:06 23:39	4:08 16:28	10:18 22:51	1:15 13:42	8:46 21:24
Nov.30	7:29 19:53	00:52 13:24	6:20 18:44	12:11	5:10 17:34	11:23 23:51	2:17 14:43	10:12 22:34
Dec. 1	8:30 20:57	1:52 14:29	7:21 19:48	00:39 13:16	6:11 18:38	12:28	3:16 15:41	11:30 23:35
Dec. 2	9:27 21:57	2:51 15:31	8:18 20:48	1:38 14:18	7:08 19:38	00:50 13:30	4:11 16:34	12:32

a. Pick one of the sites. Does high tide occur at the same time every day? What time interval separates successive high tides?

3a. Pick one of the sites. *Does high tide occur at the same time every day? What time interval separates successive high tides?*

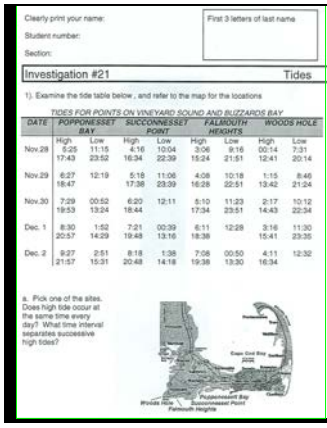
3b. *Is this interval (=**tidal period**) the same as observed in other towns?*

3c. *According to your ideas about what causes tides, should high and low tides occur at the same times at these sites? Why do they differ so much?* p. 45-46

3 Important Observations

- Two high tides, two low tides per day,
- Period between high tides is ~12 hours, 25 minutes (in each town),
- Timing of high tides varies greatly along this coast!

I go on to introduce concepts of lunar day, tide generating forces & tide prediction, tidal period, spring & neap tides, progressive tides & rotary standing waves, and types of tides. **All in a single 75-minute period.**



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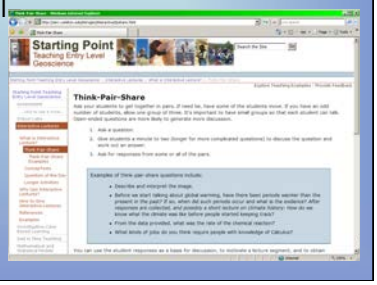
a. Pick one of the sites. Does high tide occur at the same time every day? What time interval separates successive high tides?

These 4 Cape Cod towns lie close to one another, yet they have such different high tide and low tide times. They do share a 12:25 tidal period (= semi-diurnal).

For More Info: Think-Pair-Share

http://serc.carleton.edu/introgeo/interactive/tpshare.html



Minute Papers

Minute Papers

- Pose questions to your during class time
- May be used for attendance / class participation
- Does not take much time to implement
- Promotes metacognition (thinking about learning)

Using Minute Papers

- In the last 5 minutes of class hand out a note card and pose a question on the board
- Have the students turn in the card as they leave the class

Minute Paper Sample Questions

- What were the main ideas of today's lecture?
- What about today's lecture is still not clear? (muddiest point)
- What test question do you think I might ask you to see if you understood today's lecture?
- In your own words, explain _____.

Minute Paper Tips

- You do not need to read every response carefully
- Write down key themes and patterns
- The next day in class, share with the students what you have learned ("Many of you thought …")
- This is a good way to learn students' misconceptions

On your note card, answer the following question:

Which activity that you learned so far today will you most likely use in your class? Why?

We've talked about making lectures an active learning experience…

Is there a way to make summative assessment an active learning experience as well?

Pyramid Exams

2-Stage "Pyramid Exams"

- All exams are multiple choice
- Students take each exam twice
- "Solo" = 75% of grade
- "Group" = 25% of grade - *the auditorium erupts in conversation!*
- **Win-win for everyone!!**
- **Active learning** during an exam: group discussion, debate, problem-solving, diverse perspectives
- Everyone's **grade is bumped up** a little (e.g., 80/100=85; 60/90=67.5)
- Student's feel like they come away **knowing the stuff** a little better
- Opportunity to **succeed in science**!