Teaching Time in Large Enrollment Intro Classes: An Active Approach

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1. Abstract

Teaching deep geologic time presents a number of challenges in large general education courses. First, our general education courses are very large, up to 300 students. Second, at Arizona these courses are for non-science majors only, with many students lacking basic mathematical skills such as scientific notation that can help establish the great length of geologic time. Third, for the vast majority of students in our classes, this is the first, and last, geology course they will take.

We have adopted several active approaches to address some of these challenges. In one, we use a 45 foot rope to represent the Earth's history. While this is probably very common, we try to involve the class actively.

We use about 20 randomly selected volunteers from the class, each given a 3x5 card with an important geologic event written on it, and a clothes pin. The events are numbered from the beginning of Earth history ~4.6 billion years ago to the end of the last major glaciation event about 10,000 years ago.

These 20 students, one by one, are asked to come to the Geologic Rope and place their card on the rope at the right point along the rope. This helps to show how bunched up major geologic events are in the relatively recent past, that dinosaurs are a relatively recent life form, etc.

Most of this may be similar to many classrooms, but we have attempted to involve the entire class at the same time. Students, individually and as part of a graded quiz, have to calculate the percent of Earth's history either from the beginning or back from the present, of major geologic events, such as the beginning of well-preserved fossils or the extinction of the dinosaurs. And once they have the percentages, they must convert this into ages in their own lives, which they can approximate as 20 years for most.

This last aspect is very important, for it emphasizes basic quantitative skills while at the same time helping students relate Earth history to the time line of their own lives. They are typically amazed when their calculations show that, on their individual timeline, dinosaurs went extinct just over three months ago.

I will show other activities we use for radiometric age dating in these large classrooms, with an emphasis on addressing the common misconception that all radiometric material is gone after two half lives.

2. The Beginning of Class ...

Geologic Time = Deep Time

Let's consider an anology to your lifetime ... let's assume that you are 20 years old.

Earth's oldest preserved rocks formed 4000 myrs ago, when the Earth was only about 600 myrs old. How old (percentage) was the Earth at that time?

... 600 million / 4600 million = 0.13 = 13%

You were 0.13 * 20 = 2.6 years old when the same percentage of your life had passed.

What is preseved from your life from before 2.6 years?

3. In-Class Activity

Each of 16 students chosen / volunteered at the beginning of class is given a 3x5 card on which is written a number form 1 to 16, a major geologic event, and an age in millions of years.

A 50 foot rope is placed at the front of the classroom. The student with Card #1 (Formation of the Earth; 4600 Million Years Ago) is asked to go to the front of the class, pick up the leftmost end of the rope, and attach Card #1 to the rope at that point with the clothespin that has been provided.

Throughout the lecture, as the major geologic events are introduced one at a time, in order, the student with that card comes up to the rope and attaches the card to the rope with a clothespin.

In this way, students see, visually, that most of the major geologic events have occurred in the relative recent past, compared to the full Earth History.

4. QUIZ!!!

Please take out a single, full-sized piece of paper. Use/share a calculator. You may collaborate with your neighbors, but you must write your own answers.

1a. The oldest evidence of life dates to about 3500 myrs ago. What % of Earth history passed before this first evidence was preserved? (Hint: 3500 myrs ago was 1100 myrs after Earth formed.)

1b. Assuming you are 20 years old, how old were you when the same percentage of your life had passed?

5. 50 Foot Geologic Rope with 16 Major Events Idenitified Along the Rope ...

6. 150 Students Following Activity / Calculation

7. Students taking quiz ...

8. Information for Along Geologic Rope ...

Geologic Time Rope

EVENT	Age (MA)	% Geo Time	Distance
#1 Formation of Earth	4600	100.00	50.00 ft
#2 Oldest Rock	4100	89.00	44.57 ft
#3 Earliest fossil record: algae	3500	76.09	38.54 ft
#4 Earliest shelled animals (marine)	600	13.04	6.52 ft
#5 Primitive fishes: First vertebrates	500	10.87	5.43 ft
#6 First Land Plants	425	9.24	4.62 ft
#7 First amphibians	380	8.20	4.13 ft
#8 First dinosaurs	245	5.33	2.66 ft
#9 First mammals	245	5.33	2.66 ft
#10 Flowering plants & hardwoods	120	2.61	1.30 ft
#11 Extinction of the dinosaurs	65	1.41	0.71 ft
#12 Abundant placental mammals	62	1.40	0.70 ft
#13 Grazing mammals diversify	35	0.76	0.38 ft
#14 Australopithecus appears	5	0.11	0.02 ft
#15 Ice Ages begin	1.6	0.03	0.01 ft
#16 Last Ice Age ends	0.01	0.0002	0.0001

9. Evaluation

During the Fall 2005 semester the department offered two large-enrollment sections of our General Education course, one with 150 students and the other with 300 students. Taught by two different instructors, both of whom were new to the department and started with the same PowerPoint lectures. One instructor used the Geologic Rope activity, while the other instructor did not. Both lectured on the topic the same day. Also, both gave an exam two weeks later on the same day. Both included the following two questions on their exams:

*Which of the following lists the events in correct order from **oldest** to **youngest**?*

- *A. Earliest life appears on Earth, abundance of oxygen in atmosphere, first humans appear, ice ages end.*
- *B. Moon forms, ices ages end, mammals rule the land, dinosaurs rule the land.*
- *C. Earth forms, abundance of oxygen in the atmosphere, earliest life appears on Earth, first humans appear.*
- *D. Plants appear on land, animals appear on land, first humans appear, dinosaurs go extinct.*

And

Discuss the Geologic Time Scale in relation to its length and importance (i.e., what did you learn from the Geologic Time Scale activity we did in class). Make sure to discuss at least 3 major events in Geologic History, when they occurred, and why they were important.

In both sections the first question led to a much lower percentage of correct answers than the exam average, apparently because many students seized upon "Earth forms" as the oldest possible event, and stopped processing the question. Still, in the class where the Geologic Rope activity was used, the class average on the first question was 6% higher.

The breakdown for the second question was as follows:

Section	% who scored < 50%	% who scored 50-75%	% who scored > 75%
w/ Rope	16%	24%	60%
w/o Rope	10%	51%	39%

Evaluation can be significantly improved in the future, but this preliminary alanysis is consistent with improved student learning using the in-class Geologic Rope activity.

10. A Second Example …

Radiometric dating of rocks is an integral part of establishing the Geologic Time Scale. One persistent student misconception is that after two half-lives all of the parent radioactive material is gone. Two alternative activities specifically address this common misconception.

In the first, the instructor brings in at least one Hershey Kisses® for every student in the class. The Kisses® are placed in a pile on an Elmo®, and projected onto one screen throughout the lecture. A timer is set to 5 minutes. The instructor then proceeds to teach about the concept of radiometric age dating, including half life. Every time the timer goes off, regardless of what the instructor is doing, she/he acts interrupted, goes over to the Elmo®, and sweeps half of the remaining Kisses® into a bag, without explanation, and resumes teaching. If students ask what is going on, but the instructor has not covered half life, she/he says that the question will be answered shortly and continues teaching. Students see, graphically, that after two half lives not all of the Kisses® are gone, etc. At the end of the class the Kisses® are distributed to the students.

In the second activity, all students are given a shiny new penny upon entering class. During class, as half life is defined, they are asked to stand, as able. The students are asked to toss/flip their coins. All those whose coin lands 'heads' up remain standing. Those still standing toss/flip their coins again, and again the 'heads' remain standing. Clearly, after two half lives, many (about one quarter, of course) are still standing. The process continues until the last student tosses a 'tails' and sits down.

In both cases the number of Kisses remaining or students still standing are counted after each half life and the results are plotted versus time to show the characteristic exponential decay.

Neither activity has been formally evaluated, but anecdotal evidence suggests much better understanding of the nature of radiometric dating compared to straight lecturing.