



# Rates of Change and Deep Time in the Middle Grades Classroom: An Effort to Increase

Fredrick D. Siewers, Michael T. Carini, Richard F. Gelderman, Charles H. McGruder, Julia L. Roberts, Rico T. Tyler, and Andrew H. Wulff

## Abstract (#97612)

The nature and scientific measurement of geological and cosmological time are among the most misunderstood and difficult to teach concepts in all of K-12 science education. To address this issue, a multi-disciplinary team of geologists, astronomers and education professionals at Western Kentucky University developed a series of professional development workshops for pre- and in-service middle grades teachers. The goals of those workshops were to 1) to develop teacher's content understanding of rates of change and the ages of the earth and universe; and 2) to provide teachers with materials, activities and teaching strategies to help them more effectively educate students about rates of change and the concepts of deep time. Two four-day workshops were held, with each workshop divided into two two-day sessions. Each workshop day consisted of a blend of in-depth content discussions, hands-on activities, and classroom implementation forums. The teachers were provided with all the materials necessary to implement the lessons learned during the workshops as well as publications pertaining to deep time and evolution. Teachers were assessed prior to and immediately after each workshop day and were required to submit a classroom implementation plan as part of their involvement in the workshops.

We have been successful in meeting our workshop goals. The participants clearly advanced their content understanding of geological and cosmological time and the implementation plans received clearly show a desire to apply many of the activities learned in the workshop. Ironically, and despite state science standards mandating coverage of concepts of rates of change and deep time, teachers find that they do not have the time to fully educate their students about geological and cosmological time. We are currently assessment results and are working to disseminate the workshop materials (<http://astro.wku.edu/universe>).

## Introduction

In the United States today, evolution is under fire in our K-12 curricula. Recent attempts to revise how evolution is taught in US schools have found fault not just with the theory of organic evolution but with current scientific theories about the age and evolution of the cosmos. Our multidisciplinary team (including geologists, astrophysicists, and educators) has initiated a series of workshops to address these issues in Kentucky's public schools. The goal of the workshops is to provide clear, easy to implement curriculum materials to help middle grade science teachers explain to their students how we know the ages of the earth and the entire universe.

## Workshop Structure

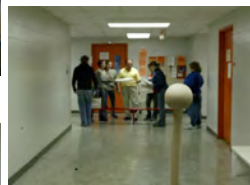
During each workshop the teachers were introduced to a series of inquiry-based, hands-on activities designed to integrate thematic content from the life, earth, and physical sciences. Additional resources (various physics lab materials, earth materials kits, posters, CD-ROMs, etc.) and information were provided to allow each teacher to become familiar with the scientific perspective deep time and of an ancient and evolving universe. The inquiry-based activities emphasized the methods by which scientists study cosmic distances, ages, and evolution. Essential to the organization and delivery of each workshop was:

- The **relative short duration of the workshop**. Each workshop ran for four days. Our goal was to allow overburdened teachers to devote a substantive time to the workshop without imposing too much at any one point in their schedules.
- The **emphasis on teams or pre- and in-service teachers**. Teams were able to share content expertise and teaching experience, and they were able to discuss how best to convey the content of the workshop to middle grades students.
- The **alignment with state and national science education standards**. These included the National Science Education Standards and AAAS Project 2061.
- **Pre- and post tests and knowledge surveys**. These allowed for a quick assessment of workshop objectives and modification during the second year of delivery.

## How Old is your Cosmos?: Distance & Age of the Universe

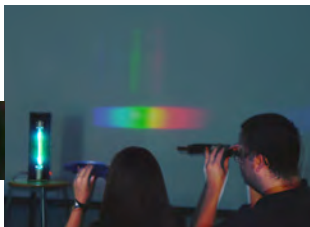
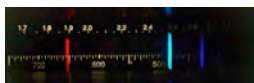
### Day 1: Scale of the Milky Way

Indirect Measurement of Size and Distance (parallax)  
Inverse square law of light (Standard Candles)  
Star properties - color, surface temp, mass, luminosity, and apparent magnitude



### Day 2: Age of the Universe

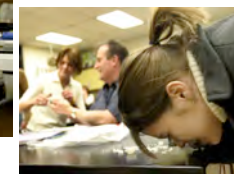
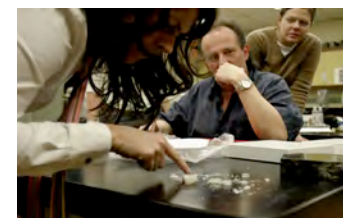
Light and Color  
Emission lines and Spectroscopy  
Doppler Shift  
Expansion of the universe  
Cosmic Distance Ladder



## How Old is your Earth?: Earth Processes & Rates of Geological Change

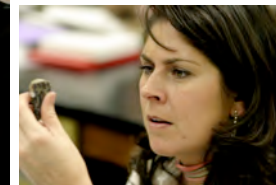
### Day 1: Earth Materials and Rates of Change

Earthquakes, Vulcanism and Plate Tectonics  
Rock Cycle  
Minerals and Rock Properties  
Dissolution Experiment  
Principles of Absolute dating  
Earth Surface properties



### Day 2: Relative Time and Interpreting Earth History

Steno's Laws and Unconformities  
Fossils and biostratigraphy  
Progression of life and evolution  
Field Trip



# Student Understanding Through Professional Development Workshops For Teachers

Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101, [fred.siewers@wku.edu](mailto:fred.siewers@wku.edu)



## Pre-Workshop Assessment Age of the Universe

- a) According to the predominate scientific understanding, how old is the Universe?  
b) What evidence supports this?
- How do astronomers study the universe?
- In addition to planets and stars, what categories of objects make up the universe?
- a) How do objects in the universe form and change over time?  
b) What has caused (and continues to cause) these changes?
- Why does the Sun look different from other stars?
- Why do we use the distance light travels in one year to measure distance between stars?
- Why is looking at a distant astronomical object like looking back in time?
- What effects how bright we see a given star to be? List at least three factors.
- a) Why can't the geometrical/trigonometric method of parallax be used to measure the distance to another galaxy?  
b) Concisely explain how do astronomers measure the distance to the furthest galaxies.
- Concisely explain what must happen to create a rainbow.
- a) Give three separate pieces of observed evidence that the Big Bang occurred.  
b) Were stars and galaxies created during the Big Bang?

## Age of the Earth Relative Time Pre-Workshop Assessment

- How "complete" is the geologic record?
  - How are fossils used to date events in Earth history?
  - a) What are unconformities?  
b) What types of unconformities are recognized?
  - Describe the Law of Superposition.
  - On the time line below, position the following events in Earth history.
    - assembly of Pangea
    - first shelly fossils
    - extinction of dinosaurs
- 4.55 Billion yrs ago present time
- What specific kinds of rocks are common to south central Kentucky?
  - What are the ages of rocks in south central Kentucky?

## Assessment and Evaluation

### Immediate

#### Pre and Post tests

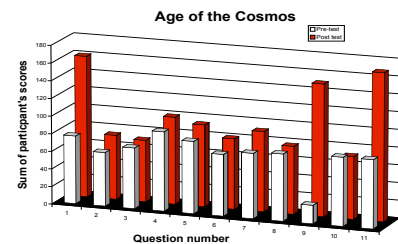
### Ongoing

#### Implementing workshop materials in the classroom

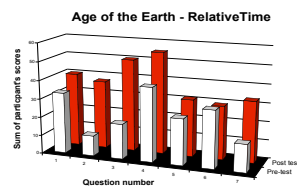
- Submission of an implementation plan by in-service participants
- Observe implementation
- Assist with implementation

#### Classroom visits to:

- Observe the classroom environment
- Observe implementation of workshop materials
- Assist in implementation of workshop materials



Results of the Age of the Cosmos pre- and post test assessment. The total number of points the participants received vs. question number is plotted.



Results of the Age of the Earth pre- and post test assessment. The total number of points the participants received vs question number is plotted.

## Successes and Challenges

### A. Participants expressed appreciation for the theme of the workshop

- Large amount of interest in how scientists determine geological and astronomical ages
- Desire to understand evidence for evolutionary change in physical and biological systems



### B. Inquiry-based presentation was successful

- Selected workshop activities were successful
- Chose to rely on established activities, rather than re-invent the wheel
- Providing teaching materials is critical to the participants

### C. The mixing of pre- and in-service teachers was deemed successful

- In-service teachers have experience with classroom logistics
- Undergrad, pre-service teachers at ease with content and full of enthusiasm

### D. Target audience of middle grades science teachers was good choice

- Science content for grades 5-9 even less frequently addressed by professional development opportunities
- Interdisciplinary themes inspire enthusiasm and tend to match state/district directives for middle grade teaching

### E. Participants expressed that the content matched standards

### F. Scheduling difficulties

- Scheduling around presenter and participant schedules is difficult
- Order of presentation (astronomy vs. geology) appears not to matter
- Two approaches were used, with good and bad points for each:
  - four semi-continuous days (2004 June 3, 4, 7 & 8)
  - or
  - a pair of two-day sessions, separated by a week (2005 February 18 & 19 and 25 & 26)
- Tendency by organizers to overschedule workshop days, providing more content than could be readily absorbed



### G. Participant comfort level

- Most teachers were comfortable with lowest level concepts
- Presentation of evolution did not seem to be a big issue, all participants recognized it is a difficult issue

### H. On-going assessment is difficult

- All parties requested a respite immediately after workshop's conclusion, but then got tied up with all other demands.
- Long term evaluation requires substantial resources, which are rarely included in final budget

### I. Successful Professional Development requires a serious investment of time and resources

### J. Science teachers in rural schools tend to be either oversubscribed or uninterested.

Teachers interested in content-rich professional development workshops are very often serving as coaches, club advisors, etc.

### K. Despite the challenges of time and money, the workshops are worth doing and are beneficial to teachers

## Field Trip: Geology of south central Kentucky



<http://astro.wku.edu/universe/>

The authors gratefully acknowledge support from NASA IDEAS, WKU's Kentucky Climate Center, WKU's Institute for Astrophysics and Space Science, and the departments of Physics & Astronomy and Geography and Geology.

Support for Proposal number HST-ED-90251.01-A was provided by NASA through a grant from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc. under NASA contract NAS5-26555.