Correcting Misconceptions in Geologic Time

Introduction

Most college students have scientific misconceptions which have formed from prior classroom instruction, personal experiences and/or inaccurate media. The field of Earth Sciences is based upon abstract concepts that cannot be easily, or at all, observed by humans, which can cause students to misunderstand geological information. According to Julie Libarkin (2005, p. 18), Professor of Geological Sciences at Ohio University, four key concepts within Earth Sciences have been identified as areas with high rates of misconceptions: understanding vernacular, water and soil formation, plate tectonics and geologic time. Our study focuses on geologic time misconceptions held by students enrolled in EES 101, Introduction to Geology, at the University of Rochester and if the workshop setting is appropriate for targeting and correcting these misunderstandings.

Geologic time is confusing to students for several reasons. Primarily, the human time scale is too short to observe concepts of geologic time. In comparison to the total time of the Earth’s existence, humans have only inhabited the Earth for just a brief moment and cannot observe events such as mountain and ocean building or tectonic drift. Since its formation, there have been drastic changes in the Earth’s environment and understanding these changes may be difficult to students who view the Earth as having a static, stable environment. Additionally, certain geologic time periods are focused on more than others. For example, pre-college courses and popular media focus on the age of the dinosaurs, Pangea and modern, surficial processes with time to other 4.4 billion years of Earth’s history. This imbalance could create
misconceptions on Earth’s age and what it was like when it was formed. Furthermore, certain religious beliefs contradict concepts of geologic time and could be another source for confusion on such areas.

Background

According to Libarkin (2005), “alternative conceptions held by students, particularly college students, are not well documented or understood” in Earth sciences (p. 17). Except for her research, there have been minimal studies focusing on this topic. Although most students hold geological misconceptions, most educators do not know the topics or extent of the misconceptions. From her research working with college students and educators on misconceptions, Libarkin (2006) stated “experienced faculty often have a difficult time believing the alternative conceptions held by college students” (p. 7). Understanding the prior knowledge students have before taking a geology course can help professors change their teaching styles to target this information and correct student’s understandings. Although our survey was conducted as the end of the semester, most students initially had weak understandings of geologic time despite already covering the age of the Earth and its formation in class. This suggests educators must first understand what misconceptions exist among their students and then specifically focus on that idea to dispel the geological myths.

Survey Design & Processing Rubric

Organization of the survey follows from Libarkin (2005, p. 4) and asks workshop students three specific questions related to the conditions on Earth at the time of Earth’s formation, as well as one relativistic question in which students complete a brief timeline with their conception of the timing of major events in geologic history (e.g. first life, dinosaurs,
The survey was distributed three times (on November 16th and November 30th, 2010 and then again on December 7th). The first survey was distributed before students were exposed to the material, the second approximately 1.5 hours after two workshop leaders gave the workshop students a 10 minute short lesson on the concepts of geologic time covered in the survey, and the final survey was distributed one week after the lesson.

In processing the results from the survey it was useful to assign arbitrary values to the responses in order to highlight the development of the survey pool across the various trials. Following Libarkin we subdivided the range of possible responses to each of the four survey questions based on whether the student’s response showed a “strong understanding”, “moderate understanding” or “weak understanding” of the concept being tested. We then assigned 0, .5 or 1 points to the corresponding answer for that student for statistical purposes (0 = weak understanding; 0.5 = moderate; 1 = strong). It was assumed that questions without responses indicated the student did not know the answer and were categorized as a weak understanding.

In distinguishing between the various responses we used the following rubric:

**Question #1**
“If you had a time machine and could travel back to when the Earth was formed:
What do you think the Earth would look like?”

- **Strong**: gas, magma, unsuitable for life, no atmosphere
- **Moderate**: unsuitable for life, chemistry of Earth different than today, “wasteland-esque”
- **Weak**: plants, Pangea, animals, no response

**Question #2**
“How many years back in time would you have traveled?”

- **Strong**: 4-5 billion
- **Moderate**: correct unit of billion
- **Weak**: anything else, no response

**Question #3**
“Would there be any living things? If so, which organisms do you think you might encounter?”

Strong: none
Mod: microorganisms, prokaryotes, eukaryotes, bacteria, etc.
Weak- plants, animals, dinosaurs, aliens, biblical references, no response

Question #4
“The line below represents the time from when the Earth formed to today. Please mark on the timeline when first life, dinosaurs and humans appeared.”

Strong: Humans at far right end, dinosaurs in last 1/4; first life in the first 1/3
Mod: Humans in last ¼; dinosaurs in last 1/3; first life in first ½
Weak: anything else, no response

Results

First Survey, n=20

For the initial survey the average response across each of the four questions fell between 0.2 and 0.6 (less than a moderate level of understanding). We received 31 conceptually “strong” responses across all students and questions. No student showed a strong level of understanding across all questions, and 6 students responded with all weak responses, or all but one weak response to the four questions.

Second Survey, n=19

In the second survey the average response for each of the four questions fell between 0.82 and 0.86 (between moderate and strong level of understanding). We received 63 conceptually strong responses, and 13 students responded with a strong level of understanding to every question. Two students responded with all weak responses, or all but one weak response.

Third Survey, n=17
In the third and final survey the average response for each of the four questions fell between 0.58 and 0.91 (between moderate and strong level of understanding). We received 35 conceptually strong responses, and 3 students responded with a strong level of understanding to every question. One student respond weakly to all but one question and no students provided all weak responses.

![Mean Level of Understanding](image)

Figure 1: The graph above shows the average score, broken down by question, of each survey.

**Analysis and Discussion**

The results from the first survey are alarming in terms of the lack of familiarity with the subject of geologic time. We attribute a portion of the relatively low score to students in the workshop not taking the survey seriously. This notion is solidified by the variability in responses
that we said demonstrate a “weak” level of understanding, such as the age of the Earth is “~BC,” or at the time of the formation of Earth the planet looked “more advanced than today, but whoever was here caused the Earth to destruct and all records of anything and everything were lost.” This “joke” factor, which biases the results toward the weak end of the level of understanding, is unavoidable given the relaxed atmosphere of the workshop setting in which the survey was distributed.

In contrast, the second survey results show a significant improvement over the first. This can be directly credited to several factors. First, students heard a 10 minute lecture on the material covered in the survey at the start of the workshop (approximately 1.5 hours earlier). During this survey the workshop leaders introduced the material by making reference to the misconceptions observed in the first survey’s responses, and then targeted these misconceptions directly. A second factor is related to the student pool having already been exposed to the questions two weeks prior. Thirdly, answers to the four questions were available on a large, scaled, timeline of Earth’s history. Without doubt, these three factors contributed to the marked increase in survey response “level of understanding”. In spite of this positive trend, two students gave weak responses in second survey, which we again attribute to the “joke” factor. However, one student stated that prokaryotes existed at the time Earth was formed and responded seriously to all other questions. This would imply that this student still held the misconception on the evolution of living organisms.

The third survey results were, on average, in between the values of the first and second. For this survey, the geologic time scale was not available to students, so all answers were derived independently. One factor relating to the high scores however is that students were exposed to the exact same survey two times prior. However, scores were significantly higher than the first
survey indicating that the students adequately retained the information and their alternate conceptions were corrected. Of particular note, question 3 had higher results in final survey than in the second survey. This may be a result of a smaller sample size and the absence of joke answers since all answers collected seemed to be serious.

The study was limited due to its small sample size and short time frame. Longer and larger studies in the future may want to compare the effectiveness several methods for combating misconceptions identified in surveys. Possible settings that could be used include lectures by the professor, group problem solving in a workshop model, individual assignments and recitations given by a peer leader. These studies should use a pre-quiz to identify misconceptions, target the concepts in the appropriate setting and evaluate the effectiveness through a post-quiz. This could be compared to a control where no pre-quiz on misconceptions was given to the students. Additionally, studies could be expanded to several other areas of geologic misconceptions.

**Conclusions**

The ability to identify and directly target misconceptions related to geologic time is shown to be effective in the short term and students were able to demonstrate their newly learned knowledge the following week. In the first survey, we were surprised by the quantity of weak responses and expected students interested in geology to have a basic understanding of geologic time. This implies that if educators do not take the time to identify misconceptions and simply assume students have basic information correct, these weak understandings will persist unless specifically targeted.

Several factors, identified above, undoubtedly led to higher results in the second and third surveys. Regardless of these factors, the important point is that students improved their level of
understanding from sub-moderate to, in almost every case, strong understanding of the material after they received a 10 minute lesson by a peer workshop leader that targeted their misconceptions and these improvements sustained the following week. These factors (pre-existing knowledge of the survey questions, availability of answers in the form of a timeline, recent exposure to concepts) are better treated as tools to dispel misconceptions enabling students to more firmly engage with the material through recall and/or repeated exposure. Furthermore, identifying and targeting misconceptions appears to be critical in students’ abilities to change their understandings. These factors should be used to the workshop’s advantage. For example, a pre-quiz distributed at the start of the workshop would force students to outline the workshop’s material before they saw it, and a post-quiz may reemphasize concepts.