Mastering the Concept of Geologic Time: Novice Students’ Understanding of the Principles of Relative Age

Michelle A. Speta, Leslie F. Reid
Department of Geoscience, University of Calgary

ABSTRACT
Misconceptions can adversely affect students’ mastery of the fundamental geoscience concepts necessary for development of the knowledge base required to become a professional geoscientist. In the fall of 2009, in-class learning assessments were introduced into a large (400 student) undergraduate introductory geoscience course to help students develop expert-like, problem-solving skills for geologic problems. They were also designed to reveal students’ misconceptions on geoscience concepts in order to help direct the course of instruction. These assessments were based on simple, real-world scenarios that geoscientists encounter in their research.

One of these assessments focused on the concept of geologic time. It asked students to give the relative ages of granite, schist and shale based on a sketch of two outcrops, and to describe the reasoning behind their answers. In order to test all of the principles of relative age, the assignment had two possible solutions. A post-course analysis of student responses on these assessments was carried out using a modified constant comparative analysis method to identify common misconceptions. This analysis revealed that 61% of students failed to identify both possible solutions. Furthermore, 55% of students did not understand the principle of superposition and/or applied it to intrusive igneous and metamorphic rocks. 18% treated the once connected outcrops as having separate geologic histories. These results suggest that when to apply the principle of superposition, and how to apply the principle of original continuity were the aspects of relative geologic time with which the students had the greatest difficulty. Students also had difficulty using the principles of relative age to provide appropriate scientific reasoning for their choices.

Changes were made to the learning assessments for the fall 2010 semester based on the results of this analysis.

ANALYSIS METHOD
We modified a constant comparative analysis method described by Hewitt-Taylor (2001) as shown in the schematic cycle in Figure 2.

Two rounds of reading through the entire data set were necessary to ensure that all misconceptions were identified.

RESULTS
We found the three most common errors made by students on the learning assessment were:
1. Failing to identify both possible solutions
2. Misunderstanding the principle of superposition
3. Missing the principle of original continuity

The analysis also revealed that many of the errors made in the proposed geologic history of the outcrops reflected a weak understanding of how each of these rock types formed.

The frequency of each misconception is shown in Figure 3.

Table 1: Student Quotes Demonstrating Misconceptions

<table>
<thead>
<tr>
<th>Misconception</th>
<th>Example of Student Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle of superposition</td>
<td>The principle of superposition states that sediment layers are on the top of the rock. The shale would be the youngest because of superposition stating that rock is youngest.</td>
</tr>
<tr>
<td>Principle of original continuity</td>
<td>The principle of original continuity states that the strata on the bottom are older than the strata on the top. The shale would be the youngest because of superposition stating that rock is youngest.</td>
</tr>
<tr>
<td>Principle of horizontal uniformity</td>
<td>According to the principle of horizontal uniformity, the strata on the bottom are older than the strata on the top. The shale would be the youngest because of superposition stating that rock is youngest.</td>
</tr>
</tbody>
</table>

Preliminary results from the 2010 learning assessments indicate that the principle of superposition continues to be an issue for students, however a comprehensive analysis will not be completed until the semester ends.

Figure 1: 2009 Learning Assessment

Figure 2: Schematic diagram depicting the modified constant comparative analysis method used in this study.

Figure 3: Misconception Frequency Histogram (n=104)

Table 2: 2010 Learning Assessment Changes

<table>
<thead>
<tr>
<th>Issues with 2009 Assessment</th>
<th>Changes to 2010 Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than half of the students did not support their proposed geologic history with appropriate reasoning</td>
<td>Replaced instructions on how to present reasoning with a discussion on the processes that formed the rock, emphasizing the application of the principles of relative age, discussing the nature of the contact between the units</td>
</tr>
<tr>
<td>More than half of the students failed to identify both possible solutions in the assessment to discuss errors</td>
<td>Revised course feedback revealed that students wanted a follow-up review of the assessment to discuss errors</td>
</tr>
<tr>
<td>Students had the greatest difficulty with principles of superposition and original continuity</td>
<td>More explicit instructions and the addition of a context to methodology to encourage students to think about how each rock formed</td>
</tr>
</tbody>
</table>

REFERENCES

ACKNOWLEDGEMENTS
The authors wish to thank the students of this course for their participation in this project. The authors also wish to thank the University of Calgary for funding this project. This project was supported by the Teaching Professors Program.