Real-time Assessment of Student Progress in the Lab: The Isostasy Model Example

Lab Objective: Students should be able to discuss how density differs between rocks of oceanic crust and continental crust and the implications of the ocean floor and continents.

Procedure: Students first examine isostasy with wood blocks (basalt and andesite), and then rocks (andesite, basalt, and peridotite). They can compare isostatic rebound with the blocks in water and the Isostasy Model. Now with familiarity of isostasy in the physical world, they can address questions related to computer-modeled crustal isostasy with the density values of the rocks they and their peers collected.

The Isostasy Model: We can use Equations 1 and 2 to calculate the thickness of an object found below and above a reference, respectively.

\[
\text{Thickness}_{\text{above}} = \text{Total Thickness} - \text{Density}_{\text{wood}} \times \text{Density}_{\text{water}}
\]

\[
\text{Thickness}_{\text{below}} = \text{Total Thickness} \times \text{Density}_{\text{wood}} / \text{Density}_{\text{water}}
\]

Students select the Earth layer by the density values they determine.

Materials: Hand samples of andesite, basalt, and peridotite; graduated cylinders, a scale, beakers or cups, wood blocks, and computer(s) with internet access.

Handout: The Isostasy Model Example

Method: Students teach each other without and with treatment. The number of students in each treatment is equal to the number of students in each without treatment.

Results: Students in the treatment lab outperformed the students in the without treatment lab in each of the summative assessment questions. This effect is most notable when comparing the total points students received. The sum of 5 or higher was achieved by 80% of the treatment students compared with about 30% of without treatment students.

Conclusion: The higher scores of the treatment lab suggest this version is more effective in reaching its objectives. We did not attempt to systematically assess the effectiveness of real-time models as opposed to models with only post-processing feedback. However, students found the computer lab an enjoyable and engaging experience and many students praised the opportunity to learn through hands-on activities.

Investigation

Abstract (abbreviated): We compare student performance in versions of a lab exercise: (1) backed by a web-based spreadsheet and model, and; (2) a similar exercise without the web-based component. We compare student performance with and without treatment labs. The number of students in each class or other concurrent classes conducting the same exercise. The instructor can monitor progress and model results in real-time, as well as adjust the model for a group to highlight certain concepts or correct a misunderstanding. We will present our exercise, the accompanying summative assessment used to gauge student performance with the two versions of the exercise, and our analyses.

Background: The National Science Education Standards (1996) describe authentic assessments as “Evaluations [that] require students to apply scientific information and reasoning to situations similar to those they will encounter in the world outside the classroom, as well as to situations that approximate how scientists do their work.” These assessments can be broadly divided into two types: formative, for performance enhancement, and summative, for performance evaluation. Student performance can be improved by providing multiple opportunities for formative assessment in small group settings that encourage students to elaborate on their understanding and confront any misconceptions (Shepard, 2000; Black and Wiliam, 1998).

Small group collaborative learning represents a powerful tool for enhancing student learning, as well as social skills, self-esteem and attitudes towards others (Rosent, 1989; Slavin, 1990). Individual students can work together to make these collaborative learning systems. Studies in Computational Intelligence, 350: 69-91.


Delta Kappan, 80: 139-148.


References

Download the lab worksheets, spreadsheet, and answer key can be downloaded as a Google Drive folder. Scan this QR code with your smartphone or visit the link below.

https://docs.google.com/folderview?id=0B2YzbFhalY2VibG5n

Questions:

1. Consider that the wood blocks represent the “crust” and the part of each rock below the surface of the water represents the “root” of the mountains. Then answer the following questions:

1.1. The crust and root columns for Andesite and Basalt.

Time 1
Time 2
Time 3

1.2. The crust and root columns for Peridotite.

Time 1
Time 2
Time 3

1.3. The crust and root columns for Continental shin and oceanic crust.

Time 1
Time 2
Time 3

2. Draw and label a cross section of the crust and mantle from Raleigh east to the ocean. Be sure to show differences in thickness, and label any density differences in the root (2 pts).

Time 1
Time 2
Time 3

Summative Assessment

Questions:

1. Complete the following assessment right after the lab.

1.1. How do you think the model viewer helped you with your lab activity? (5 points)

1.2. What was the most realistic model you saw on the computer? (5 points)

1.3. What was the least realistic model you saw on the computer? (5 points)

1.4. Did you find any density differences in the crust. (2 pts)

Student scores are reported below as frequency per group. (5 points)

Table 1: Student scores in versions of a lab exercise:

<table>
<thead>
<tr>
<th></th>
<th>With treatment</th>
<th>Without treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 2</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 3</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
</tbody>
</table>

Table 2: Example Questions:

1. Which is more realistic, and include these adjustments in your sketch.

2. How do you think the model viewer helped you with your lab activity? (5 points)

3. Did you find any density differences in the crust. (2 pts)

Student scores are reported below as frequency per group. (5 points)

Table 3: Student scores in versions of a lab exercise:

<table>
<thead>
<tr>
<th></th>
<th>With treatment</th>
<th>Without treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 2</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 3</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
</tbody>
</table>

Table 4: Student scores in versions of a lab exercise:

<table>
<thead>
<tr>
<th></th>
<th>With treatment</th>
<th>Without treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 2</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 3</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
</tbody>
</table>

Table 5: Example Questions:

1. Which is more realistic, and include these adjustments in your sketch.

2. How do you think the model viewer helped you with your lab activity? (5 points)

3. Did you find any density differences in the crust. (2 pts)

Student scores are reported below as frequency per group. (5 points)

Table 6: Student scores in versions of a lab exercise:

<table>
<thead>
<tr>
<th></th>
<th>With treatment</th>
<th>Without treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 2</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 3</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
</tbody>
</table>

Table 7: Example Questions:

1. Which is more realistic, and include these adjustments in your sketch.

2. How do you think the model viewer helped you with your lab activity? (5 points)

3. Did you find any density differences in the crust. (2 pts)

Student scores are reported below as frequency per group. (5 points)

Table 8: Student scores in versions of a lab exercise:

<table>
<thead>
<tr>
<th></th>
<th>With treatment</th>
<th>Without treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 2</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 3</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
</tbody>
</table>

Table 9: Example Questions:

1. Which is more realistic, and include these adjustments in your sketch.

2. How do you think the model viewer helped you with your lab activity? (5 points)

3. Did you find any density differences in the crust. (2 pts)

Student scores are reported below as frequency per group. (5 points)

Table 10: Student scores in versions of a lab exercise:

<table>
<thead>
<tr>
<th></th>
<th>With treatment</th>
<th>Without treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 2</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
<tr>
<td>Time 3</td>
<td>10 10 18 38</td>
<td>60 60 60 60</td>
</tr>
</tbody>
</table>

Table 11: Example Questions:

1. Which is more realistic, and include these adjustments in your sketch.

2. How do you think the model viewer helped you with your lab activity? (5 points)

3. Did you find any density differences in the crust. (2 pts)