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MARINE, EARTH, and ATMOSPHERIC SCIENCES

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

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GLPR NC STATE UNIVERSITY Geoscience Learning Process Research

Investigation

Abstract (abbreviated): We compare student performance in versions of a lab exercise:

(1) backed by a web-based spreadsheet and model, and ← with treatment version

(2) a similar exercise without the web-based component. ← without treatment version

The exercise provides an introduction to plate tectonics in the context of a Physical Geology lab; however, the exercise is adaptable for other courses. Student groups can compare results with groups in the same 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 analysis.

Background: The National Science Education Standards (1996) describe authentic assessments as "exercises [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 (Bossert, 1989; Slavin, 1990). Individual students can work together to co-construct new knowledge and skills (Damon & Phelps, 1989) and solve problems that they are unable to solve on their own (Vygotsky, 1978). Computer-Supported Collaborative Learning (CSCL) environments take advantage of the prevalence of technology in the classroom to support student-student and student-teacher collaboration (Atkisson and Brent, 2011).

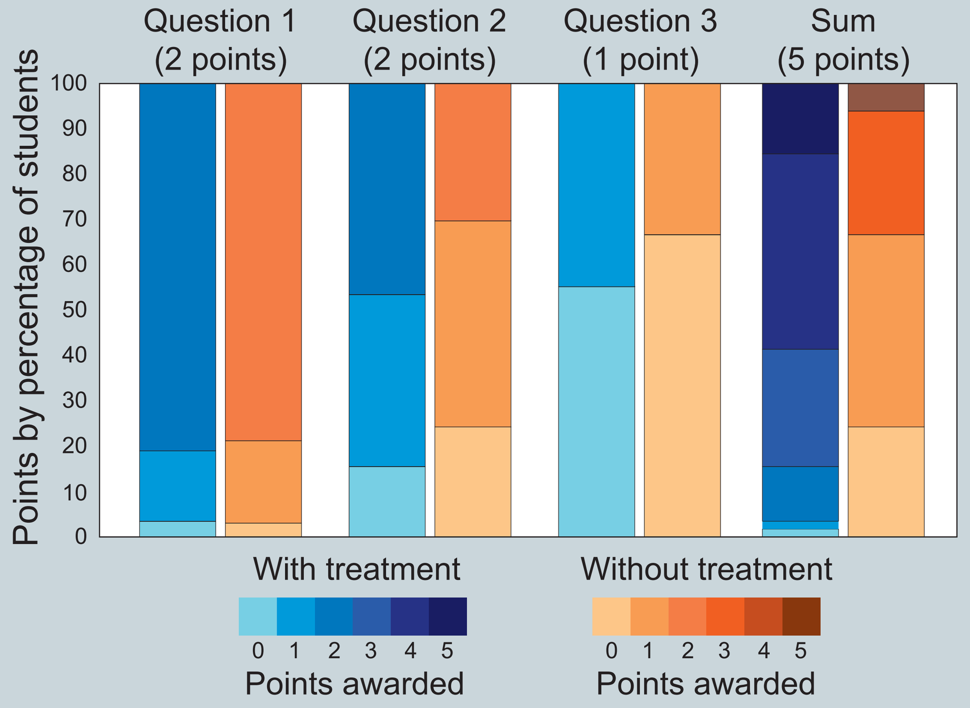
Hypothesis: We test the null hypothesis (H_0)—the means of student scores (μ) on the summative assessment are equal between the treatment (T1) and without treatment (T2) labs—versus an alternative hypothesis (H_a)—the mean of T1 is greater than T2:

$$H_0: \mu_{T1} = \mu_{T2}$$
$$H_a: \mu_{T1} > \mu_{T2}$$

Method: 3 teaching assistants (TAs) conducted with and without treatment labs. The number of students in each section is shown in the table to the right.

	TA 1	TA 2	TA 3	sum
with treatment	10	10	18	38
without treatment	18	18	6	42
sum	28	28	24	80

Results: Students in the treatment labs outperformed the students in the without treatment labs in each of the summative assessment questions. This effect is most notable when comparing the total points students earned. **A sum of 3 or higher was acheived by 80% of the treatment students compared with about 30% of without treatment students.**



The null hypothesis can be rejected at a 95% confidence level that is indicated by a two-sample t-test.

Conclusion: The higher scores of the treatment lab suggests that this version is more effective in reaching its objectives. We did not attempt to systematically assess the effectiveness of real-time modification to the lab. However, TAs reported that Isostasy Model trials elicited numerous questions from students, which allowed them to focus students' efforts on aspects of the model's functionality. We invite others to use this lab, share their results, and implement further adaption of the Isostasy Model Lab.

The Isostasy Model Lab

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

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

Procedure: Students first examine isostasy with wood blocks (balsa and ebony), and then rocks (andesite, basalt, and peridotite). They can compare isostatic rebound with the rocks in water and the Isostasy Model. Now with famailiarity 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.

I: Density and isostasy of wooden blocks

II: Block/rock measurements and density calculations

III: Density and isostasy of earth's crust

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

$$\text{Thickness}_{below} = \text{Total Thickness x (Density}_{wood} \text{ / Density}_{water}) \quad \textbf{Eq. 1}$$
$$\text{Thickness}_{above} = \text{Total thickness} - \{\text{Total Thickness x (Density}_{wood} \text{ / Density}_{water})\} \quad \textbf{Eq. 2}$$

Students select the Earth layer by the density values they determine

Modes:
"My calculations"
"This section's calculations"
"All sections' calculations"
"Manual data entry"

Model inputs can change between wood/water and crusts/mantle.

Students enter Equation 2 into these cells

Student spreadsheet inexperience is addressed with this guide and a short pre-lab activity

These values are used in the Isostasy Model below when "Source of Density Data" is set to "My Calculations"

Students can compare results amongst their peers instaneanously

The model viewer updates automatically to display the input materials and values

Example Questions:

Examine the model produced by your rock density values. Make a labeled sketch showing the relative thicknesses and distribution of the two types of crust and upper mantle. Before you begin sketching, consider necessary adjustments needed to make this model more realistic, and include these adjustments in your sketch. Hint: the mantle is not exposed at the surface.

Are there large differences between the model produced by "This section's calculations" and the model produced by "My calculations"? How about in comparison with all sections? What could explain this?

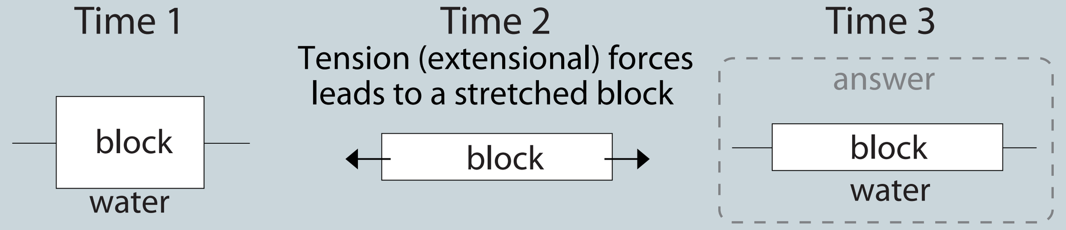
Enter values into the Isostasy Model that produce results that are not realistic. Indicate the values you used and describe why the results are not realistic.

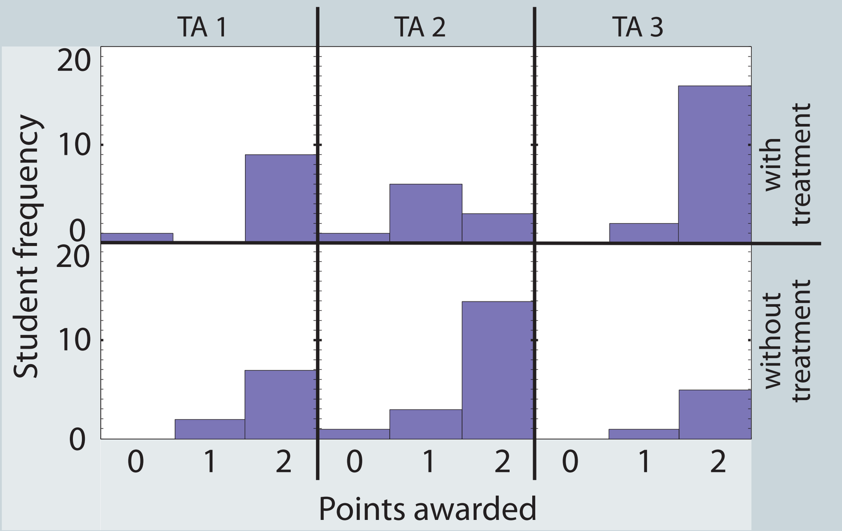
Summative Assessment

Questions: Students individually completed the following assessment right after the lab.

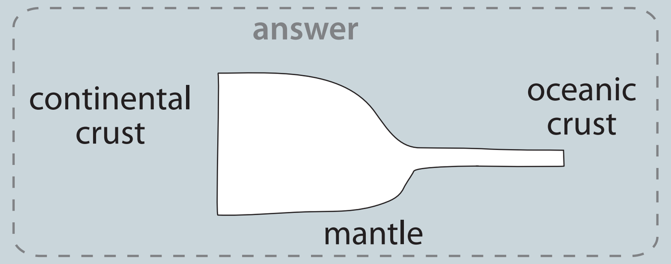
Results: Student scores are reported below as frequency per points earned for each question for a given TA and population (with or without treatment).

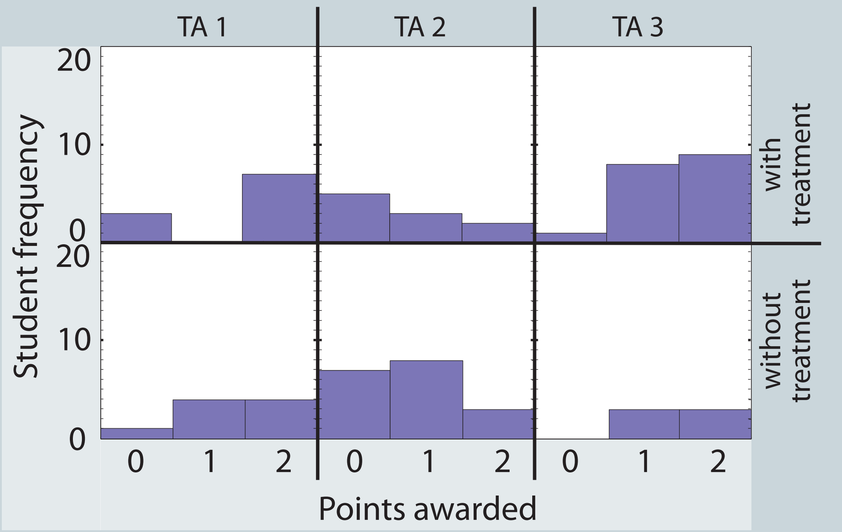
1. *Consider that the wood blocks represent the "crust" and the part of each block below the surface of the water represents the "root of the mountains" that extends downward into the "mantle" (the water). Using the diagram below, draw how the block will float in water during Time 3. (2 pts)*



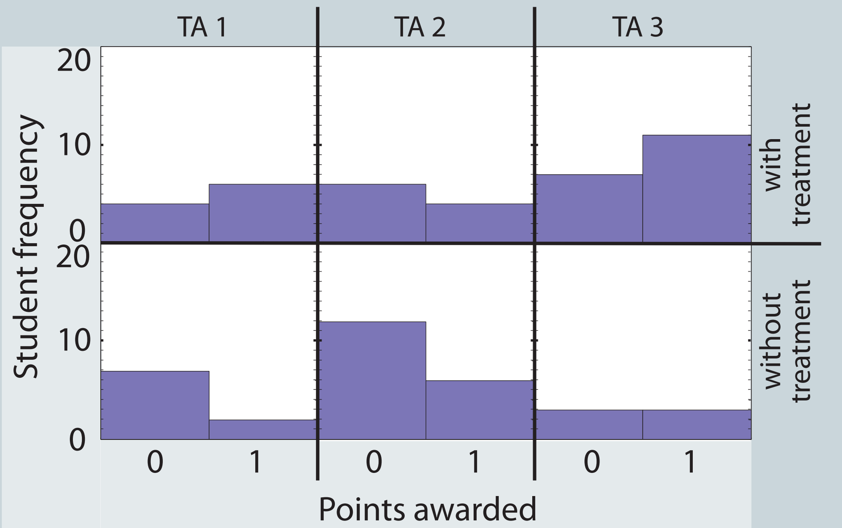


2. *Draw and label a cross section of the crust and mantle from Raleigh east to offshore. Be sure to show differences in thickness, and label any density differences in the crust. (2 pts)*





3. *Metamorphic rocks are formed deep within the crust. However, this rock type is seen at the surface in some places in North Carolina. Explain how removal of mass from the top of the crust explains exposure of these rocks at the surface. Consider that the ground surface of North Carolina is slowly eroding. (1 pts)*
    a. *As the top of the crust is removed, the metamorphic rocks slowly convect their way to the top.*
    b. *As the top of the crust is weathered and eroded, the root rises, eventually exposing the metamorphic rocks formed at depth.* (answer)
    c. *As the top of the crust is eroded, the root spreads out laterally, which exposes the metamorphic rocks.*
    d. *As the top of the crust is removed, this lowers the density of the crust and causes the metamorphic rocks to rise and get exposed.*



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/folder/d/0B2YzbF wNwy9PUVZNbWhVTVVXR2s/edit

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