THE BONDING PROPERTIES OF WATER: AN ASSESSMENT OF STUDENT UNDERSTANDING

Wohlpart, S.L., Demers, N., MacDonald, J.H. Jr., and Hair, T.
Florida Gulf Coast University, 10501 FGCU Blvd. South, Fort Myers, FL 33965

ABSTRACT

Fundamental to most concepts explored in the geosciences is an understanding of the physical properties of water that result from the structure and interactions of its molecules. The purpose of this study was to assess the ability of students in a general education environmental geology class at a regionally accredited university in southwest Florida to demonstrate their understanding of the properties of water using diagrammatic and textual representations. The assessment, which was administered by two different instructors over the course of three semesters, asked students to explain the chemical properties within a water molecule and between water molecules and to illustrate how the adsorbent properties of water affect soils. This assessment was administered as a pre-test at the beginning of the semester and again as a post-test later in the semester following instruction on water and its interaction within the geosphere. In addition, magnetic water molecule models were used by students to explore the dipolar nature of the water molecule following the pre-test. Results from this study indicate that students entered the class with little prior knowledge of the properties of water and that learning gains on this subject were retained throughout the semester. Differences in retention were observed between the courses which might be explained by the timing of the post-test in relationship to the delivery of the content. Based on these results, the inclusion of instruction on the bonding properties of water in introductory geology courses is important to ensure that students have the necessary understanding of this critical concept.

Figure 1. Students working with magnetic water molecule models.

Properties of Water Pre/Post Test

1. Use a labeled diagram and as much text as necessary to explain the chemical properties (bonding features) that occur *within* a water molecule.
2. Use a labeled diagram and as much text as necessary to explain the chemical properties (bonding features) that occur *between* water molecules.
3. Use a labeled diagram to illustrate how the adsorbent properties of water affect soils.

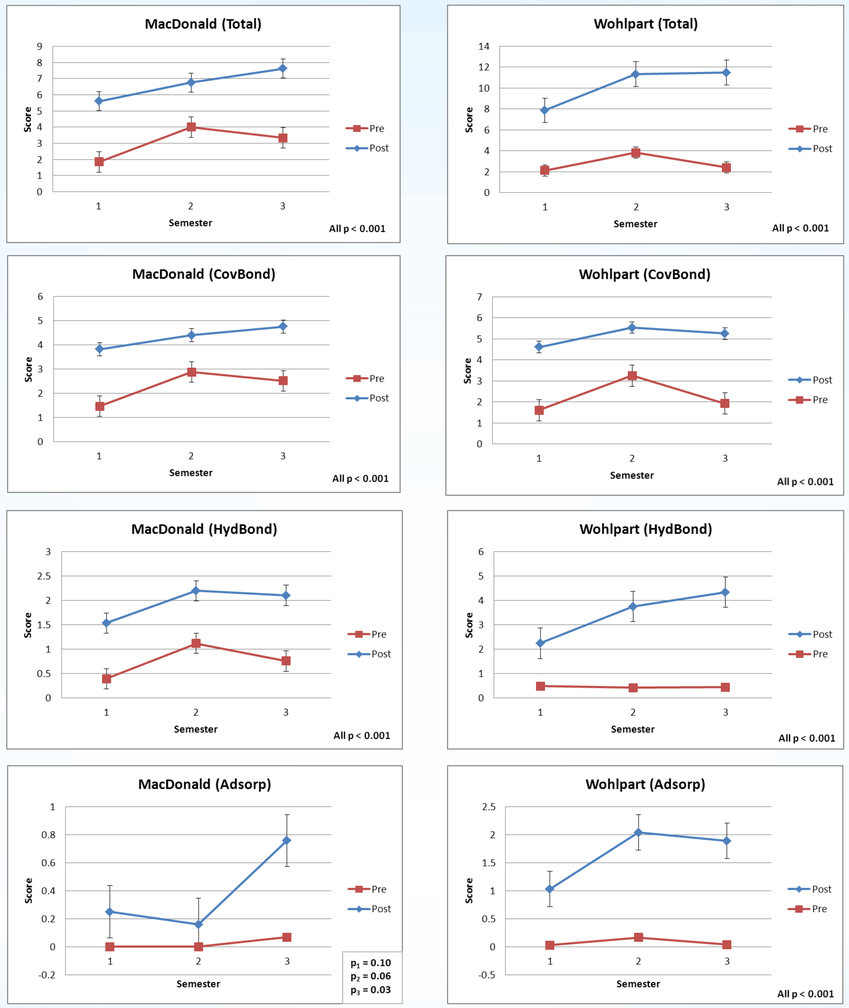

Figure 2. Pre- and post-test mean score comparisons for each concept tested (covalent bonds, hydrogen bonds, and adsorption) and total mean score comparisons for each semester by instructor (Macdonald and Wohlpart). P-values are for each pre/post paired *t*-test.

Methods

- This study was conducted over three semesters, by two different instructors (MacDonald and Wohlpart) in an introductory environmental geology course geared towards a general education audience.
- Each semester, the pre-test was administered prior to content delivery.
- Subsequently, but still prior to any instruction on the bonding properties of water, students were given an opportunity to manipulate magnetized water molecule models designed to simulate the tendency of water molecules to bond with each other and with ions. A series of guiding questions that accompany this activity are designed to increase student awareness of the dipolar nature of the water molecule.
- Later during each semester, following the water molecule activity and instruction on the properties of water and the interaction of water within the geosphere, the post-test was administered.

Results and Discussion

Twenty one out of the twenty four paired t-tests run using data collected for this study show significant variation between the pre- and post-test results. The p-values for the prompt testing student understanding of adsorption as administered by MacDonald was not significant. However, the mean scores for these tests were low to begin with and the p-values are such that we can still assume with over 90% confidence that there was improvement between the pre- and post-tests for this concept.

Post-test scores from both classes during the first semester demonstrate that significant learning gains were achieved for each concept tested. This suggests that students came to the class with little prior knowledge of the concepts being tested and that the use of the molecular models combined with instruction on the topic led to an improved understanding and retention of the subject material.

Post-test results for the second and third semesters illustrate an improving trend with greater significant learning gains from one semester to the next. One possible explanation for this trend would be a change in the delivery of the material from a discrete lesson to the infusion of the concepts throughout the course. Re-visiting the concepts within the context of several course topics provides an opportunity for a deeper understanding of the material.

Differences in retention between students working with each instructor could be attributed to many factors, including differences in the timing of the post-test relative to instruction. As this study continues, standardization of the delivery of the pre- and post-tests relative to the water model activity and instruction of the key concepts will be important in order to maximize our understanding of the benefits derived by this approach.

Conclusions

The results from this preliminary study indicate that students come to this general education environmental geology course with little prior knowledge of the chemical properties of water. Given the integral nature of this topic in geology, it is important that introductory geology courses be modified in order to ensure that students gain a basic understanding of this fundamental concept. This study demonstrates that the use of the magnetic water molecule models for hands-on exploration in combination with instruction on the topic can serve as an effective modification.

Acknowledgements

The authors of this poster would like to thank the Whitaker Center at FGCU for its support of STEM education and Christal Niemeyer for her assistance with printing this poster.

Certification

NIH Certification Number (MacDonald): 154131
FGCU IRB Protocol ID # 2007-36