

Helping Students Connect Science Coursework to the “Real World”

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Abstract. It is fundamentally important to help students connect the material they learn in their science courses to the world they encounter outside the classroom. In this preliminary report, we describe how we facilitated such connections in our undergraduate students by creating materials for a First-year Seminar course, *The Earth* (a non-science-majors course). The materials included specific in-class, small-group discussion questions; talking points in lecture; and a journal where students recorded their observations of the natural world. Our analysis indicated that we improved our students’ attitudes and beliefs about how their coursework relates to the real world, and these improvements were better than those of students with similar experiences but who were not exposed to the additional, tailored course materials.

INTRODUCTION

Much has been said about the importance of improving students’ attitudes and beliefs regarding the nature of science and scientific inquiry and the difficulties associated with augmenting such attitudes.[1-5] In this preliminary work, we began to address some of these concerns by focusing our attention on improving one narrow set of attitudes. Specifically, we wanted to help our students link the material they were studying in their science class to actual, natural phenomena and situations where understanding science can be important for decision-making. In other words, we wanted to help our students connect their science coursework to the “Real World.” In this paper, we refer to observations, questions, or items intended to foster such connections as “bridging” activities.

This paper relies on work previously published by one of us [JM].[5] That article characterized the influence that different instructional styles had on students’ attitudes and beliefs. For this study we used a subset of that population as a comparison group, which, for this article, we named *Trans*, after the instructional style, *Transitional*, they belonged to in reference 5 (N = 47). The experimental group for this study we designate as *Earth* (in reference to the course the students were enrolled in for this study).

POPULATION AND COURSE STRUCTURE

Our study involved a small group (N = 12) of first-year students at McDaniel College enrolled in *The Earth*, a First-year Seminar course designed for non-science majors. One of us [JM] served as the course’s instructor and the other [WK] was the students’ peer mentor. (McDaniel College’s student demographics are outlined in reference 5.)

The course is structured as a *Transitional* course, which implies students spend about half of their class time working on materials that have some research-based components. (For more information, again see reference 5.) The course we report on here differed from the details provided in the aforementioned reference in one critical way: We included bridging activities as part of some in-class materials (which were not graded), a project, and in-class discussion.

For the in-class material, we included bridging questions in four of these activities. These questions specifically asked students to discuss and write down how the day’s topic related to people’s lives and in some cases, their own experiences. Below are two examples, the first from the discussion of the hydrological cycle and the other from the material on tides and waves:

Explain how rain can be transformed to produce energy for your consumption. What are positive and negative effects of hydrologically-based energy production?

Barrier islands and capes are excellent examples of shoreline geography that is strongly influenced by the ocean. Describe how capes and barrier islands form. Mention the balance in sedimentation and erosion. Name a potential problem of living on Cape Cod or the Outer Banks.

In the first example, we explicitly used the possessive pronoun “your” to connect students to the question, and we linked the whole hydrological cycle to energy production, which is an important part of our students’ lives. In the second example, we introduced barrier islands and capes and tried to personalize the material by using popular holiday destinations, in particular the Outer Banks, which are close to McDaniel College.

The students were also expected to keep an *Earth Journal* throughout the semester. The minimum requirements were two short outings per week to record the weather and one longer outing per week to make more detailed observations. (The students were advised to make the longer outing last at least thirty minutes.) We first collected and graded the journals about one-third of the way through the term. Since the students had been exposed to so little course material, we did not expect them to include any bridging observations in this first cycle. After the journals were returned, we gave the students the additional requirement of recording some bridging observations or thoughts. We collected and graded the journals for the second and final time at the end of the term.

Finally, to help foster students’ attitudes and beliefs connecting the real world to coursework, we spent a great deal of time informally discussing how the material in class related to the human race and, in some cases, individual students’ experiences. Briefly, and in part, the course content included weather and global warming, earthquakes and mountain building, population growth and energy consumption, oceans and coastlines, visual atmospheric phenomena (rainbows, halos, et cetera), and the biosphere. Making real world connections was further facilitated by events that occurred in the fall that naturally tied into the course: the four hurricanes that hit Florida, rising gas prices, and the concern that Mount Saint Helens might erupt, to list a few. Connections between the material we were discussing in class and the real world abounded.

Beyond the materials just described, the course had traditionally-graded assignments, including ten homework sets (which included conceptual questions and numerical problems); graded preparatory questions designed to encourage students to complete the reading assignment for that day; and ten-minute quizzes (3), hour-long tests (3), and a three-hour final exam (all of which had various combinations of conceptual questions, sketches, and numerical problems). None of these graded assignments contained any bridging items.

SURVEY INSTRUMENT

Our survey instrument is a modified version of the Epistemological Beliefs Assessment for Physical Science (EBAPS) created by Laura Lising and Andy Elby, with input from Priscilla Laws and David Jackson.[6] This is a 32-item survey with two types of items – five-point Likert scale and multiple choice. The exam is dichotomously scored by awarding one point for the two most expert-like responses and zero for all other choices. Beyond awarding an overall score, the designers of the exam grouped items related to narrow sets of attitudes into clusters. There are five such clusters; we focused our attention on responses to the *Reality* cluster items.

The first four items in the *Reality* cluster are Likert-type and are measured on a scale of strongly disagree, somewhat disagree, neutral, somewhat agree, & strongly agree. The last two items are multiple-choice. Below lies a compilation of the items in the *Reality* cluster. (The most expert-like response is in parentheses next to the item number. The next most-expert-like response corresponds to the adjacent option on the survey. For example, the next most-expert-like response for item 3 is *Somewhat Agree*, while for item 29 it is *B*.)

#3 (Strongly Agree)

Learning science made me change some of my ideas about how scientific phenomena can be used to understand the world around me.

#11 (Strongly Disagree)

Science phenomena are related to the real world and it sometimes helps to think about the connection, but it is rarely essential for what I will probably be doing in this course.

#20 (Strongly Disagree)

Understanding science is important for people who design rockets, but not important for politicians.

#22 (Strongly Agree)

Learning physics, chemistry, and physical science will help me understand situations in my everyday life.

#24 (E)

Scientists are having trouble predicting and explaining the behavior of thunderstorms. This could be because thunderstorms behave according to a very complicated set of rules. Or, that could be because some thunderstorms don't behave consistently according to any set of rules, no matter how complicated and complete that set of rules is. In general, why do scientists sometimes have trouble explaining things? Please read all of the options before choosing one.

- (a) The system simply doesn't obey definable rules.
- (b) Most of the time it's because the system doesn't obey definable rules; but sometimes it's because the system follows rules that are very complicated or difficult to figure out.
- (c) About half the time it's because the system doesn't obey rules, and the other half it's because the rules are complex or difficult to figure out.
- (d) Most of the time it's because rules are complex or difficult to figure out; but sometimes it's because the system doesn't follow definable rules.
- (e) A natural system always follows definable rules, but the rules may be very complex or difficult to figure out.

#29 (A)

Julia: I like the way science explains how things I see in the real world.

Carla: I know that's what we're "supposed" to think, and it's true for many things, but let's face it, the science that explains things we do in lab at school can't really explain earthquakes, for instance. Scientific laws work well in some situations but not in most situations.

Julia: I still think science applies to almost all real-world experiences. If we can't figure out how, it's because the stuff is very complicated, or because we don't know enough science yet.

- (a) I agree almost entirely with Julia.
- (b) I agree more with Julia, but I think Carla makes some good points.
- (c) I agree (or disagree) equally with Carla and Julia
- (d) I agree more with Carla, but I think Julia makes some good points.
- (e) I agree almost entirely with Carla.

ANALYSIS

The results for the entire 32-item survey revealed a familiar trend in the overall score: The *Earth* group, as the *Trans* group before them, showed no statistically significant change in the overall score. Looking at the six items in *Reality* cluster, the *Trans* group did not show a statistically significant improvement at the 95% confidence level, although there is a marginally significant improvement at the

90% confidence level. We did not see a similar increase with the *Earth* group, although our group did start with a significantly elevated *Reality* cluster pre-test score. (See Table 1.)

TABLE 1. Comparison of overall and *Reality* cluster pre-test and post-test scores for the *Trans* and *Earth* groups.

	Pre	Post
Overall		
<i>Trans</i>	57	61
<i>Earth</i>	57	55
Reality		
<i>Trans</i>	71	77
<i>Earth</i>	78	81

The insignificant change in the *Earth* group's *Reality* cluster scores from pre-test to post-test prompted us to look more closely at those scores and to compare them more critically to the *Trans* group to see if there were changes and differences glossed over by the summative statistics. In particular, because the *Earth* group was so small, we had separately investigated how individual responses to *Reality* cluster items changed from pre-test to post-test, so we suspected that some information about their response patterns had been lost by the smoothing of the data that occurs when the two most-expert-like responses are lumped together.

Figure 1 is a histogram of the students' responses to *Reality* cluster items, as a whole, on the pre-test and post-test. We would like to highlight the fact that the pre-test scores for the two most-expert-like responses (bins 1 and 2) for both groups are not statistically different; however, the percentage of most-expert-like post-test scores for students in the *Earth* group (58%) is significantly higher than students in the *Trans* group (38%).

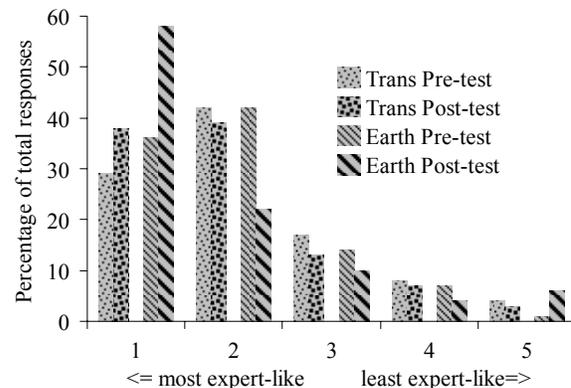


FIGURE 1: Details of the *Trans* and *Earth* groups' pre- & post-test responses to the *Reality* cluster

DISCUSSION AND CONCLUSIONS

Figure 1 reveals an interesting evolution of responses to *Reality* cluster items, which was not obvious simply by looking at the aggregate *Reality* cluster scores. Although both groups had roughly the same percentage of the top two most-expert-like responses, the *Earth* group had a majority of its expert-like responses at the extreme end. We feel this fact reflects very well on our instructional strategy and materials, as it is widely considered difficult to shift attitudes of any sort all the way to the strongly agree/disagree end of the spectrum.

Despite our success, we feel as if we missed a real opportunity to make further significant inroads into the connections students draw between their coursework and the real world by not using the *Earth Journals* more effectively. While grading the journals for the second time it became clear that students did not record serious, if any, bridging observations or thoughts. This was due in large part to the fact that, unlike the rest of the journal, the students did not get feedback on their bridging observations until the semester was finished. In the future we will establish a framework so students can make bridging observations right from the start.

Also, it is worth noting that the *Earth Journal* potentially increased the number of hours students spent working on coursework. However, we do not know this is actually the case, and we would argue that the extra study time added by the journals did not contribute to the improvement outlined above. In light of our comments about the paucity of bridging observations in the journals, it seems that any extra time students devoted to the journals would not have been explicitly directed to their building the desired scientific epistemology. As has been demonstrated previously in references 1 - 5, if a student is not explicitly and plainly engaged by the coursework in a particular epistemologically enhancing exercise, then that student's attitudes will simply not improve.

There remains an open question as to whether we would have seen improvements in these attitudes in this course without our materials. The *Trans* group courses covered optics, sound, and astronomy, but not earth science, so perhaps the increases we documented may be connected to the content and not the intervention. (Reference 5 offers evidence that shifts in broad attitudes are independent of course content, but dependent on instructional environment). It is true that individual students may have felt the earth science class was particularly connected to the real world, but, one could easily say

the same thing about the other science courses, too. All science courses (particularly non-science-majors courses, such as those in the *Trans* group) have strong connections to the real world; we just need to help our students understand that fact.

It seems that the bridging activities included in the in-class worksheets and the intentional lecture-discussion points contributed to the increases we have documented. So why didn't we include more such materials? Aside from the obvious response that we were not sure our materials would have any effect, we did not want to overload the course with materials geared only toward one attitudinal set. There are other facets of students' scientific epistemologies that need to be addressed, so we kept our intervention measured to leave room for future materials designed to impact other attitudes.

In conclusion, by including a modest amount of material specifically directed at improving students' attitudes regarding connections between their coursework and the real world, we were able to increase those attitudes as measured by the *Reality* cluster on the EBAPS. Certainly more work needs to be done in this area, but considering that most reports indicate that instruction often has no effect (or even negative effects) on attitudes, we regard these improvements as an important, preliminary step.

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