SCIENCE COURSES FOR NONSCIENCE MAJORS

How Much Impact Can One Class Make?

BY DAVID REED AND MARK LYFORD

Student survey data are used to highlight persistent benefits from a science-for-nonscience-major course.

It has been widely documented that scientific literacy is lacking in the general public (Bybee and DeBoer 1994; DeBoer 2000; Gardner et al. 1983; Mooney and Kirshenbaum 2010; NCES 2012; NRC 1996; Siebert and McIntosh 2001). While measures of literacy vary greatly and often are based on understanding of scientific concepts and facts, reports indicate the general public also lacks knowledge about scientific processes (NSB 2010). Increasingly, many issues we currently face as a society are grounded in science, such as climate change, energy use, and water use. Each of these issues is complex from a scientific standpoint since individual issues require basic knowledge from a variety of disciplines (i.e., understanding climate change requires understanding fundamental concepts of Earth science, chemistry, physics, and biology). Understanding these issues also requires knowledge of how scientific endeavors are conducted, with a sense of the role science plays in working on these global issues. Moreover, these issues are complex because they are tied to myriad nonscience issues (e.g., economics, politics, human health, environmental concerns). Finally, perhaps equally important if not more important for the general public, is fostering a positive attitude about science to garner support and a level of trust of the scientific endeavors that will play a role in solving these global challenges. Clearly, education at all levels can play a role in increasing knowledge about science and scientific endeavors as well as improving individual attitudes and comfort with science.

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The abstract for this article can be found in this issue, following the table of contents.
DOI:10.1175/BAMS-D-13-00003.1

In final form 7 January 2014

INTERDISCIPLINARY COURSE DESIGN. Here, we focus on efforts at improving scientific literacy, attitudes, and future behaviors for nonscience majors in an introductory integrated science class designed and taught by Lyford at the University of Wyoming. LIFE 1002 (Discovering Science) is a freshman-level integrated science class designed for nonscience majors meeting the university science requirement. Looking nationally, the design and implementation of introductory science courses for nonmajors varies greatly in terms of educational goals and approaches, ranging from traditional overview courses focused primarily on content to courses designed to engage students in real-world applications. The overarching goals of LIFE 1002 are threefold: 1) to integrate concepts from across scientific disciplines by focusing on real-world issues like energy use and climate change, 2) to explore the nature of science and scientific endeavors well beyond the traditional "scientific method" approach (e.g., questions science can and cannot answer, the limitations of science, scientific uncertainty, understanding the world through models), and 3) to explore the inextricable connections between science and society. While these three goals are frequently articulated to the students, an unstated course goal is to improve student attitudes about science and comfort talking with others about science. Like at many other institutions, many of these students enter the course either uninterested in science or afraid of science or have never had a single positive experience with science. While the unstated goal is to improve comfort with and attitudes about science, it is important to state that the course is designed to be relevant yet challenging, two points that are frequently discussed with the students during the course of the semester.

Students attend three 1-h lectures (1 section, all students), a 2-h laboratory (6 sections, maximum 24 students), and a 1-h discussion (6 sections, maximum 24 students) each week. The lecture focuses on all the goals stated above but particularly on integrating concepts from across the science disciplines as well as discussing the nature of science. Science concepts that are covered are filtered by asking the following question: "Is understanding this concept required to understand climate change, or energy use?" In other words, the societal issue serves as the filter by which science content is selected. Hence, the course is by no means a comprehensive coverage of all concepts in biology, chemistry, Earth sciences, and physics. The laboratory builds on the concepts taught in the lecture but has a primary emphasis on how science works. Students engage in a wide variety of interdisciplinary activities, a few of which are experiments that they design and implement. Each activity also ties to the issues being covered in the lecture, hence building a sense of relevance in the laboratory as well. Finally, the discussion is where students are particularly challenged to explore the complexity of energy use and climate change from a scientific and societal standpoint. Here, students are expected to conduct guided research to develop products focused on energy use and climate change. As an example, for energy use, students are asked to develop an energy plan for the United States that calls for a 25% reduction in either petroleum for transportation or coal for electrical generation. In doing so, students must research alternate energy sources looking at cost, feasibility, scale of implication, connections to economics and politics, and potential unintended consequences of their recommendations.

STUDENT SURVEY AND RESULTS. For the fall 2012 semester, we developed a voluntary and anonymous pre- and post-survey, which covered a variety of topics, ranging from student interest and comfort with science, to political backgrounds, to expectations for performance in the course, recording student responses on a five-point Likert scale (the survey can be found at the online archive). Of the 142 students enrolled in the course, we recorded 130 pre-survey responses and 110 post-survey responses from students. A total of 99 students completed both the pre- and post-survey during the semester. In addition, we asked the students to complete the same survey 3 months after completing the course. A total of 26 students completed all three surveys. Results for all three surveys (pre- and post-: n = 99; 3 month: n = 26) were compared using a Wilcoxon signed-rank test. No discernible statistical connection between course grade and likelihood of survey completion or responses to the survey was found in all three surveys. In addition, statistical comparisons showed that the 26 students who completed the 3-month post-survey were statistically indistinguishable from the other 73 students who completed the pre- and post-surveys. They were not simply the students who were more motivated or interested. We also note that, of the 142 students who enrolled in the course, only 3 withdrew. Hence, our results were not skewed in any way by the loss of less motivated or interested students. Initially, we were looking for predictors of success in the course, as well as whether one science class could make an impact on student attitudes and comfort with science. We share results from selected portions of the survey, as interesting patterns emerged relative to student comfort in science related to their expectations for their grade in the course and their confidence in studying science (Fig. 1).

Comparing student responses across all three surveys, significant improvements were seen in student interest in science as well as their comfort with science in multiple facets of their lives (Fig. 1). An "unplanned" control was the question related to their comfort participating in the discussion on the economic cost of taking action versus inaction on a science-related issue. The post-survey was given prior to students engaging in this activity, and no difference was shown between the pre- and post-survey. Yet, after completion of the semester, student comfort went up significantly, suggesting the differences in student attitudes were an effect of the course.

When asked 3 months after the completion of the course, "Do you feel like science is a larger part of your daily life now than before?" one particular student response was the following:

> I feel like science is a bigger part of my life now. I know that it doesn't reflect in my grade [C], but gaining a better understanding of basic and moderate sciences as [*sic*] help me in my daily life. It has helped me in daily life by understanding the importance the natural resources that we have and it has helped me to have a better understanding of taking an initiative in doing reasearch [*sic*] on science. And to realize that science is actually all around me.

While this is just one student response, in general students signaled that they have continued to think and interact with science topics. This particular response was highlighted since the student struggled and received a lower grade than initially desired but kept an overall positive mood of science.

One of the most interesting results that emerged was that, while students showed a greater interest in and comfort with science at the end of the course, their own expectations for their grade decreased

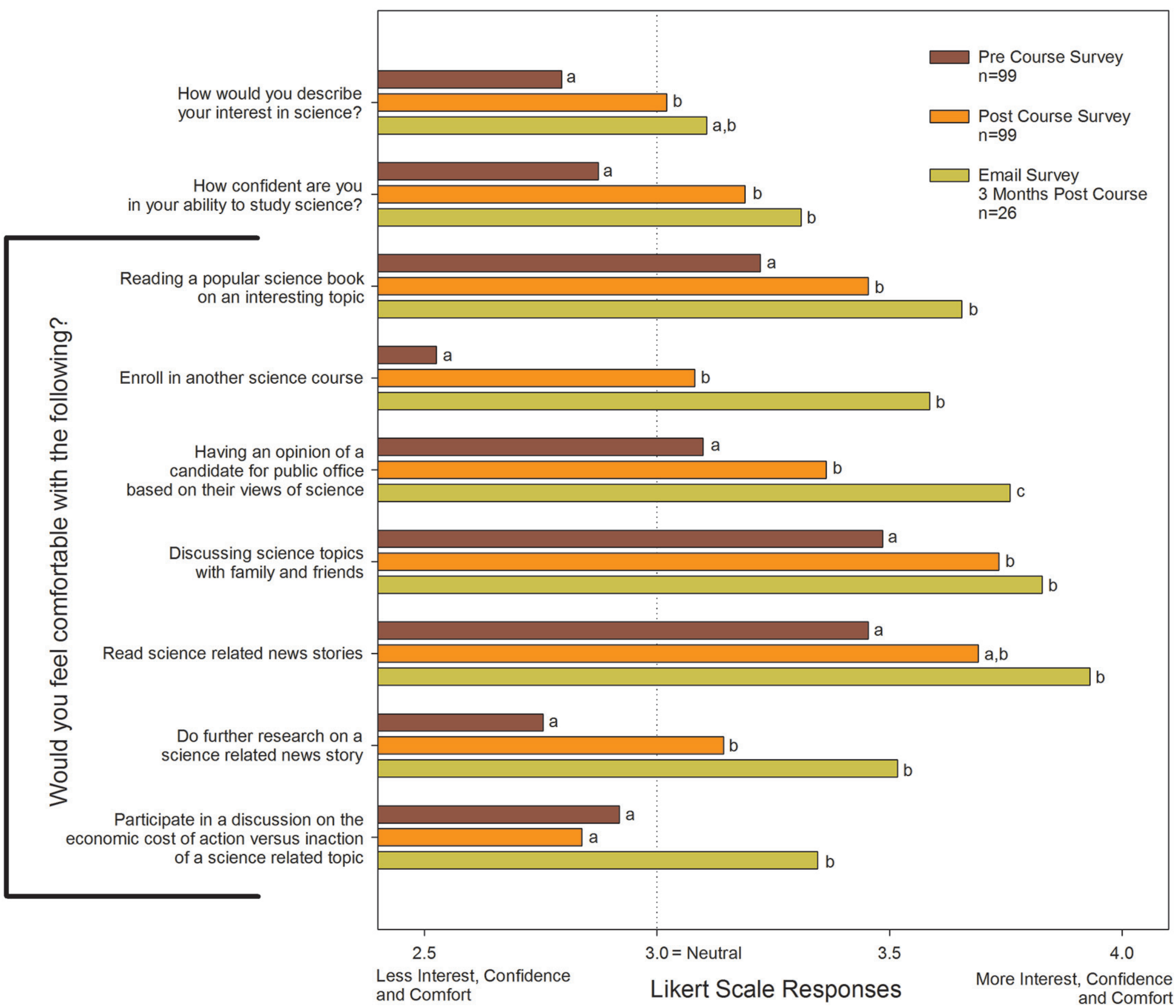

Fig. 1. Likert scale (1–5 scale) student survey responses are shown with the dashed line signifying a neutral response to a given question. Statistical differences were found with a Wilcoxon signed-rank test. Additional written prompts were added to the follow-up survey that was done via e-mail, but otherwise question wording did not change between surveys. The sample size of each survey is noted as *n*.

significantly by the end of the semester. On the pre-survey, 60% expected to earn an A, 36% expected a B, and 4% expected a C. On the post-survey, this shifted to 29% expecting an A, 50% expecting a B, 19% expecting a C, and 2% expecting a D. So, while they knew they likely would not get the grade they thought they might at the beginning of the course (i.e., the expectation was this would be an easy non-majors course), their attitude, comfort, and favorable behaviors still increased. Moreover, even with lowered expectations for a final course grade, students felt more confident in studying science. This suggests that one can indeed teach a rigorous course for non-majors that remains challenging to students and asks students critically about scientific issues while still seeing improved interest and attitudes about science.

POTENTIAL FACTORS DRIVING THIS CLASSROOM CHANGE. We believe taking non-science major students and helping to positively shape their interactions in science, while maintaining high standards from the course itself, can be accomplished because of a number of tangible and likely intangible factors. First, centering a course on relevant current issues like energy use and climate change helps students realize why science actually matters in their daily lives. Second, merging science and nonscience disciplines makes these issues even more real world. In fact, if one knows the majors of the students in the class, they can tailor some of the nonscience concepts toward these students' majors (e.g., history or economics). Also, by having students wrestle with these complex issues in discussion and having to produce a realistic product—an energy plan for the United States—they grow in their critical thinking skills and their ability to relate these issues to their daily lives.

While these factors in part might explain why student interest and comfort levels increase over the course of the semester, there are likely myriad intangible factors attributed to the instructors in the course that also play a role in attitudes and comfort, as well as an increasing confidence in studying science in the face of decreasing expectations for performance. Being honest with students up front that this course is not necessarily easy science class is critical. Yet, one must also express a sincere willingness to help students succeed. Indeed, these are common themes throughout this course. Finally, as any educator recognizes, the enthusiasm and approach individual instructors bring to the classroom experience can make all the difference. While these intangible factors may be hard to prescribe, we believe a fundamental factor that led to improved student attitudes and interest was based on the design of the course, centered on relevant issues and engaging students in realistic activities.

ACKNOWLEDGMENTS. D. Reed was supported by Wyoming NASA Space Grant Consortium for this project. We thank C. Buchanan, M. Jones, and J. Irwin for the extra time commitments as teaching assistants for this project and Yost R. for survey collection and processing assistance.

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