Using Citizen Science to Engage Introductory Students: From Streams to the Solar System†

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We present two examples of citizen science learning activities, with discussion of how these activities align with teaching strategies shown to increase retention of under-represented minorities and improve learning for all students in science. For introductory science students from diverse backgrounds, citizen science provides a unique hands-on opportunity to engage students in the process of scientific discovery and to contribute to real science through their curriculum. These tools also increase engagement of science majors and address the current national priority of increasing student retention in science, technology, engineering, and mathematics (STEM) fields.

INTRODUCTION

Citizen science, the collaboration between professional scientists and the public, provides a unique opportunity for innovation in science, technology, engineering, and mathematics (STEM) education. The goals of citizen science are to enable new scientific research, broaden participation in scientific studies, and increase national awareness surrounding topics in science (1, 4–6, 10, 14). Participating in citizen science increases epistemological beliefs about science and the ability to think in a scientific manner (6, 14). Citizen science provides unique, hands-on opportunities to engage students in the process of scientific discovery, to make scientific contributions, and it is aligned with research-supported educational practices (2, 7, 9, 11). In this paper, we show two examples that demonstrate the use of citizen science to support the transformation of curricula.

Citizen science can engage students from various backgrounds to increase their scientific literacy and appreciation for science. Through citizen science, faculty can emphasize how students’ work can be used for real, practical science progress. Activities can be integrated in a variety of ways, from projects forming the backbone of a course to individual homework assignments. Citizen science projects with minimal (or no) costs to implement are readily available. Moreover, students can continue to participate in these projects long after the semester’s end.

PROCEDURE: INTEGRATING CITIZEN SCIENCE INTO THE CURRICULUM

The solar system: an integrated homework activity

In introductory astronomy, students can use citizen science projects to explore our solar system, even participating in discoveries with current space missions. During the spring 2015 course, students explored asteroids and the geologic history of our solar system in class, in labs, and through the textbook, while new data from the National Aeronautics and Space Administration’s (NASA’s) Dawn mission were highlighted in the media. As volunteers can reliably reproduce experts’ crater identifications, the students were able to identify and mark craters on images sent back to Earth by the Dawn mission (8), helping them appreciate their importance in models of geologic history (15).

The citizen science project Asteroid Mappers provided students with the opportunity to analyze data from the Dawn mission and was incorporated into the curriculum through a brief introduction during lecture, a homework assignment, and a follow-up in-class reflection (Appendix I). Class time introduced the assignment and got students thinking about the mission goals. Next, a graded homework assignment asked students to read about the Dawn mission, articulate its scientific purpose, and through participation in the Asteroid Mappers project, identify craters on actual images (Appendix 2). By participating in this activity, students learned how to recognize craters and had the opportunity to contribute to an ongoing scientific research endeavor—advancing the science they were learning about in the course. A brief ungraded entry exercise and discussion allowed students to share their experience with others and to connect their work...
to the larger science goals of the citizen science project. The informal class discussion revealed that many students found the activity engaging and demonstrated that they were making connections between the space images and a previous lab where they created model craters. Further research into the direct impact of assignments like this is ongoing. Similar assignments are easily integrated into existing curricula and they have the potential to make a large impact on students’ understanding of science as a way of thinking rather than a static body of knowledge.

Introduction to environmental challenges: biomonitoring field project

In this course, citizen science provided students with the opportunity to investigate interdisciplinary perspectives on key environmental issues, examining interactions between humans and natural systems through a project monitoring the health of a local river (Appendix 3). The project involved biological monitoring with benthic macroinvertebrates in a local tributary of the Charles River, part of the larger field-science program run by the Charles River Watershed Association (CRWA). This project replaced traditional reading, lecture, and lab book–based activities to provide real-world examples for understanding the following learning goals: 1) understand local, regional, and global environmental systems and processes, 2) understand urban impacts in watersheds, 3) gain experience in formulating and testing hypotheses, and 4) interpret results of these tests. Most importantly, students were able to learn from and collaborate with a scientist who was specifically managing the project they participated in. Students became engaged in their project and came to understand that their data would help the individual scientist achieve his goals, as well as the organization’s goals for understanding and managing the watershed.

Training sessions lead by CRWA scientists and the course instructor were held to discuss habitat types, quality, factors that impact habitat quality (urbanization, historic and current sources of pollution, abiotic conditions), and how these factors influence assemblages of organisms found in an area. Training also included safe sampling techniques to collect, preserve, and identify the benthic macroinvertebrates. Working in groups, students assessed the habitat for their section of the river using the Environmental Protection Agency (EPA) Rapid Bioassessment protocol and used kick nets to collect samples of benthic macroinvertebrates. Later, students separated the macroinvertebrates, identified them, and sorted them into classes used to determine a water quality score. Samples from other river sections differing in habitat quality and macroinvertebrate assemblages were available for comparison. In a written lab report, students analyzed their data, drawing conclusions about the environmental status of the river (Appendix 4). Student ability to integrate knowledge gained in understanding the impacts of urbanization on aquatic systems and derived ecosystem benefits in terms of general food webs, geochemical cycles, and climate change was assessed in a midterm (Appendix 5). This activity engaged students in understanding their local watershed and how human activities impact it, while at the same time contributing data to CRWA for management decisions regarding habitat and water quality within the Charles River Watershed.

CONCLUSION

Citizen science activities, such as the two presented here, support research-based educational practices associated with increased student learning, persistence, and retention in the sciences (2, 3, 7, 9, 11, 12, 14, 16). Resources for faculty interested in incorporating citizen science into curricula are presented in Appendix 6.

Projects require minimal background knowledge, allowing students in introductory science classes to participate in research early in their college careers, an intervention shown to have a positive effect on the persistence of women and minorities in science (9, 12, 16). Students directly engage with data and analysis, allowing them to put new knowledge of the subject matter directly into action (7). Overall benefits include understanding that their work contributes to new discoveries and hearing from scientists about ways in which their contributions are meaningful (4, 13, 15). Moreover, these activities expose students to future job ideas, increase their overall knowledge of scientific concepts, and embed practices (e.g., data analysis, logical analysis, creative and critical thinking, independent research, identifying cause and effect relationships) supporting basic scientific literacy.

SUPPLEMENTAL MATERIALS

Appendix 1: Description of Asteroid Mappers activity in Introductory Solar System
Appendix 2: Homework assignment for Asteroid Mappers activity
Appendix 3: Description of Biomonitoring Field Project in Introduction to Environmental Challenges
Appendix 4: Lab report checklist for Biomonitoring Field Project
Appendix 5: Example of midterm incorporating Biomonitoring Field Project
Appendix 6: Resources for faculty incorporating citizen science into undergraduate curricula

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