

IBI\* SERIES WINNER

# An Inquiry into the Water Around Us

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On a bright October morning, three young women in laboratory coats work together amid chemicals, instrumentation, and laboratory notebooks. The scene looks like a typical university chemistry lab, but two of the scientists are actually local high-school students analyzing water samples they have collected from around their community. Their undergraduate lab partner is completing the general chemistry lab module “An Inquiry into the Water Around Us,” which harnesses the intellectual power of three important pedagogical components: inquiry-based learning, service-learning, and instruction in scientific communication. The project brings science, technology, engineering, and mathematics (STEM) majors into direct collaboration with younger students to explore the critical community issue of water quality. This combination approach has the potential to promote recruitment of STEM majors, motivate underrepresented secondary (middle- and high-school) students to attend the university and pursue STEM careers, support retention of female STEM majors, and shape a more civically engaged population of future scientists through the inclusion of service-learning, a pedagogy that takes the college classroom into the community (1, 2).

The module’s centerpiece is a 2-month collaborative investigation between college students and their high-school lab partners, which brings together students on their respective campuses through interactive Web conferences that introduce and summarize the project. Once the project is launched, the secondary students collect water samples from local lakes, wells, and other community sources to investigate alongside the



Three students working on the laboratory experiment.

university students. Related experiments are performed separately at each institution, and one collaborative experiment is performed when the secondary students visit the university campus (see the photo). Each is intended to increase students’ understanding of chemistry concepts while encouraging scientific problem-solving, communication, and civic awareness.

Virtual communication tools create a unique learning opportunity and simplify service-learning logistics, such as scheduling and transportation (3, 4). Dialogue between the two populations takes place synchronously through Skype and/or FaceTime and asynchronously through personal letters. These details allow maximum student interaction and minimal travel, which gives the project a small carbon footprint and a large academic impact.

True to the nature of inquiry, the module focuses on the process of science and models authentic research practices in the classroom (5). The amount of guidance provided varies for each experiment, as activities are at many points on the inquiry spectrum. Experiments begin with key questions, and students are tasked with designing their procedures to collect evidence and make claims in response. The most-guided activity is the Analysis of Hard Water Ions, where students are provided with an “established method,” intended to mimic U.S. Environmental Protection Agency (EPA) methods used by envi-

An Inquiry into the Water Around Us, an IBI prize-winning module, brings the college classroom into the community.

ronmental chemists. The least-guided activities are Phosphate Analysis and Total Ion Concentration. In every experiment, students organize their results, construct meaning from their data, and make claims based on their evidence. Each set of lab partners investigates a unique local water sample that contributes to the overall analysis; aggregation of class data allows students to analyze data in context and observe trends that might have broad community implications.

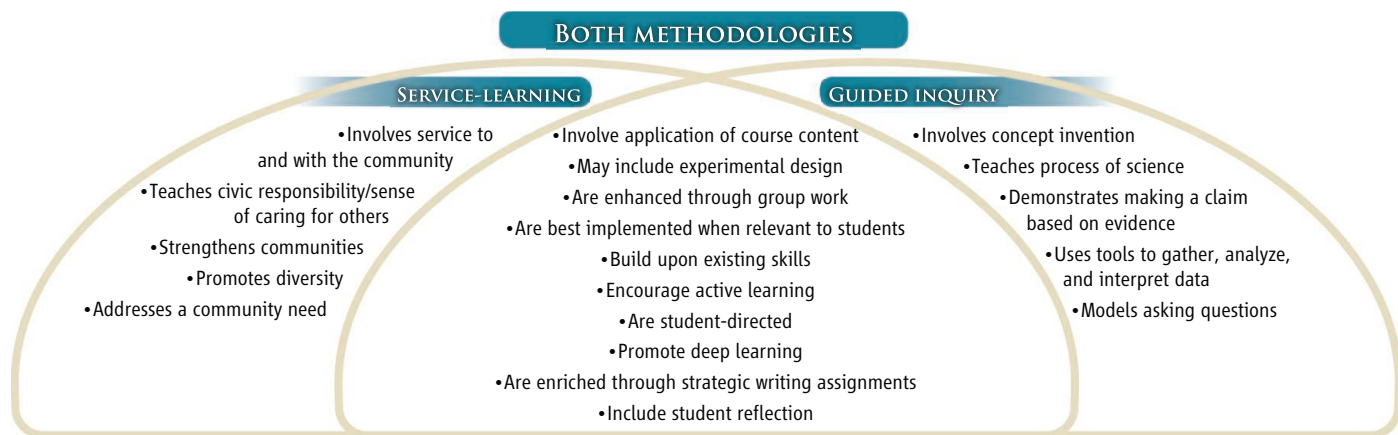
Service-learning engages students as co-investigators, giving both populations the opportunity to take ownership of the work. The module encourages undergraduate students to identify themselves as part of the scientific community, as well as their local community, and inspires them to use their knowledge and position in civically minded ways.

The module’s emphasis on informal and civically focused communication instruction encourages students to think about how scientists interact with their communities. Reading assignments include local newspaper articles and periodicals that discuss excess nutrients in local water systems and the debate over EPA regulations, framing the project within a broad context. Students are given writing assignments to explain scientific findings to their secondary school partners through personal letters. Instruction in this regard is critical: During the first iteration of the project, many of the university students’ letters summarizing the research results could not be sent because they included incorrect assumptions, unnecessary sensationalism, or inappropriate tone. After modifying the assignments, a strategic approach to writing instruction and practice was developed in the “Scientists Write!” portion of the curriculum. This weekly homework activity reinforces lessons about scientific communication and frames targeted writing assignments. Focusing on topics such as audience, purpose, and word choice, writing assignments are now

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\*IBI, Science Prize for Inquiry-Based Instruction; [www.sciencemag.org/site/feature/data/prizes/inquiry/](http://www.sciencemag.org/site/feature/data/prizes/inquiry/). †Corresponding author. [erin.saitta@ucf.edu](mailto:erin.saitta@ucf.edu)



The unique and overlapping fundamental themes (5–10).

integrated to complement and deepen the learning process.

Although inquiry and service-learning are extensively researched and widely implemented individually, there is currently no published dialogue on how the two can be applied simultaneously in a science lab. We have found that the two methodologies, particularly when supported by an emphasis on scientific communication, complement each other with overlapping themes as seen in the chart above. Both encourage active learning and the application of course material. Inquiry-based learning adds a focus on concept invention and the process of science, whereas service-learning contributes to students' civic awareness and underscores social relevance.

Standardized departmental content-mastery assessments indicate that the university students who have participated in the service-learning inquiry module learn chemistry content to at least the same extent as those in the inquiry-only curriculum. End-of-semester surveys indicated that 93% of students felt that the project helped them evaluate information, communicate ideas, and apply course

content in the real world. In addition, all 82 students who have completed the module thus far reported that the experience allowed them to engage in positive interactions with people from different social, economic, and ethnic backgrounds from their own.

Two key lessons learned from successful implementation of the module include

1) Well-managed ongoing and direct correspondence between the secondary and college students is crucial. Although our first iteration of the project included a single group-to-group virtual connection, learning outcomes and satisfaction levels for both populations were improved when students made multiple personal connections throughout the project.

2) Simply making a positive connection with secondary peers is not sufficient to help college students learn to communicate effectively. To maximize the student learning outcomes in content and communication, writing about science for a variety of audiences must be explicitly addressed in the course.

An Inquiry into the Water Around Us was designed to be a valuable addition to any general-chemistry inquiry curriculum. The experiments teach chemistry content

in a course that meets once a week and uses equipment that can be found in most laboratories. The inquiry activities investigate actual environmental samples and include social and political dialogue important to the local community. The service-learning component requires no outside travel for undergraduates yet serves as motivation for engagement.

References and Notes

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Supplementary Materials

[www.sciencemag.org/cgi/content/full/341/6149/971/DC1](http://www.sciencemag.org/cgi/content/full/341/6149/971/DC1)

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