Case study: Introductory Chemistry at Beloit College

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What works for introductory chemistry students at Beloit College is a new course that trades lectures and examinations for more time in the laboratory. Lots of hands-on laboratory experience, students and faculty working together to discover important chemical concepts, and projects that tie chemistry to everyday experience have proved to be effective in catching and holding student interest. Both students who continue in science and those who do not come away from the course with a better understanding of how science progresses and contributes to society.

Structure and Properties of Materials, a one-semester introductory chemistry course for both science majors and non-majors, starts each new topic with an explanatory laboratory investigation. Students work collaboratively to get data for class interpretation, then chemical concepts emerge from class discussion before students apply them to new situations or to questions they have posed themselves. Instead of being a collection of unrelated topics, the course has a theme: properties of everyday materials and a molecular explanation of their behavior. As a result, the textbook has become a resource to help answer questions rather than a blueprint for the course, and lectures have given way to discussion about points that students find interesting or difficult. Instead of mid-terms and final exams, students complete week-long laboratory projects and write formal reports for them, or answer a short "questions of the day" that emphasizes explaining the conceptual basis for observations rather than duplicating end-of-chapter problems.

With this approach, which emphasizes science as investigation and provides more hands-on experience, students spend their time designing and carrying out a study of the environmental sources of lead in soil rather than memorizing rules for balancing oxidation- reduction reactions or for calculating the pH of a buffer solution. They understand that science is driven by both the usefulness of what it produces and the desire to understand how and why. Although some traditional topics are skipped because they are extraneous to the questions being asked, the experience gained from completing 30 labs in the first semester shows up in advanced courses as students come better prepared to as scientific questions and devise ways to answer them. As one student explained it, *"We covered more topics in my high school chemistry class, but I understood more in this one."*

Following the NSF-funded Project Kaleidoscope National Colloquium on ***what works*** in undergraduate science education, held at the National Academy of Sciences in February, 1991, we decided to experiment with such a lab-intensive, investigative, and collaborative approach to general chemistry. They developed the course during the Fall of 1991, each teaching a section of it, using the collaborative approach they wanted their students to follow. The course continues to evolve as new laboratory projects are developed. It serves also as a site for testing developing materials for and NSF-funded project to introduce solid state concepts and examples into general chemistry courses, a project that was published in *Teaching General Chemistry: A Materials Science Companion*.

With three years of experience, we find that while the old format was highly successful for students who became science majors, the new course continues to serve that audience well, but also reaches other groups of students more effectively. The drop-out rate for those who enroll in the course has fallen significantly, student satisfaction with the new format is high, and enrollments in follow-up courses continue to be strong. The only problem has been to supply enough sections to meet the growing student demand; almost half of all Beloit College students have taken the course by the time they graduate.

Nationally, interest in this experimental approach to general chemistry has been high. Although some faculty are skeptical because students will not have covered as much material, many are attracted by the emphasis on open-ended investigation, hands-on learning, and creating a "community of learners" among students and faculty. The course was recently included among the first group selected by Project Kaleidoscope as a *Program That Works* and has been featured in several Project Kaleidoscope workshops. Elements of this approach are also central to curricular reform efforts of the ChemLinks Coalition, a group of 15 liberal arts institutions that received a planning grant to prepare a full application to the NSF program: *Systemic Change in the Undergraduate Chemistry Curriculum.*