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NSF Highlights

Projects Supported by the NSF Division of Undergraduate Education

Modeling Effective Teaching and Learning in Chemistry

by Barbara Burke and Edward Walton

This NSF-sponsored project has allowed us to create a one-quarter chemistry course for pre-service teachers. This is the first course in the undergraduate science program at California State Polytechnic University, Pomona (Cal Poly Pomona) to use an approach truly in tune with the national science reform efforts. Our new chemical sciences course is constructivist and uses hands-on, learner-centered activities so that students experience science, and therefore more deeply learn important chemical principles.

Goals

The project began with three important goals.

- To increase the chemical knowledge base of pre-service teachers, using hands-on, learner-centered, inquiry-based, reflective pedagogies.
- To provide experiences that enable the students to become life-long learners of science. "The acquisition of the skills for continuous learning should be an explicit component of all learning experiences…" (*1*)
- To provide undergraduates with experiences in elementary schools by having them conduct activities as part of an after school science club for children.

We believed that the development of this course required the participation of university faculty in both science and education, practicing teachers, and undergraduate students with teaching as their career goal. "The strongest programs result from collaborations" (*1*).

We valued the insights of teachers and students, and created a development team with these members:

- The chemistry faculty in charge of the Chemical Sciences course
- A faculty member from the Department of Teacher Education
- An instructor of science education from our Center for Science and Mathematics Education
- Practicing teachers (two elementary school teachers, one middle school teacher) who had knowledge of what is needed for elementary school teaching. (They provided guidance and recommended and validated course design and activities.)
- A group of undergraduates, some of whom had taken the traditional course within the past two years and some of whom were science majors, to recommend projects and test investigation activities

The team developed the learning experiences that provided our students with a solid base of knowledge and understanding. Those experiences also served as models of teaching and learning upon which our students may draw when they assume their roles as facilitators in the K–8 science classroom.

The New Course Description

The chemical sciences course was traditionally taught as a lecture and a separate laboratory. It included topics from atomic structure to drugs and medicines. The students are liberal studies majors who plan to be teachers. About one third to one half have had no previous experience with chemistry. The new course contains all the same topics. In the new course the same time frame was used for the 50-student class, however the lecture includes activities and serves as a model of good teaching as espoused in the National Science Education Standards. The only scheduling change to accommodate our new course design was to schedule our lab to start so that it coincides with after-school K–6 programs.

We formed a course development team consisting of two K–8 mentor teachers, two new teachers who had taken this course, a science educator, the chair of the education department, a chemistry major, and the two principal investigators. As a result of our team's discussion and planning, the Chemical Sciences course was enhanced to include these innovations. The course:

Introduces science clubs at local elementary schools to involve college students with elementary school children. (There are a total of four schools.)

Integrates lectures and laboratories to assure best use of time and relevance of activities.

Adopts the ACS activity book *The Best of Wonder Science* as our text to model active teaching, to motivate pre-service teachers, and to stimulate higher learning (*2*).

Has the college students write papers on people in science so that students appreciate the human dimension of science and have models to share with elementary students.

Uses directed-inquiry laboratory activities so students experience science investigations.

Uses collaborative test-taking to promote the view that sharing and talking enhance learning, and that fellow students are sources of information and support.

Includes professional chemists and elementary science teachers as visiting speakers who can offer real-life examples.

Requires students to keep a diary and make weekly entries so that they can share insights and questions with instructors and get regular feedback.

Uses team teaching to provide students with more than one outlook and approach to teaching and chemistry.

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Evaluations

Survey Results on Attitudes toward Science and Teaching

Part of becoming a "lifelong learner" of science is the development of an appreciation for science and a curiosity about it. Attitude survey results indicate that this course is successful at improving, and indeed developing, a positive attitude about science.

There was a full point increase (a point increase is equivalent to moving from "agree" to "strongly agree" or from "neutral" to "agree") in response to questions such as these:

- I can teach concepts related to chemistry to K–6 students.
- I know how to conduct a science investigation.
- I understand some key concepts related to chemistry.

There was more than a half point increase in these questions.

- I would like to take more science.
- I enjoy talking to scientists.
- I feel I understand the science involved in most current issues.
- I enjoy reading articles about science in a newspaper or magazine.
- I see myself as a scientist.

Comparing these students to general chemistry students (science majors) in an attitude survey taken by both showed that, in regards to understanding, visualizing, and applying concepts in chemistry, our chemical sciences students indicated significant increases, while the general chemistry students showed little change.

Cognitive Evaluation

A pre/post content test was developed. It consisted of 31 multiple choice questions taken directly from the final exam for the traditional course and served as a representative sample of the content we expected students to learn. The results indicated improved content learning, with a change from 5% to 74% in the number getting more than two-thirds correct and a change from 27% to 0% for the number getting fewer than one-third correct.

Final Exam Comparisons with Traditional Class

Another measure of content learning was obtained by comparison of the performance of our students in the new course with those in the traditional course. Eight questions from the traditional final were included in the final exam of the new course. A trained student using the same rubric independently graded the questions. We found that the students in the new course did better on the essay questions that required thinking and expression.

Team Teaching

One of the most surprising discoveries was the impact of team teaching. Pre and post content tests comparing classes taught by the team of two faculty with a class taught by a faculty/student-teacher team showed no significant statistical difference in student performance.

The team teaching experience gives the chemistry student-teachers a whole new view of chemistry. They began to have a greater appreciation for the application of chemistry and the communication of chemical concepts to the general public. They were happy to see more chemical demonstrations and hands-on activities, and thought that learning more about the people who did chemistry was valuable and exciting. They commented that these components are missing in traditional chemistry courses they have taken.

We think this new course design is a model for teaching science to pre-service teachers. It provides content and models effective teaching. More information about it may be found at *http://www.ceemast.csupomona.edu/nova/* (accessed Nov 2001).

Acknowledgments

Partial funding of this project was obtained from the National Science Foundation's Division of Undergraduate Education, Course and Curriculum Development Program, Grant No. DUE-9653107. Matching funds from the California State Polytechnic University, Pomona are greatly appreciated. Partial funding was obtained from the NASA NOVA program. The support of the Chemistry Department at the California State Polytechnic University, Pomona is also greatly appreciated.

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