1999

Chemistry Reform Takes Root in University Settingeforms in Mathematics and Science

Thomas Pentecost
Grand Valley State University, pentecot@gvsu.edu

10 Chemistry Reform Takes Root in University Setting

Thomas C. Pentecost
Aims Community College and University of Northern Colorado

Which of the following scenarios is more attractive?

(1) You arrive for chemistry class and listen and watch an instructor work problems about gas laws for fifty minutes.

(2) You arrive for class and you and a few other classmates analyze data about the relationship between pressure and volume and develop the gas laws based on data.

Unfortunately, the first scenario is the one most students who have had general chemistry remember. At the University of Northern Colorado (UNC), the Chemistry Department has attempted to move toward the second scenario. The progress of this change is described in this chapter.

Rocky Mountain Teacher Education Collaborative (RMTEC) chemistry reform at UNC proceeded in three distinct directions in an effort to reach the second scenario. The general chemistry course was the target for two revision efforts. An upper division chemistry course taken by all chemistry-teacher education majors was the focus of the third effort. Each of these efforts has been or is being evaluated by faculty and chemical education graduate students. The following description is divided into three sections – one for each reform effort.

Cooperative Learning in the General Chemistry Classroom

This reform targeted the delivery method used by faculty in the general chemistry course. A set of cooperative learning activities (Geiger, Straushein, & Jones, 1997) was developed to facilitate the use of coopera-

tive learning in the classroom. Goals of cooperative learning for general chemistry classes at UNC include: increasing student achievement, teaching students to become active learners who assume a greater responsibility for their own learning; teaching students group processing and social skills; encouraging interactions between students of diverse backgrounds; and building a sense of classroom community.

To evaluate the effectiveness of course revisions, a detailed statistical study was conducted with respect to the above goals (Geiger et.al., 1998). One faculty member taught two sections of first semester general chemistry — one without cooperative learning groups, and one with cooperative learning activities. Achievement was measured by comparing scores on in-class exams and final course grades. An independent observer measured student interaction and involvement. The observer noted who asked questions, the types of questions they asked, and who answered the instructor's questions.

Results suggest several conclusions. First, the use of cooperative groups does not increase chemistry achievement, as measured by tests; however, the use of cooperative groups does change the distribution of grades. This suggests that for some students, the use of cooperative groups influences their achievement. Smith, Hinckley, and Volt (1991) found that lower achieving students in the cooperative group setting scored significantly higher than their counterparts in the traditional laboratory setting. It also appears possible that female students' achievement is improved in the cooperative learning environment. Second, cooperative group settings increase the voice of females during class discussions. Not only is the involvement of female students increased in this setting, but the increase in the number of higher order questions suggests that they are actively involved in learning. Third, cooperative groups increase the percentage of higher level questions from both male and female students. Classroom observations suggest that both male and female students took a more active role in the cooperative group classroom than in the lecture setting. Even without statistical gains in achievement, cooperative groups offer advan-

tages to students when compared with lecture sections. Reports of similar findings support this assertion. (Dougherty, R.C., Bowen, C.T., Berger, W.R., Mellon, E.K., & Pulliam, E., 1995; Cooper, 1995)

Introduction of Inquiry Into the General Chemistry Laboratory

A second focus was to introduce guided inquiry experiences into the general chemistry laboratory. This reform involved rewriting the freshman chemistry lab manual. Each experiment was evaluated for the use of inquiry. Experiments were rewritten or modified so that students are expected to develop procedures of their own. Students are given a task, for example, to determine the energy change during the melting of ice. They identify experimental variables and determine how to measure them. Students then perform the experiment and analyze the data. Over the past 2 years, the second semester course has been further modified to include a larger inquiry project. During this project, students select and design an investigation on their own. The instructor acts as a supervisor or collaborator. Students submit a research idea and proposal to the instructor who evaluates the proposal and provides feedback to the student. The student then performs the experiment and analyzes the results. Students are given the opportunity to repeat the experiment to improve the results or incorporate any changes they feel are necessary. This inquiry project is currently being evaluated. Initial results (Krystyniak & Langdon, 1998) indicate that students enjoy the experience. The development of this inquiry experiment is an example of the institutionalization of the RMTEC model. Graduate students involved in this project were not at UNC during the RMTEC revisions.

Guided Reading Approach to *Survey of Physical Chemistry* Course

The third reform effort involved the one-semester *Survey of Physical Chemistry* course. Students in this course are majoring in chemistry with an emphasis in one of the following areas: Pre-Health, Industrial Chemistry, and Secondary Education/Teaching.

Revisions focused on getting the students more actively involved in the course. The need for students to be active participants has been reviewed in Herron (1996). Our revisions were based heavily on the work of Zielinski (1994, 1995) and her use of guided readings. Specifically, our goals for the revision were as follows: maintain a rigorous survey of physical chemistry that will deepen students' understanding of physical chemistry; move from an instructor-centered environment to a student-centered learning environment; and have students assume responsibility for their learning.

Course delivery was redesigned to be based on the use of guided reading packets instead of lecture. These packets consist of questions and problems students answer while they read assignments from the text. Types of questions range from straightforward questions where the answer is found directly in the text, to more complex, higher order questions that require students to stretch their understanding of the material.

Students are given guided reading materials and a daily assignment. They are expected to come to class with the guided reading assignment completed. Class time is spent in one of three ways. The majority of class time is spent in small-group discussion of student answers to the assigned questions and problems from their guided reading packet. One student is chosen to be the discussion leader and the instructors float around the class, dropping in on different groups to monitor their progress and resolve any unanswered questions. Time also is spent in student presentations of their solutions to assigned problems. Finally, lectures have not been totally

replaced; instead, mini-lectures of 5-15 minutes are periodically presented on more complex or supplementary material.

Use of guided reading packets has been evaluated (Pentecost & James, 1999), with goals for the revision in mind. To determine if the classroom environment had changed from instructor-centered to student-centered, classroom observations by an independent observer were done. Student interviews were conducted to determine if the responsibility for learning had been shifted to the students. Finally, course evaluation surveys developed by RMTEC were used to evaluate students' perceptions of the learning environment.

Results indicate that the guided reading packet approach can create a student-centered classroom environment. In this environment, students realize that the responsibility for learning has shifted to them. This approach also increases the frequency of the students' use of the textbook. Results suggest that while students are receptive to this type of teaching, it would be most effective if students were exposed to student-centered learning environments earlier in their college careers. It seems that for some students, the sudden shift in focus from instructor to student was not pleasant. As it was, students seemed to appreciate the effort to improve the instruction and found the approach helpful.

Conclusion

Chemistry reform at the UNC has taken root. Other instructors have begun using cooperative groups in their courses to some extent. The inquiry laboratory experience is becoming institutionalized so that it remains a vital part of the general chemistry laboratory program. The physical chemistry course is being taught for the fourth year using the guided reading approach. Students taking chemistry at UNC are more likely to find chemistry an active and inviting subject rather than a passive study of isolated facts.

References

Cooper, M.M. (1995). Cooperative learning. *Journal of Chemical Education,* 72, 162–164.

Dougherty, R.C., Bowen, C.T., Berger, W.R., Mellon, E.K., & Pulliam, E. (1995). Cooperative learning and enhanced communication. *Journal of Chemical Education,* 72, 793-797.

Geiger, L.C., Straushein, B., & Jones, L.L. (1997) *Student companion: New tools and techniques for chemistry molecules, matter and change.* New York, NY: WH Freeman and Company.

Geiger, L.C., Straushein, B., Pentecost, T.C., & Cooney, J. (1998). A statistical comparison of a student-centered interactive approach to a traditional lecture approach in the general chemistry classroom. *Journal of Research in Science Teaching,* submitted for publication.

Herron, D, (1996). *The Chemistry classroom: Formulas for successful teaching,* Washington, DC: American Chemical Society .

Krystyniak, R. & Langdon, L. (1998, August). *Incorporating an inquiry experiment into the general chemistry laboratory.* Paper presented at the 15th Biennial Conference on Chemical Education, Waterloo, Ontario.

Pentecost, T.C., & James M.L. (1999). Creating a student centered physical chemistry class. *Journal of College Science Teaching,* (accepted for publication).

Smith, M.E., Hinckley, C.C., & Volk, G.L. (1991). Cooperative learning in the undergraduate laboratory. *Journal of Chemical Education,* 68, 413–415.

Zielinski, T.J. (1994, August). *Promoting critical thinking in physical chemistry through guided reading instruction and mastery learning strategies,* Paper presented at the 13th Biennial Conference on Chemical Education, Lewisburg, PA.

Zielinski, T.J. (1995). Promoting higher-order thinking skills: Uses of Mathcad and classical chemical kinetics to foster student development. *Journal of Chemical Education,* 72, 631-638.

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

NOTICE

REPRODUCTION BASIS

☐ This document is covered by a signed "Reproduction Release (Blanket) form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

☒ This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").