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From the Editor

The Value of Undergraduate Research

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An undergraduate research requirement in chemistry increases the pressure for curriculum changes. Students must be properly prepared for the research experience.

I recently attended the national American Chemical Society meeting in Las Vegas (September 1997) and previous to that in San Francisco (April 1997). While there, I visited the Student Affiliates poster sessions that were held at those meetings. I did this both out of my own interest in undergraduate research (I have had five students present posters at national ACS meetings.) and to encourage the ACS Student Affiliates presenting successful chemistry club activities to contribute to this journal.[1] I had a student presenter at one of the first of these events, San Francisco in April of 1992, and the growth of the student participation has amazed me. The sessions are now split into the subdisciplines of chemistry and there are more presentations at each of these than there were altogether in 1992. This makes me wonder what has sparked this growth in undergraduate research.

At my institution, Boise State University, two semesters (4 units) of undergraduate research are required for graduation with a degree in chemistry. As part of the requirement, a final

[1] *The Chemical Educator* solicits faculty sponsored articles about successful chemistry clubs or club activities. Articles should provide information and ideas useful in establishing or revitalizing student chemistry clubs. We provide an annual $1000 award for the best article of this type that is published. Please see the article from the University of Michigan Chemistry Club in this issue.

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report and a senior seminar discussing the research are also obligatory. This is not the case at all universities. Does the requirement benefit the students? Would the units be better placed in other courses, either in chemistry or general education? What is the value of undergraduate research in the curriculum?

My answers to these questions are emphatically yes, emphatically no, and that I believe that undergraduate research is the culminating educational experience for my students. For some form of creative endeavor in the subject to be required for graduation is not unusual in many majors. In the humanities a work of art, of music, or writing is common. In the social sciences, an undergraduate thesis, exploring an important social issue is often required. In business also, a final research project, usually a study of a local business is expected for graduation. These projects are the crowning educational achievement for a student and help them to make the transition from the learning and training world they are leaving to the real world where they are expected to use their training to contribute new ideas that benefit society as a whole.

So too in the sciences, students should be provided this experience. It surprises me that, in view of the very nature of science, science departments are often the last to institute this requirement. I suspect that at one time we considered the extensive laboratory experiences associated with our courses to be adequate, but I believe that those experiences were more skill training than thought training. In addition, many of those courses have grown tremendously in enrollment because they are requirements for many new and popular majors, especially those in the heath sciences. Unfortunately, the laboratory component of these courses has often been reduced to support this increased enrollment on tight budgets. Another factor is the growing pressure from the community and thus the administration to provide a more generalized education. Colleges, especially metropolitan universities serving a large number of what have become known as nontraditional students, are expected to prepare students for life as well as a career. Today’s curriculum includes a considerable amount of new training that teaches community interaction, the understanding of diversity, an appreciation for subjects outside the major, and advanced communication skills. Today’s social decisions require this broad knowledge base; still, these aspects of a college education place pressure on a subject curriculum that has, in itself, been growing by leaps and bounds.

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An undergraduate research requirement in chemistry increases the pressure for curriculum changes. Students must be properly prepared for the undergraduate research experience. Just requiring it is not enough. Unprepared students often approach it with a tremendous anxiety and sometimes with indifference and resentment. For this reason, we need to make changes in the way we teach all of our courses. Students must be taught to think as researchers. This ability must evolve throughout their college experience. In this issue we present several articles that describe some interesting changes in course curricula and that provide some excellent ideas for laboratory experiments that provide real-world inquiry-based experiments for students. Werner and Carroll discuss the changes made in their Quantitative Analysis course to provide students with a “real-world” inquiry-based learning experience at Union College. Lauterbach, et al. describe how students have designed and constructed equipment in advanced laboratories at Purdue University, and Pfennig, Newirth, and Van Arman present a term-long project-based integrated laboratory for advanced students that has been used at Vassar, Haverford, and Franklin and Marshall Colleges. Computational chemistry has become an extremely common tool in academic research and industry. Bocarsly and David provide a modern computational component to enhance a traditional physical chemistry laboratory exercise, bond lengths in cyanine dyes and the particle-in-a-box model.

Those of us at primarily undergraduate colleges and universities are painfully aware of the time/workload restraints we face when considering our own personal pursuit of research activities. Adding the further burden of involving inexperienced undergraduate students in this research adds to the challenge. Still, we chose to teach at these institutions because we enjoy working with undergraduate students. I believe the rewards far outweigh the effort. Research is a chance to hone our own skills as scientists, develop new ideas, rekindle our excitement in scientific discovery, transfer this excitement to others, and teach the techniques of scientific inquiry to our students. It allows us more easily to make the changes that modernize the courses we teach, because we are comfortable with new techniques and familiar with current developments. We can present chemistry to students as it is currently practiced. Often, the techniques and results of our research provide a basis for the development of new experiments for core courses or for advanced undergraduate laboratories. This issue contains several examples of such experiments.