

Undergraduate Research

Research can be the most rewarding and educationally valuable aspect of an undergraduate chemistry degree. Students grow both professionally and personally in ways that are not possible through traditional classroom and laboratory classes. In addition, faculty members and chemistry programs are strengthened and kept vibrant through the pursuit of research and through the mentoring relationships developed via student-faculty collaborative work. The Committee on Professional Training strongly supports departments' efforts to establish active and vibrant undergraduate research programs, recognizing the role that research can play in developing a wide range of student skills. The 2008 ACS Guidelines allow for the use of undergraduate research both as in-depth course work, as well as a means of meeting 180 of the 400 laboratory hours required for certification provided that a well-written, comprehensive, and well-documented research report is prepared at the end of a project. (Samples of such research reports must be submitted with the periodic reports.)

Characteristics of Undergraduate Research

Research is the development of new knowledge or understanding in order to advance science. While the specific areas of research vary immensely in the chemical sciences and in chemical education, there are some traits that are common to undergraduate research in general.

Undergraduate research is conducted with a faculty advisor or mentor. The student's research project is typically based on the faculty mentor's research interests, which allows the student to draw upon the mentor's expertise and resources and also allows the faculty mentor to develop a productive research program. The mentor meets regularly with the student to make research plans, assess risks associated with the proposed research, and review results. The student is encouraged to take primary responsibility for the project and to make substantial input into its direction. The student-mentor relationship also builds student confidence, offers encouragement when necessary, and provides guidance and assistance for the student's future education and career development.

While the nature of each project depends on the specifics of the project, an ideal undergraduate research project:

- represents original scientific work that is intended for publication in a peer-reviewed scientific journal
- has a clearly communicated purpose and potential outcomes

- has well-defined objectives and methods
- is substantial in scope (as opposed to a collection of small projects)
- has reasonable chance of completion in the available time or contributes significantly to an ongoing, long-term project
- requires contact with the chemical literature
- avoids repetitive work
- requires use of advanced concepts
- requires a variety of techniques and instruments (not exclusively library work)

An undergraduate research project must represent a substantial investment of time, particularly if it is being used to meet the in-depth or laboratory hour requirements outlined in the 2008 ACS Guidelines. Research can satisfy up to four semester credit hours or six quarter hours of the in-depth course requirement for student certification. At a minimum, the amount of hours a student spends in the laboratory conducting research should match with the usual formula for translation of laboratory hours into credit hours.

Development of Student Skills

Through undergraduate research, students develop problem-solving skills in a fashion that no other educational experience can match, allowing them to integrate a variety of concepts encountered in the classroom and apply them to real-time, real-life questions that arise in the lab. Undergraduate research provides a context in which students can develop an appreciation for and become adept at:

- delving deeply into the chemical literature
- designing and executing their own experiments, working around inevitable experimental obstacles
- interpreting their data and considering questions of reproducibility
- learning the importance of careful and thorough observation, recording, and reporting
- working both independently and collaboratively as needed
- considering questions of scientific ethics and professional conduct
- communicating their work and results by means of oral, poster, and written presentations to their peers and colleagues.

More information on student skills can be found in the student skills supplement.

The Written Research Report

For research to have any meaning or effect, it must be communicated to the scientific community. Peer review is the generally accepted means of monitoring and insuring the quality of research. While not every undergraduate research project will result in a peer-reviewed publication, it should be the intent of each project to contribute to such a result. When an individual student research project is not of wide enough scope for an entire publication, it should contribute to a more comprehensive study that merits publication. For this reason, it is of paramount importance that any undergraduate research project must



culminate in a thorough written report that includes a thorough description of background work on which the project is based (complete with appropriate references, full experimental details...). The faculty supervisor should constructively criticize drafts of the report. Oral and poster presentations are an extremely useful step in this process. However, a research project must not culminate solely in an oral or poster presentation, as it would not become part of the archived body of knowledge. A written report adds to the permanent scientific knowledge base and can be used by future researchers pursuing related projects. A separate supplement (available on the CPT website) provides guidelines for preparing a research report. Student co-authorship on a paper, while highly encouraged, is not a substitute for a comprehensive report written by the student. Examples of student research reports must be included with an institution's periodic report if research is used as an in-depth course for student certification. Research done off-campus and/or during the summer, even though it might not be for academic credit, may count toward certification. In such cases, the student must prepare a comprehensive report that is evaluated and approved by a faculty member of the home institution.