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Committee on Professional Training

American Chemical Society 1155 Sixteenth Street, N.W. Washington, D.C.

In This Issue . . .

ACS supports the academic hiring process through Academic Employment Initiative activities at its 2005 national meetings. See page 5 for details.

CPT to cosponsor YCC symposium *Starting a Successful Research Program at a Predominately Undergraduate Institution* at the San Diego ACS Meeting. See page 5 for details.

Revision of ACS Guidelines for Undergraduate Chemistry Programs

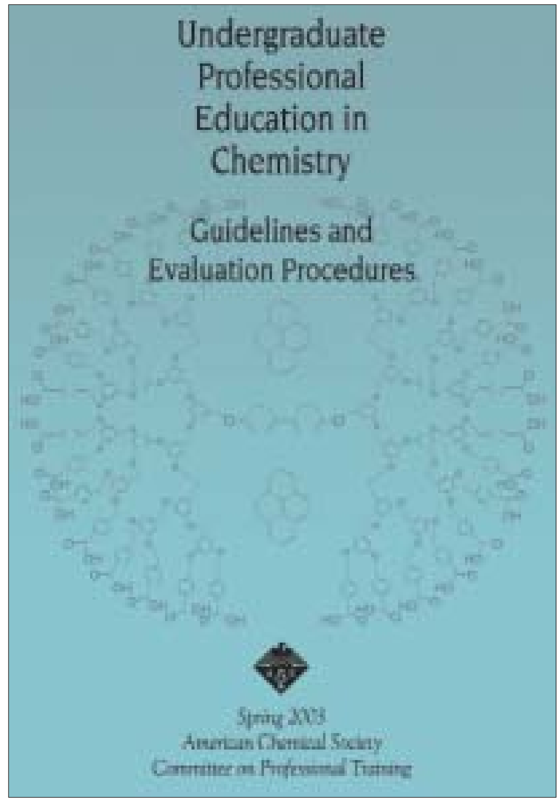
The guidelines for ACS approval of undergraduate chemistry programs include both curriculum requirements and faculty, staff, and facilities requirements. These guidelines are available online from the CPT homepage (www.chemistry.org/education/cpt) or as hardcopy upon request from CPT (cpt@acs.org). Briefly, the current ACS curriculum guidelines require classroom and laboratory coverage of "core" chemistry areas of analytical, inorganic, organic, and physical chemistry, as well as classroom coverage of biochemistry. They also require six semester hours of "advanced" courses that build on the core, along with laboratory work or research that bring the total laboratory contact hours to 500. Graduates who meet the curriculum guidelines of an approved program are then certified to the ACS by the program chair.

While the guidelines contain minimum requirements for approval of an undergraduate chemistry program, they do not prescribe any particular curricular structure or pedagogical approach, and the ACS approves a wide variety of programs. In fact, CPT encourages curricular innovation and novel pedagogical efforts when implementing the ACS guidelines. The ACS also offers degree options in biochemistry, chemical physics, chemistry education, environmental chemistry, materials, and polymers.

In light of changes occurring in both chemistry and education, CPT is considering major revisions of the guidelines for ACS approval of undergraduate chemistry programs. This review of the ACS guidelines is also consistent with the initiative to "reinvent" the content of chemistry education put forward by 2002 ACS President Dr. Eli Pearce and with the most recent challenge issued by 2005 ACS President Dr. William Carroll, Jr. to envision the chemistry enterprise in 2015.

To begin the process of revising the ACS guidelines, CPT is seeking comments from all sectors of the chemistry community about the undergraduate chemistry curriculum. CPT will use this information to develop proposals for revising the ACS chemistry curriculum guidelines, which will be publicized with a request for further comments from the chemistry community.

In particular, CPT seeks responses to the following questions:



- What should an ACS-certified chemistry graduate know and be able to do?
- How should a chemistry curriculum balance required core courses with elective advanced courses?
- What should be the relative roles of traditional chemical disciplines (*e.g.*, analytical, inorganic, organic, physical chemistry) and more recently developed interdisciplinary areas (*e.g.*, biochemistry, environmental science, green chemistry, materials science) in chemistry education?
- What amount and type of laboratory work is appropriate for an ACS-certified graduate?
- What ancillary skills should be required of ACS -certified chemistry graduates?
- Are there any curricular impediments in the ACS guidelines for an undergraduate student pursuing an ACS-certified chemistry degree?
- Are there any curricular impediments in the ACS guidelines for a chemistry program seeking approval or maintaining approval?

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- Should approved departments be required to regularly assess the effectiveness of their curriculum and use the results to continually improve their program?
- What is the value of ACS approval to your program and of an ACS-certified chemistry degree to your graduates?
- Do the ACS-approved degree options in biochemistry, chemical physics, chem istry education, environmental chemistry, materials, and polymers add value to your chemistry program?

Improving chemistry education is a major goal of the chemistry community, and it is important to hear as many opinions as possible. The Committee values every response to the above questions, as well as comments on any other issue relating to the ACS guidelines, and will carefully consider each one.

Please send your comments to CPT by email at cpt@acs.org with a subject heading of “ACS Guidelines Revision.” Receiving your comments by December 31, 2004 will be particularly valuable as CPT needs to summarize them and begin planning for curriculum discussion in the summer of 2005, though comments are of course welcome at any time.

The Committee looks forward to the participation of the entire chemistry community in the next revision of the ACS guidelines for undergraduate chemistry programs. ■

Incorporating Environmental Chemistry into the Chemistry Curriculum

Matthew Fisher and Kathryn Parker, *ACS Committee on Environmental Improvement*

The spring 2003 "Guidelines for Undergraduate Professional Education" prepared by CPT include several statements that reflect the importance of understanding the relationship between chemistry and the environment[1]:

- All chemists, including those whose interests focus strongly on research, can benefit from an understanding of economics, marketing, business, and the environment.
- Discussions of real-world problems and an early introduction to instrumental and computational techniques can give students an immediate sense of how chemistry is done today.
- Within chemistry courses themselves, advantage should be taken at all levels of course sophistication to point out the connections between science and society.

These statements are consistent both with aspects of the Chemist's Code of Conduct adopted by ACS[2] and recent reports such as *Beyond the Molecular Frontier*[3] that highlight opportunities and challenges for the chemical sciences in the 21st century. In the latter publication, four of the nine chapters focus either directly on environmental issues or areas of chemistry that have clear environmental impacts. The incorporation of environmental topics into the chemistry curriculum provides faculty with an opportunity to connect environmental issues important to society to the underlying chemistry. It also serves to make important links between chemistry and other disciplines. Incorporation of environmental topics can be achieved in primarily three different ways: offering separate courses in environmental chemistry, often in the context of a department offering the ACS-approved environmental chemistry option; incorporating environmentally related chemistry into core courses; incorporating green chemistry throughout the curriculum.

One approach used by some departments is offering separate courses in environmental chemistry. Since the ACS-approved environmental chemistry option requires "six semester hours of advanced work in chemistry of the environment," this approach works particularly well for departments that choose to offer this option. Typically these courses focus on some or all of the following topics:

- atmospheric chemistry (tropospheric and stratospheric chemical reactions, climate change)
- water chemistry (aquatic chemical speciation and colloids and natural organic matter, water pollution, water analysis)
- soil chemistry (soil formation, cation exchange properties, acid-base reactions)
- energy (energy uses, nonrenewable sources, renewable sources)
- nuclear chemistry
- pest control
- toxic chemicals

There are a number of textbooks that are available for teaching such a course[4]; many of them assume that students have already completed a year of general chemistry. While these courses offer the opportunity to explore environmental chemistry in greater depth, because of their elective nature the number of students that can be reached is limited. Another drawback to this approach is that students may see environmental issues as separate from chemistry as an overall discipline and therefore not integral to it.

Another approach is to use environmental questions as the context to illustrate the chemical concepts already covered in a number of courses. *How People Learn*, the recent publication from the National Research Council on the science of learning[5], stresses the importance of students learning concepts in a variety of contexts in order to fully understand them and be able to apply them in problem solving. The approach of using environmental issues to provide context can be utilized in courses ranging from general chemistry to upper level analytical courses. One particularly valuable resource is the *Journal of Chemical Education*; in July 2004, searching the Journal’s online index for “environmental chemistry” as a keyword returned 194 citations. These articles provided a number of concrete ways to incorporate environmental chemistry into the teaching of electrochemistry, instrumental analysis, analytical chemistry, organic chemistry, and general chemistry. In addition, there are a number of other resources that have been developed for use in general chemistry. These include *The Chemistry of Water*[6], *Pesticides in Fruits and Vegetables*[7], several of the ChemConnections modules[8], several of the ChemCases developed by faculty at Kennesaw State University[9], and three general chemistry lab tutorials developed by teaching staff at Washington University in Saint Louis[10]. All of these resources provide an interdisciplinary context to illustrate chemical concepts such as aqueous solutions and solubility, suspension and precipitation, electrochemistry, kinetics, stoichiometry, interaction of electromagnetic radiation and matter, equilibria, and acid/base chemistry. A major advantage of this approach is the potential to reach a very large number of students and further develop their understanding of chemistry's connection to environmental issues.

A third approach is to incorporate green chemistry throughout a department's curriculum. Green chemistry isn't simply the inclusion of environmental topics in a chemistry course. Rather, it is an approach that utilizes "a set of principles to reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and application of chemical products."[11]. As such, green chemistry can have a profound impact on the future research and teaching of today's students. Since its initial development in the early 1990's, green chemistry has continued to grow in importance. While the incorporation of green chemistry into the chemistry curriculum is important from the perspective of developing particular knowledge and skills in bachelor degree chemists, it also provides a powerful opportunity to explore the environmental issues that drive much of green chemistry. By using green chemistry as a springboard to explore environmental topics, faculty provide students with an opportunity to see how chemistry has an impact on real-world questions and to see how chemistry is connected to economic, engineering, or political issues. Green chemistry also provides a wonderful opportunity to develop critical thinking skills, as analysis and evaluation are key in understanding the advantages posed by a green alternative to a traditional chemical reaction or process.

Today, there are an increasing number of resources available to help faculty incorporate green chemistry into already existing courses. Many of these materials have been produced by the ACS in cooperation with the EPA. Publications designed to help faculty incorporate green chemistry into the curriculum include *Going Green: Integrating Green Chemistry into the Curriculum*[12], *Introduction to Green Chemistry*[13], *Real-World Cases in Green Chemistry*[14], *Greener Approaches to Undergraduate Chemistry Experiments*[15], and a new lab manual for organic chemistry titled *Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments*[16]. In addition, the University of Oregon's Department of Chemistry offers a five-day workshop each summer for chemical educators on incorporating green or sustainable chemistry concepts into the chemistry curriculum and laboratory[17].

Regardless of the particular approach taken, it is important for faculty to realize that it is possible to have both rigorous chemistry content and meaningful connections to environmental issues. But accomplishing both goals requires that careful attention be given to the nature of assignments and exams that students complete. Assessments that emphasize the application of chemical concepts to environmental challenges will reinforce student awareness of the impact that chemistry has on the environment.

Regardless of the particular approach taken, it is important for faculty to realize that it is possible to have both rigorous chemistry content and meaningful connections to environmental issues.

The overall goal of these approaches is to help students develop a better understanding of the critical role chemistry plays in environmental issues, some of the important chemical concepts that are involved, and some of the ways that chemistry connects to other disciplines. In this way, students will be better prepared to participate, as both chemists and citizens, in the efforts of our society to address critical environmental issues. ■

Footnotes

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Industrial View of Chemistry Training at the Bachelor's Level

Results of the CPT Survey of Industrial Employers

According to ACS data,[1] 41% of chemists went to work immediately after receiving their bachelor's degree in 2003. (Over the past ten years this number has varied between 40 and 50%.) Of B.S. chemists going to work, 66% found jobs in industry. Because industry is such a large "customer" for newly minted bachelor-level chemists, the Committee on Professional Training sought the opinion of industrial managers on the effectiveness of the chemistry education of their newer bachelor chemistry employees. The timing of this survey fits well with CPT's current effort to review the ACS guidelines for ACS-approved undergraduate chemistry programs.

About 10,000 midlevel managers in industry were contacted by mail and asked to go online to answer questions about their bachelor-level chemistry employees who were within five years of the date of their bachelor's degree. Questions centered around criteria for hiring, the importance to the job of a variety of scientific and social skills, and the abilities of these relative new hires in key scientific and social skills. We received 964 replies, about average for online surveys of this type.

Further, many companies recognize the value of ACS-certified degrees: according to the ACS 2003 Starting Salary Survey, the average starting salary for inexperienced bachelor-level chemists with -certified degrees was $34,000, compared to $31,000 for those without certification.

Several important conclusions can be drawn from the survey results:

- Key skills needed by bachelor-level chemists include critical thinking, teamwork, ability to communicate, ability to execute experiments and analyze data, computer skills, and instrument proficiency. Of these skills, newly hired bachelor-level chemists are strongest in their computer abilities and weakest in written communications. (See Table I.)

Table I. Importance and Quality of Training for Key Job Skills Needed by Bachelor-Level Chemists*

Job Skill	IMPORTANCE OF SKILL: Important + Very Important	IMPORTANCE OF SKILL: Very Important	QUALITY OF TRAINING IN SKILL: Very Good + Good	QUALITY OF TRAINING IN SKILL: Very Good
Critical Thinking	96%	50%	59%	10%
Teamwork	96	48	60	15
Oral Communication	95	37	57	10
Written Communication	94	45	48	8
Analyzing Data	94	53	56	12
Computer Skills	94	33	78	20
Execute Experiments	89	49	67	14
Instrument Proficiency	89	45	57	10

* Skills for which Important + Very Important was ≥ 90% and/or Very Important was ≥ 40%.

- The primary job responsibility for most bachelor-level chemists is either analytical services (40%) or basic/applied research (36%). In addition, 30% of respondents described the work of their bachelor-level chemists as "routine use of established technologies," 26% as "innovation and/or discovery," and 44% as a "mix of routine and novel work."
- About one-third of hiring managers said that having an ACS-certified degree is an important consideration in the hiring process of bachelor-level chemists. This rose to 40% when the work to be done is classified as nonroutine and to 46% when the hiring manager him/herself had a certified degree.
- Overall, undergraduate research experience was viewed as important/very important to the work by 35% of managers. This rose to 53% for bachelor's chemists who do innovation and/or discovery work.

In addition to asking specific questions, we invited respondents to comment on factors they feel are important to training and hiring of recently degreed bachelor-level chemists. Of the comments received, 187 managers described important elements they look for in new hires. Included among these key factors were practical knowledge/hands-on experience (29% of those commenting), communication skills (23%), and undergraduate research/intern experience (17%). Perhaps more instructive were comments from 99 managers who cited specific areas where they find candidates particularly weak. These voluntary comments can be categorized to give us an idea where weaknesses in training exist among bachelor-level chemists seeking industrial jobs.

- Basic laboratory skills/hands-on experience were cited as weak by 27% of those

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CPT to Conduct Enrollment Survey

Attention all department chairs! Please watch your mail for the CPT enrollment survey. CPT is surveying the enrollments in selected courses for a three-year period to evaluate current trends in the teaching of chemistry in the United States. The targeted courses reflect the wide student audience served by the chemistry curriculum. Compiled data from the survey will be made available on the CPT web site so that an individual department will be able to compare its enrollment patterns with those of other institutions throughout the country.

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citing deficiencies. “More lab training before graduation would help.” “Perhaps more hands-on lab techniques and instrumentation in school will close the gap…” Many cited undergraduate research or internships as a way to meet this need: “Undergraduate research experience is important for chemists seeking their first industrial position.” Many respondents commented that students are taught the theory of instrumentation but have little or no hands-on experience using *modern* instruments.

- Ability to communicate, especially in writing, was cited as a shortcoming by 25%. According to one respondent, “The writing ability of recent employees is woefully inadequate.”
- Knowledge of the skills used extensively by industry (beyond the typical laboratory/research setting) was a general category cited as lacking by 23%. This includes knowledge of quality assurance/quality control practices, good manufacturing/laboratory practices, statistics/design of experiments, and basic business concepts such as cost/benefit ratios and profitability. Again, industrial internships were cited as an excellent way to pick up some of these skills. “Most undergraduate programs do not prepare their graduates for the realities of company work.”

Implications for CPT

One-third of hiring managers said that having an ACS-certified degree was an important consideration in the hiring decision for bachelor-level chemists. Thus, chemistry graduates can significantly enhance their chances of finding employment by graduating with a certified degree. However, 49% of respondents did not know if any of their bachelor-level chemists had an ACS-certified degree and 43% did not know if any of these chemists came from ACS-approved programs. (It should be noted that a company’s Human Resources staff, rather than the hiring managers who were the target of the present survey, are often responsible for ensuring that candidates have a degree from an approved school.) Clearly, CPT must do a better job of educating employers on the value of ACS-approved programs and ACS-certified degrees: the quality control of the approved programs and the rigor of the chemistry education of certified graduates. (In reality, more than 90% of bachelor-level chemists graduate from ACS-approved programs. Further, many companies recognize the value of ACS-certified degrees: according to the ACS 2003 Starting Salary Survey, the average starting salary for inexperienced bachelor-level chemists with certified degrees was $34,000, compared to $31,000 for those without certification.[2])

In 2005, CPT will begin an in-depth review of the requirements for approval for undergraduate chemistry programs. An understanding of the needs of industry will be an important input into this review. We will pay particular attention to hands-on practical experience of graduates, use of modern instruments, communication skills, and methods for graduates to gain an appreciation of business-related skills. ■

[1]Michael Heylin, “2003 Starting Salary Survey,” Chemical & Engineering News, 82(16), 51 (April 19, 2004).

[2]Janel Kasper-Wolfe, personal communication.

In 2005, CPT will begin an in-depth review of the approval process for undergraduate chemistry programs. An understanding of the needs of industry will be an important input into this review.

Starting a Successful Research Program at a Predominantly Undergraduate Institution

San Diego ACS Meeting

Sponsored by the Younger Chemists Committee (YCC), cosponsored by CPT

Starting a successful research program at a predominantly undergraduate institution poses unique challenges for a beginning faculty member. Yet, many such members of the college professoriate have little, if any, preparation for what to expect in establishing an undergraduate research program. Several experienced faculty speakers who have had success in maintaining undergraduate research programs will speak at the symposium. Representatives of funding agencies such as The Petroleum Research Fund and Research Corporation will speak about their programs as well. The arrangement of the symposium will provide time for panel discussions so that attendees will have the opportunity to ask questions and take part in the discussion.

ACS Academic Employment Initiative

The ACS continues to run the NSF-sponsored program to support the academic hiring process through presidential activities at its 2005 national meetings. During the Spring National Meeting in San Diego, senior and recently-hired faculty will answer graduate students’ and postdocs’ questions on the academic recruitment process at a presidential symposium on the topic. This event will take place on Sunday, March 13, 8 am – 11am, followed by a networking reception from 11am – noon.

At the Fall National Meeting in Washington, DC, those seeking faculty positions will again have an opportunity to present their posters at the Sci-Mix interdisciplinary poster session. This will provide faculty recruiters with an opportunity to meet and talk to as many candidates as reasonably possible. The ACS Office of Graduate Education will compile short biographical summaries on the candidates, which will be posted online about two weeks prior to the meeting and will be available for recruiters in printed form during the SciMix session. AEI candidates should submit their posters through the Online Abstract Submittal System (OASYS) at http://oasys.acs.org/oasys.htm. For more information about the AEI program please see the AEI web site at www.chemistry.org/aei.html or contact the ACS Office of Graduate Education at graded@acs.org.

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