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Commentary

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# An Overview of the Changes in the 2015 ACS Guidelines for Bachelor's Degree Programs

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**ABSTRACT:** The Committee on Professional Training (CPT) of the American Chemical Society (ACS) has recently approved a new set of Guidelines and Evaluation Procedures for Bachelor's Degree Programs. Input from the community was invaluable in informing the deliberations of CPT during the three-year process of Guidelines revisions. The Guidelines describe standards that are used to approve programs to offer ACS certified undergraduate degrees. The most significant changes in the Guidelines are described in this commentary.

**KEYWORDS:** *Curriculum, Professional Development, First-Year Undergraduate/General, Administrative Issues, Standards National/State, Student/Career Counseling*

## INTRODUCTION

The American Chemical Society (ACS) released its first list of approved programs in 1940. Since then, a lot has changed in chemistry education, the nature of chemical research and the employment and professional opportunities for chemistry graduates. Technological advances in recent years seem to exacerbate the pace at which change occurs. To keep aligned with current trends in education, the broadening scope of scientific and societal issues that require chemical expertise and the changing professional opportunities available to chemists, the American Chemical Society, through the Committee on Professional Training (CPT), reevaluates and revises the "ACS Guidelines and Evaluation Procedures for Bachelor's Degree Programs" (the Guidelines) on a regular basis. In March 2015, the ACS released the latest edition of these Guidelines.

The ACS Guidelines set standards for the institutional environment, faculty and staff, infrastructure, curriculum, safety, undergraduate participation in research, student skill development and program self-evaluation with the goal that programs provide professional chemists with the training and experience necessary for successful careers. Currently approved programs span the range from small undergraduate institutions with only a few faculty members and chemistry majors to large public Ph.D.-granting institutions. The ACS Guidelines must accommodate this diverse array of institutions. From time to time CPT finds it necessary to revise the Guidelines to reflect the changing landscape of undergraduate education (e.g., decreased financial support, technology-aided instruction, expansion of part-time instructional positions at some institutions, course delivery in online and virtual formats). The Guidelines speak not only to the learning outcomes desired in certified degree recipients but to the resources a program needs to provide an excellent and rigorous education to its graduates.

CPT has recently completed a three-year process of developing and approving the 2015 Guidelines.[1] As a first step in this process, we asked approved programs to provide feedback on the 2008 Guidelines through a *Guidelines Impact Survey* in the spring of 2012. The results of this survey[2] informed our discussions of the revisions. As we developed and refined the revisions to the 2008 Guidelines, we published updates on the status of the Guidelines revision in the CPT *Newsletter*, comment columns in *Chemical and Engineering News*[3,4] and in this *journal*,[5] held symposia related to aspects of the Guidelines being considered for change at both national ACS meetings and the Biennial Conference on Chemical Education, held open meetings seeking feedback from the community, and sent direct mailings to department chairs with proposed changes, all in an effort to solicit feedback from the community about changes we were considering. More information on these activities can be found in the *CPT Newsletter*.[6] The feedback was extensive and invaluable in shaping the final form of the 2015 Guidelines, which have now been published. The 2015 Guidelines reinforce the emphasis on excellence and flexibility that characterized the 2008 Guidelines.

The ACS Guidelines enable flexible structuring of the curriculum. Students seeking a certified degree need instruction that is equivalent to one course in each of five foundation areas (analytical, biochemistry, inorganic, organic and physical), four in-depth courses, and 400 laboratory hours beyond the general chemistry level that cover four of the five foundation areas. Foundation areas can be taught as stand-alone courses and laboratories or can be integrated across multiple courses. The detailed content of foundation courses is not prescribed by the Guidelines, although CPT publishes a series of supplements, which can be found on the CPT Web page[7] that provide guidance on the general topics and skill-building activities that are encouraged within foundation areas. In-depth courses require one or more foundation courses as prerequisites. Common examples of in-depth courses include the second semester of organic chemistry, physical chemistry and instrumental analysis. Programs have substantial flexibility in





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choosing which in-depth courses to require for the certified degree and in creating multiple degree tracks.

The 2015 Guidelines emphasize student skill development. These skills include problem solving, chemical literature and information management, laboratory safety, oral and written communication, teamwork, and ethics. The term "problem solving" is further developed in the 2015 Guidelines to indicate that students should define problems clearly, develop testable hypotheses, design and execute experiments, analyze data using appropriate statistical methods, understand the fundamental uncertainties in experimental measurements, and draw appropriate conclusions. Chemistry programs are encouraged to develop these skills across the curriculum in both classroom and laboratory offerings. The Guidelines reflect the community's recognition that curricular activities different from traditional lectures and recipe-driven experiments may be effective in developing effective professional skills. Pedagogies such as problem- or inquiry-based learning, peer-led instruction, group learning, learning communities or networks, writing through the curriculum and technology-aided instruction are encouraged. The Guidelines also encourage laboratory activities that reveal chemistry through a process of discovery through inquiry-driven and open-ended investigations. Discovery-based learning fosters independent thinking, critical thinking and reasoning skills.

## CHANGES IN THE 2015 GUIDELINES

### Faculty and Staff

**Size of the Chemistry Faculty.** Approved chemistry programs will now be required to have five full-time permanent faculty members, an increase from four. These individuals need not be tenure track appointments, but they must be involved in curriculum development and provided with opportunities for professional development. When contracts are renewed on a regular basis, the faculty should hold the expectation of long-term full-time employment. Finally, the five faculty members must be wholly committed to the chemistry program.

The increase of the requirement from four to five faculty members was made for pedagogical and pragmatic reasons. Schools with four faculty members found it challenging to have sufficient expertise in all five foundation areas. Furthermore, programs with just four faculty members commonly had trouble teaching enough foundation and/or in-depth courses to meet the guidelines on a regular basis. We recognize that expanding the size of the faculty is often a substantial challenge for programs and currently approved programs with four faculty members will have until 2025 to meet this requirement.

**Proportion of Chemistry Faculty with the Ph.D.** The guidelines state that at least 75% of the permanent chemistry faculty members must hold the Ph.D. or an equivalent research degree. We recognize that titles and duties of chemistry instructional personnel are highly variable across different institutional environments. Due to differential expectations for these personnel, solely for the purpose of reviewing annual and periodic reports of programs, CPT defines "Faculty" as personnel whose primary responsibilities are typically teaching, scholarship, mentoring, service and curriculum development and oversight. The 2015 guidelines state that full-time, permanent Faculty should teach the courses leading to student certification in an approved chemistry program. All other nonstudent personnel who engage in instructional activities (largely service courses and labs, or specialty courses, for example) are, for the purposes of these reviews, considered as "Instructional Staff". Such persons may be full-time, part-time, permanent, or temporary. Graduate or undergraduate teaching assistants are not considered as either Faculty or Instructional Staff. Using these definitions, 75% of Faculty in approved programs must have the Ph.D. degree. Instructional Staff will not be counted toward this total.

**Instructional Contact Hours.** Contact hours are the actual time spent by faculty members and instructional staff in the direct supervision of students in a classroom (face-to-face or online) or laboratory. Contact hour requirements and the amount of flexibility in meeting them have been adjusted slightly in the 2015 Guidelines. Individuals whose teaching responsibilities are in the classroom and laboratory must not exceed 15 contact hours per week. Two individuals in this category can meet the 15 h by averaging their teaching contact hours over the two semesters or three quarters that make up the academic year, provided their teaching contact hours exceed the 15-h maximum in only one term and are 18 or lower. Individuals whose sole teaching responsibilities are laboratory courses must not exceed 16 total contact hours per week. Two individuals in this category can meet the 16 h by averaging their contact hours over the academic year, provided the 16-h maximum is exceeded in no more than one term and are 18 or lower.

**Teaching Assistants.** The committee recognizes that many chemistry programs employ undergraduate and graduate students as teaching assistants and that these are positive educational experiences for these students. The 2015 Guidelines indicate that programs must properly train and supervise teaching assistants.

### Infrastructure

**Instrumentation.** The expectation that students use a variety of instrumentation as part of their undergraduate instruction has been an important part of earlier editions of the Guidelines. Departments will still be required to have an operating NMR spectrometer that is used by undergraduates. A recent change is the availability of relatively inexpensive low-field NMR spectrometers marketed for the expressed purpose of enabling programs to meet this requirement. While these instruments are suitable for many instructional purposes, they often are not suitable for certain research projects. The 2015 Guidelines require programs to make arrangements for access to a higher-field NMR spectrometer at a proximal site if the on-site instrument is not suitable for all of the program needs. Also, undergraduates will now need to use equipment from at least four of five different categories: optical molecular spectroscopy, optical atomic spectroscopy, mass spectrometry (includes GC−MS and LC−MS), chromatography and separations, and electrochemistry when completing a certified degree. These instruments must be on site.

**Chemical Information Resources.** Rapid changes are occurring in how we access journals and in the databases used to search the literature. Recent iterations of the Guidelines required programs to have access to Chemical Abstracts and electronic search capabilities. That requirement was dropped from our program evaluation process in 2013. The 2015 Guidelines require that students have access to technical databases and other resources used in developing skills to search the literature, including structure-based searching. Also, programs must provide a curriculum in which certified majors develop the ability to retrieve information by searching the


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chemical literature, evaluate technical articles, and manage many types of chemical information.

After considerable discussion, the committee kept the requirement that programs have immediate institutional access to no fewer than 14 current and archival, peer-reviewed journals whose subject matter spans the chemical sciences. While many institutions have journal access well above this number, there are some departments where this requirement is essential to their ability to maintain a modest number of available journals. We also require that institutions provide timely access to journal articles that are not available on site by interlibrary loan or a document delivery service.

**Laboratory Safety Resources and Skills.** The 2015 Guidelines require approved programs to promote a safe environment for students and faculty and to develop a culture of safety consciousness. The Guidelines delineate important aspects of safety infrastructure (e.g., personal protective equipment, eyewash and shower stations, fume hoods) and practice (e.g., general and lab-specific safety instruction, written chemical hygiene plan, responsible disposal techniques) to which programs must adhere. A department or institutional safety committee that collaborates with an institutional chemical hygiene officer is highly recommended as a vehicle to promote a safety culture.

## Curriculum

**Inclusion of the Treatment of Large Molecules and Aggregated Systems in the Curriculum.** No other topic generated as much discussion or led to more feedback from the community than our consideration of the specific role of polymers, macromolecules, and larger aggregates in the undergraduate curriculum. The recognition that the properties of large molecules and aggregated systems are different from those of small molecules and the pervasive roles of large molecules and aggregated materials in living systems, industrial products and modern research drove these considerations. The 2015 Guidelines require the principles that govern macromolecular, supramolecular, mesoscale, and nanoscale systems to be part of the curriculum for certified graduates. Furthermore, instruction must cover the preparation, characterization, and physical properties of at least two of the following four types of systems: synthetic polymers, biological macromolecules, supramolecular aggregates, meso- or nanoscale materials. We expect that most departments will meet this requirement through coverage distributed across multiple courses required for the certified degree. In that case, the coverage should constitute the equivalent of approximately one-fourth of a standard semester course. An alternative option is to offer a stand-alone course that is required for all students who earn a certified degree.

We realize that this requirement may take some time for programs to satisfy or that programs may have some difficulty determining whether they are meeting this requirement. While we want programs to meet this new requirement as soon as feasible, they will not need to do so immediately. Conformance with this requirement will be assessed at the time of a program's next periodic report. If, in the committee's eyes it is not met, the program will need to address this situation by the time of their ensuing periodic report.

**Frequency of Foundation and In-depth Courses.** The 2008 Guidelines stated that in all but the most exceptional cases a program must teach all foundation courses annually. Operationally, the committee frequently allowed smaller programs to teach only four foundation courses a year, provided all five areas were covered over a two-year period. The 2015 Guidelines require programs to offer at least four of the five foundation courses annually and teach each foundation course once in a two-year period. If all five foundation courses are not taught annually, there must be an arrangement in place such that students can complete the requirements for certification in a four-year period. For programs that have developed an integrative curriculum in which foundation areas are blended into several courses, this would translate into ensuring the equivalent of four foundation courses are offered each year and that all five foundation areas are fully covered over a two-year period. Programs are still required to teach four semester-long or six quarter-long in-depth courses annually.

**Online and Virtual Instruction.** The Committee engaged in considerable discussion about online and virtual instruction in its deliberations of the 2015 Guidelines. We recognize that the landscape of online instruction is rapidly changing and that some forms and components of online instruction can be effective means of learning. However, the committee and members of our community are concerned about the potential for online instruction to displace too much of the face-to-face learning that is important in developing certain types of skills in students. We are also concerned about faculty workload and want to ensure that time spent in online instruction is properly rewarded.

The 2015 Guidelines speak to two aspects of online instruction. The first is that online activities that are developed as substitutes for classroom instruction should be assigned at least the same contact hour value as equivalent face-to-face classroom experiences. The second is that courses taught partially or wholly online should provide at least the same skill development and content as the corresponding face-to-face experience.

The 2015 Guidelines also speak of the necessity for hands-on experiences in laboratory instruction. General chemistry labs that serve as prerequisites for foundation courses must be primarily hands-on, supervised laboratory experiences. Similarly, students must get hands-on experiences operating modern instrumentation. This hands-on expertise cannot be developed through virtual laboratory exercises.

Given the rapidly evolving nature of online and virtual instruction, the committee will continue to look to the community in the coming years for insight on the place of these modes of instruction within the chemistry curriculum.

## Development of Student Skills

The 2015 Guidelines reinforce the importance of skill development by requiring that programs develop student competence in problem-solving, use of the chemical literature, communication, team work, and ethics. The 2015 Guidelines are not prescriptive about how and where this is done in the curriculum. The committee will evaluate the extent and adequacy of a program's efforts at developing these skills in students. The committee had considerable discussion about whether to institute a capstone requirement. Although the 2015 Guidelines describe the value of a capstone experience as a way of integrating knowledge and skills introduced across the curriculum, they do not require such an experience for certified majors.

## Periodic Reporting Requirements

A significant change in our evaluation procedures is a lengthening of the time between periodic reports from five to six years. This change lessens the reporting effort for approved



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programs and reduces the number of programs the committee must review each year. The committee recognizes that some of the additions to the 2008 and 2015 Guidelines on skill development and program evaluation are more difficult to assess and have necessitated the addition of narrative questions to the periodic report form for programs. We hope that the recent switch to electronic submission of reports facilitates completing and submitting the reports. Previous responses to narrative questions will be accessible to programs the next time they need to complete the report, which may help programs complete the reports in future iterations. The format and questions on the periodic report are evaluated on an annual basis by the committee and we welcome feedback at any time from the community about the reporting requirements.

## ■ CLOSING COMMENTS

We appreciate the many comments we received from the chemistry community over the past three years. They demonstrate the extent to which our community values the education of students. Comments from the community were vital in informing our thinking and helping us to craft the final version of the 2015 Guidelines. We look forward to working with the community in the implementation of the 2015 Guidelines and in promoting excellence in chemistry programs and in the students who receive degrees from those programs.

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### Notes

The authors declare no competing financial interest.


Thomas J. Wenzel, Anne B. McCoy, and Clark R. Landis are, respectively, Chair, Immediate Past-Chair, and Vice Chair of the Committee on Professional Training.


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