Revision of the ACS Guidelines for Undergraduate Chemistry Programs

Monday, August 18, 2006

232nd ACS National Meeting, San Francisco, CA,

Cosponsored with CPT, and SOCED
W. F. Polik, *Organizer, Presiding*

Progress report on the revision of ACS guidelines for approval of bachelor's degree programs in chemistry. ***W. F. Polik, Hope College***

Proposed ACS guidelines for course and laboratory curriculum: A CPT/audience dialog. ***C. K. Larive, University of California, Riverside***

New curriculum innovations supported by the proposed ACS guidelines: Small group discussion and reporting out. ***J. W. Kozarich, ACTIVX BIOSCIENCIES***

Proposed ACS guidelines for pedagogy and process skills: A CPT/audience dialog.
J. I. Shulman, University of Cincinnati

Proposed ACS guidelines for faculty and infrastructure: A CPT/audience dialog.
J.E. Pemberton, University of Arizona

Proposed ACS guidelines for program self-evaluation: A CPT/audience dialog.
W. F. Polik, Hope College

CHED 171

Progress report on the revision of ACS guidelines for approval of bachelor's degree programs in chemistry

William F. Polik, *Department of Chemistry, Hope College, 35 E. 12th Street, Holland, MI 49422-9000, Fax: 616-395-7118*

The ACS Committee on Professional Training (CPT) is undertaking a major revision of the ACS Guidelines for approval of bachelor's degree programs in chemistry. The long-standing goals of the ACS approval process will be reviewed, along with the current rationale for revising the guidelines. The guidelines revision process, especially the opportunities for community comment and involvement, will be described. The current status of this process is the widespread distribution of proposed revisions (available at the CPT website www.chemistry.org/education/cpt), for which public comment is invited.

CHED 172

Proposed ACS guidelines for course and laboratory curriculum: A CPT/audience dialog

Cynthia K. Larive, *Department of Chemistry, University of California-Riverside, Riverside, CA 92521, Fax: 951-827-4713, clarive@ucr.edu*

In the proposed ACS guidelines, previous core and advanced course requirements will be replaced with “foundation” and “in-depth” course work. Beyond introductory chemistry, five one-semester foundation courses will provide breadth of coverage in each of the major areas of chemistry. Twelve semester credit hours of in-depth course work will further develop or integrate topics introduced in foundation courses. The flexibility of in-depth courses will allow departments to design their own specialized degree tracks that focus on a specific chemistry subdiscipline or provide an interdisciplinary experience, thereby replacing the previous ACS-approved degree options. The total number of laboratory hours required will be 400 beyond the introductory chemistry experience, with at least 180 hours of foundation laboratory work. A short presentation of the proposed guidelines will be followed by audience questions and discussion.

CHED 173

New curriculum innovations supported by the proposed ACS guidelines: Small group discussion and reporting out

J. W. Kozarich, *ActivX Biosciences, Inc, 11025 North Torrey Pines Rd., La Jolla, CA 92037, Fax: 858-558-4878, johnk@activx.com*

It is expected that most currently approved programs could meet the proposed ACS guidelines with minimal changes. However, a goal is to facilitate and stimulate curricular change in the foundation and in-depth courses. The increased flexibility

associated with the proposed ACS guidelines presents many opportunities for departments to change their curricula. Examples of such curriculum innovations will be discussed by the audience in small groups and reported out.

CHED 174

Proposed ACS guidelines for pedagogy and process skills: A CPT/audience dialog

Joel I. Shulman*, Department of Chemistry, University of Cincinnati, Cincinnati, OH 45221*

In addition to educating and training students in chemical concepts and practice, an excellent program addresses the development of process skills in its students. Excellent programs produce students who work safely in the laboratory, demonstrate effective oral and written communication, and work effectively as a member of a team. Excellent programs encourage students to ask questions, design experiments, interpret results based on current scientific information, exhibit ethical scientific conduct, and develop behaviors and thought patterns leading to innovation and a capacity for lifelong learning. The development of innovative and stimulating pedagogy enhances the program's ability to achieve excellence in content delivery while building student capacity in the process skills outlined above. The proposed guidelines and re-approval process will encourage chemistry programs to develop integrative process skills in students and explore effective pedagogies. A short presentation of the proposed guidelines will be followed by audience questions and discussion.

CHED 175

Proposed ACS guidelines for faculty and infrastructure: A CPT/audience dialog

Jeanne E. Pemberton*, Department of Chemistry, University of Arizona, 1306 East University Boulevard, Tucson, AZ 85721, Fax: 520-621-8248*

In order to meet the challenges of effectively delivering a modern chemistry curriculum, the proposed ACS guidelines increase the minimum number of faculty for approved departments from four to five (although currently approved four-member departments will remain approvable until their size increases). This number matches the number of chemistry foundation areas, allowing for faculty expertise and teaching capacity in each area. It also allows a department to observe appropriate teaching contact hour limits and offer professional development opportunities, without excessive use of adjunct or part-time faculty. The proposed ACS guidelines will maintain current infrastructure requirements regarding instrumentation and chemical information resources, as a modern and well-maintained infrastructure is essential to delivery of a high quality education. A short presentation of the proposed guidelines will be followed by audience questions and discussion.

CHED 176

Proposed ACS guidelines for program self-evaluation: A CPT/audience dialog

William F. Polik, *Department of Chemistry, Hope College, 35 E. 12th Street, Holland, MI 49422-9000, Fax: 616-395-7118*

To promote excellence in chemistry education, the new guidelines will encourage self-evaluation by approved departments as a means of continual improvement. An excellent program regularly evaluates the effectiveness of its curricular and pedagogical efforts and uses the evaluation results to further improve itself. In the five-year reevaluation form, departments will be asked to summarize their most recent self-assessment and to outline a plan for acting upon the assessment recommendations. A short presentation of the proposed guidelines on program self-evaluation will be followed by audience questions and discussion.

Progress Report on the Revision of ACS Guidelines for Approval of Bachelor's Degree Programs in Chemistry

William F. Polik

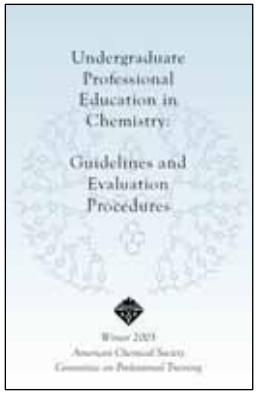
Hope College

ACS Committee on Professional Training, Chair

ACS National Meeting, San Francisco, Fall 2006

ACS Guidelines for Baccalaureate Degrees

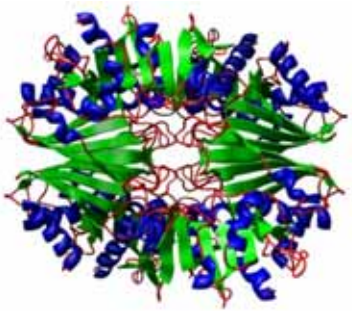
ACS Bylaws: "B. III. 3. h. 1. The SOCIETY shall sponsor an activity for the approval of undergraduate professional programs in chemistry. The Committee on Professional Training...shall act for the Board and Council in the formulation and implementation of the approval program..."



- 634 approved programs (196 research universities, 114 comprehensive universities, 324 baccalaureate colleges)
- Benefits of ACS-approval:
  - **Institution: public recognition of excellent program**
  - **Department: documents capabilities, leverages support**
  - **Faculty: professional development opportunities**
  - **Students: department has excellent capabilities ands resources; recognition of ACS-certified degree**
  - **Industry & Grad Schools: documents that students come from a capable chemistry program**

Rationale for Change

- **Chemistry is changing**
  - Interaction with other disciplines
  - Increasingly complex problems
  - More advanced techniques and instrumentation
  - Working in a global context

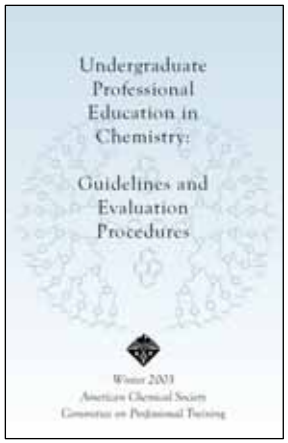


- **Education is changing**
  - Pedagogy is changing to reflect new research in how students learn (e.g., inquiry-based and active learning, team experiences)
  - Student population is becoming more diverse by age, gender, ethnicity and educational background

Past ACS Guidelines Changes

- **Regular change is needed to maintain the utility and relevance of guidelines**

- **Examples:**
  - 1999: All certified majors must have significant exposure to biochemistry
  - 2003: Chemistry Education option revised to increase number of high school teachers with chemistry training



Goals of Current Revision

- **Simplify** the ACS guidelines and procedures for approval of chemistry programs
- Provide **greater flexibility** to approved departments for designing certified degrees
- Encourage **innovation and improvement** in curriculum and pedagogy by approved departments
- Define **faculty and infrastructure attributes** that support excellent undergraduate chemistry programs

Guidelines Revision Progress Report - 1

- 2004-05: Broad **call for public comment** on ACS Guidelines and possible directions for revision
  - Notices published in *J Chem Ed*, *C&E News*, *CPT Newsletter*
  - Organization of and participation in symposia on the future of chemistry education
  - 72 pages of thoughtful letters and emails
- 2005-06: In response to comments from community, CPT drafts and publicizes **proposed changes** to the ACS Guidelines
  - Special workshop to consider community comments and draft proposed revisions

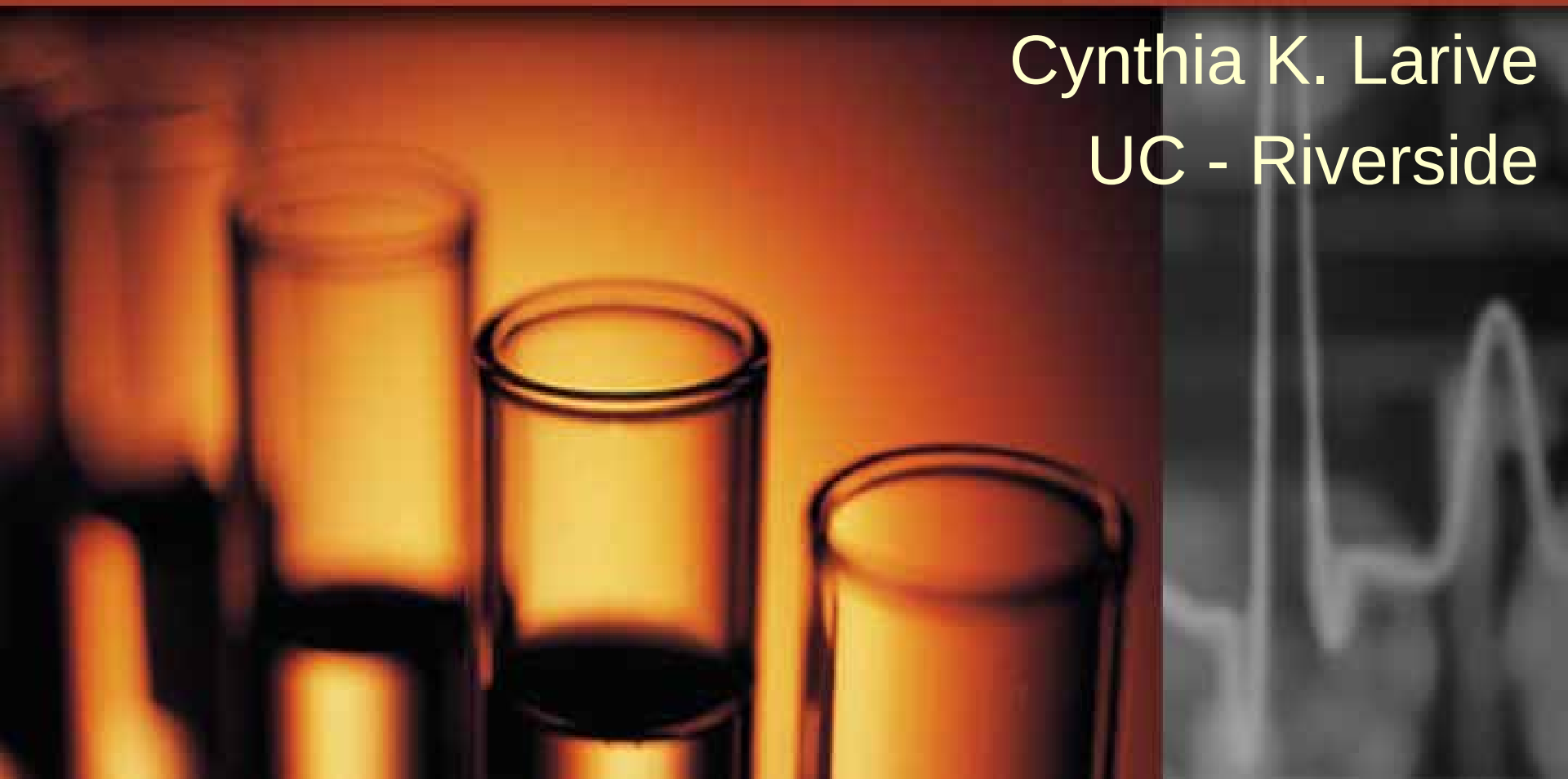
Guidelines Revision Progress Report - 2

- 2005-06: proposed changes (con't)
  - Publication of proposed revisions through direct mailings to faculty, letters to department chairs, CPT open meetings, *J Chem Ed* editorial, and organization of and participation in symposia (CUR, BCCE)
  - 130 pages of letters and emails from 87 institutions with comments, suggestions, and questions
- 2006-07: Informed by comments on proposed changes, CPT drafts and publicizes **draft** of new ACS Guidelines
- Early 2008: **New ACS Guidelines** are released

Summary of Proposed Changes

- **Curriculum:** Foundation courses, in-depth courses, laboratory hours, degree tracks
  - *1:50pm Course and Laboratory Curriculum**, C.K. Larive***
  - *2:20pm New Curriculum Innovations**, J.W. Kozarich***
- **Skills & Abilities:** Necessary for students to use their chemistry knowledge effectively
  - *3:00pm Pedagogy and Process Skills**, J.I. Shulman***
- **Faculty & Infrastructure:** Define attributes that support excellence
  - *3:30pm Faculty and Infrastructure**, J.E. Pemberton***
- **Program Self-Assessment:** Continual improvement of student learning
  - *4:00pm Program Self-Evaluation**, W.F. Polik***

Proposed ACS Guidelines for Course and Laboratory Instruction: A CPT/Audience Dialog



Cynthia K. Larive
UC - Riverside

Goals of Guidelines Revision

- Simplify the ACS guidelines and procedures for approval of chemistry programs
- Provide greater flexibility to approved departments for designing certified degrees
- Encourage innovation and improvement in curriculum and pedagogy by approved departments
- Define faculty and infrastructure attributes that support excellent undergraduate chemistry programs

Proposed Curriculum Changes: Foundation and In-Depth Coursework

Current Guidelines: Core and advanced course requirements will be replaced by:

Foundation Coursework: Beyond introductory chemistry, five one-semester foundation courses will provide breadth of coverage in each of the five major areas of chemistry: analytical, biochemistry, inorganic, organic, and physical

In-Depth Coursework: An additional twelve semester credit hours will further develop or integrate topics introduced in foundation courses

- In-depth courses have a foundation course pre-requisite, or contain a significant amount of chemistry that is necessary for a degree track
- Example: the second semester of a two-semester organic or physical chemistry sequence would be an in-depth course

Proposed Curriculum Changes: Laboratory Experience

Current Guidelines: 500 total lab hours, including introductory, organic, inorganic, analytical/instrumentation, and physical chemistry

Foundation course laboratory would be at least <u>180 hours</u>, preferably covering all five foundation areas of chemistry

The total number of hours beyond the introductory chemistry experience would be <u>400 hours</u>

Undergraduate research producing a comprehensive written report can be counted toward in-depth laboratory hours

Proposed Curriculum Changes: Degree Tracks

CPT-defined option degrees (chemistry, biochemistry chemical physics, environmental chemistry, materials, polymers, chemistry education) are replaced by...

Department-defined degree tracks: a specialized curriculum meeting foundation, in-depth, and laboratory requirements and focuses on:

- Chemistry, or
- A specific chemistry sub-discipline, or
- A chemistry-related interdisciplinary area

Example: A "Chemistry degree-track" might require the second semester of organic and of physical chemistry, along with two in-depth electives

Other examples: existing option degrees, bioanalytical chemistry, forensic chemistry, green chemistry, ...

New curriculum innovations supported by the proposed ACS guidelines: small group discussion out

J. W. Kozarich

ActivX Biosciences

Thoughts on Innovation

- "The greatest danger for most of us is not that our aim is too high and we miss it, but that it is too low and we reach it."– Michelangelo
- "The most successful people are those who are good at Plan B."-- James Yorke, mathematician
- "Innovation is not the product of logical thought, although the result is tied to logical structure. "-- Albert Einstein

SWOT Analysis

- Strengths
  - Increased Flexibility
- Weaknesses
  - Decreased Structure
- Opportunities
  - Innovative Curriculum Changes
- Threats
  - Loss of Certification Standards

A Thermodynamic Problem

$$\Delta G = \Delta H - T\Delta S$$

ACS Certification

Foundation Course Work

In-depth Course Work and Degree Track Flexibility

Plans of Attack

- Plan A
  - Map current curriculum onto new guideline structure
  - Imperfect fit but serviceable
  - Hopefully a temporary solution
- Plan B
  - Revamp curriculum to achieve good fit
  - Will take time and stages to implement
  - Ultimate goal of new guidelines

A Paradigm-Shift(?)

- Shift Curriculum Responsibility
  - From CPT to Departments
- Redefine How Chemistry is Taught
  - New textbooks (Can the foundations of organic and physical chemistry be laid down in one semester?)
- Create New Vision of an ACS Certified Chemist

Let’s Innovate

- Small Group Discussion: 10 minutes
  - Small groups – 4-6 chemists
  - Select a Time Keeper and a Secretary

- What innovations could be introduced into your curriculum under the proposed new ACS guidelines?

- Reporting Out: 10 minutes

Proposed ACS *Guidelines* for Pedagogy and Process Skills: A CPT/Audience Dialog

Joel Shulman, University of Cincinnati

ACS Committee on Professional Training

What Do We Mean By “Process Skills?”

Can be termed:

- Soft skills
- Employability skills
- Nontechnical professional competencies

Everything beyond the core chemistry knowledge and abilities that students learn in a chemistry curriculum.

Examples of Process Skills

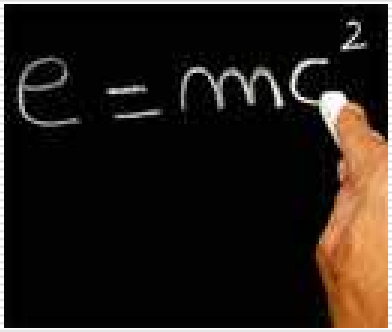
- Laboratory safety: "Students should develop a high degree of safety awareness, beginning early in the core courses…"

- Communication, both oral and written: "Effective written and oral communication skills…are no less essential to the well-trained scientist than to the humanist."

- Team skills: "The ability to work in multidisciplinary teams is essential for a well-educated scientist today."

Examples of Process Skills

- Problem solving/Critical thinking: "A strength of chemistry as general education as well as professional training is that problem-solving skills are emphasized and developed."



- Knowledge integration: "Chemistry faculty [can] improve student learning by…having students build from their past experiences" and should "…encourage integrating the subareas of chemistry…"

- Professional ethics/Social responsibility: "Chemistry is a discipline in which high standards of conduct must be exemplified…in ways that students cannot fail to observe and adopt."

Why Are We Emphasizing These Skills and Abilities?

- "Motherhood and apple pie"
- Industry, where 40% of new B.S. graduates go, has identified "outages" in some process skills, especially
  - Communication
  - Team work
- Success in graduate school depends on process skills such as problem-solving ability and knowledge integration.

So, What Will Be New About The Proposed *Guidelines?*

- Current *Guidelines* discuss all of these process skills.
- What's new is that CPT will now assess:
  - Whether chemistry programs are developing these skills in their graduates.
  - How they are doing this.
  - How they assess success in doing it.

Relationship Between Pedagogy and The Development of Process Skills

- Development of process skills will likely require student activities that are different from traditional lecture.
  - Separate “mini” courses
    - Safety
    - Ethics
    - Writing
    - Capstone seminar
  - Incorporation into existing courses
    - Poster session based on a project, with a literature component
    - Conscious design of team projects

Relationship Between Pedagogy and The Development of Process Skills

- Further examples
  - Undergraduate research
    - Written and oral reports

  - Exams that go beyond knowledge to demonstrate integration and utilization of information

CPT Expectations

- Departments will be expected to
  - Define important student process skills
  - Describe activities that will develop these skills
  - Evaluate whether (and how well) these skills are being developed

How Might CPT Assess Evaluate Programmatic Successes?

- Still in the planning stages: some possibilities
  - Narrative to include how process skills are incorporated into curriculum
    - Examples from multiple courses demonstrating how process skills are taught and assessed
    - Examples of innovative pedagogies which help develop process skills
  - Directed questions relating to process skills
  - Evaluation of comprehensive written reports from undergraduate research projects

Your comments and questions…

Characteristics of an Excellent Department: Faculty

- Energetic and accomplished faculty essential to excellent undergraduate program
- Faculty responsible for definition of overall goals of program within context of institutional mission
- Faculty define vision for student outcomes and are facilitators for student learning of content knowledge and process skills
- Faculty must be significantly engaged in educational mission of department
- Faculty should maintain professional competence reflective of current state of chemistry discipline
- Program should have mechanisms for faculty mentoring, development of faculty leadership and feedback to faculty regarding effectiveness in teaching, research and service appropriate to institutional mission

Proposed Guidelines Revisions: Faculty

Motivations for Guidelines Related to Faculty:

- Coverage of expertise in analytical, biochemistry, inorganic, organic & physical chemistry adequate to teach foundation and in-depth courses of approved program
- Significant majority should possess PhD in chemistry
- Faculty effort maintained at a level that allows adequate time for faculty to participate in appropriate professional development and renewal activities and to engage in research with students
- Collective faculty should be effective role models and represent diversity of today's students

Proposed Guidelines Revisions: Faculty

Proposed Guidelines Related to Faculty:

- Minimum of 5(4) full-time faculty with expertise representing the five areas of chemistry without excessive use of contingent faculty
- At least 80%(75%) of faculty must hold Ph.D.
- Faculty be required to teach at a level that involves real contact hours do not exceed 15 hours per week in any case
- Opportunities for regular faculty professional development and renewal should be in place (sabbaticals, participation in professional meetings, etc.)

Characteristics of an Excellent Department: Infrastructure

- Modern, operating, well-maintained suite of chemical instrumentation
- Computational capabilities and software for chemical computation and simulation
- Adequate staff support with appropriate expertise to assist department in its mission
- Modern, safe physical plant with adequate classroom, teaching laboratory, and research space to meet the department's mission, including facilities for chemical waste handling
- Library facilities with on-line access to *Chemical Abstracts*, broad range of subscriptions to chemical journals

Proposed Guidelines Revisions: Infrastructure

- Chemical instrumentation appropriate to department's curriculum; operating NMR
- Computational capabilities and software
- Adequate staff support for instrumentation repair and maintenance, stockroom support, administrative support
- Modern, safe physical plant with adequate classroom, teaching laboratory, and research space to meet the department's mission, including facilities for chemical waste handling
- Library facilities with on-line access to *Chemical Abstracts*, some minimum number of subscriptions to chemical journals yet to be discussed

Proposed ACS Guidelines for Program Self-Evaluation: A CPT/Audience Dialog

William F. Polik

Hope College

ACS Committee on Professional Training, Chair

ACS National Meeting, San Francisco, Fall 2006

Importance of Self-Evaluation

- Self-evaluation is a process by which institutions articulate their goals and determine how well they are meeting them.
- The goal of self-evaluation is program improvement
- All excellent institutions regularly engage in self-evaluation in order to improve their overall effectiveness.

Drivers of Self-Evaluation

- Internal vs. External
  - **increase number of majors, better prepare majors for graduate school or industry, teach skills and abilities, use more modern equipment, increase undergraduate research**
  - **part of college/university accreditation, or part of discipline-related approval process**
- Specific vs. General
  - **achievement of a particular goal, reaction to a problem**
  - **overall assessment of program's strengths and weaknesses**

Components of Self-Evaluation

1. Develop of review statement of goals
2. Collect data to measure progress towards goals
3. Analyze data to determine:
   - **extent to which goals are being met**
   - **reasons why or why not goals are being met**
4. Determine changes needed to meet goals more effectively
5. Implement plan and measure again

Simple Example of Self-Evaluation

1. **Goal:** increase number of chemistry majors who graduate
2. **Data Collection:**
   - number of chemistry students at each level
   - survey majors who stay and who leave
3. **Data Analysis:**
   - percentage loss at each level
   - content, perception, or presentation problems
4. **Propose Changes:**
   - target affected levels
   - for content: course structure, tutoring
   - for perception: grading policy, faculty approachability
   - for presentation: active learning, current topics, guided-inquiry, homework feedback
5. **Implement Changes and Collect Data Again**

Example of Student Learning Goals

Students will:

- Have a fundamental knowledge base in chemistry and biochemistry including: Atomic structure, Molecular structure and bonding, Quantum mechanics, Thermodynamics, Kinetics, Synthesis and Reactivity, Reaction Mechanisms, Equilibrium, Polymers and biomolecules, Metabolism
- Have good problem-solving skills, chemical information skills, and computer skills
- Have an ability to communicate effectively
- Have an ability to design and conduct experiments, as well as to analyze and interpret data
- Understand the theory and practice of laboratory techniques
- Understand the theory and practice of major instrumentation
- Use safe procedures in a chemistry laboratory
- Work well in teams
- Understand professional and ethical responsibility
- Understand relations between chemistry and other science disciplines
- Understand the impact of chemistry in a global and societal context
- Have a successful transition to their post-college activities

Benefits of Program Self-Evaluation

- Improve student learning
  - **identify what does and does not work for *your* students**
- Increase departmental communication
  - **Identification of common goals**
  - **Discussion of future efforts**
- Leverage and increase resources
  - **Internal sources respond to projected benefits**
  - **Plan and support external grant proposals**
- Increase overall efficiency
  - **focus on what is important (not just urgent)**
- Broaden thinking
  - **beyond teaching chemistry content, consider student career preparation, faculty development, institutional mission**

Proposed ACS Reporting Requirements

- Description of most recent self-evaluation
  - **rationale (department self-study, institutional re-accreditation, or activity carried out for ACS-approval)**
  - **date**
  - **Summary of overall approach**
- Main results
  - **plan for acting on the results**
  - **implementation of plan to date**
- Action plan
  - **What is planned**
  - **Progress made to date**

Resources for Self-Evaluation

- ACS Symposia
  - **Thursday, Sept 14, pm, CHED 537-541:** ***Defining outcomes and preparing for departmental reviews: Maintaining a healthy department***
  - **Spring 2006:** ***The development and implementation of learning objectives in chemistry departments A view of progress at a myriad of institutions***
- Web pages – under construction
  - **ACS Guidelines supplement on self-evaluation, including a bibliography**
  - **Case studies**

Self-Evaluation Summary

- Objectives are to
  - **determine if goals of department are being met**
  - **identify actions that will help department meet its goals**
- Designed to not be onerous or burdensome
  - **use existing self-evaluation (and perhaps improve it)**
  - **examples will be provided on CPT website**
  - **short response on ACS re-approval report form**
- Self-evaluation is a process, not a product, for continual improvement of an organization