Components of a Research-Supportive Undergraduate Chemistry Curriculum

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Undergraduate research is an inquiry or investigation conducted by an undergraduate that makes an original intellectual or creative contribution to the discipline

-Original work
-Peer-reviewed publications

Undergraduate Research Summit – Recommendations to enhance the quality and quantity of research at PUIs

http://www.bates.edu/x50817.xml

Research-Supportive Curriculum

- Develops the skills that are needed for successful participation in an independent research project
- Facilitates student participation in research by allowing time and offering credit for undertaking research

Desired Learning Outcomes

- *Knowledge outcomes* – "..particular areas of disciplinary or professional content that students can recall, relate, and appropriately deploy."

- *Skills outcomes* – "the learned capacity to do something – for example, think critically, communicate effectively, productively collaborate, or perform particular technical procedures – as either an end in itself or as a prerequisite for further development

- Affective Outcomes – "..usually involve changes in beliefs or in the development of particular values, for example, empathy, ethical behavior, self respect, or respect for others."

- Learned abilities – "..typically involve the integration of knowledge, skills, and attitudes in complex ways that require multiple elements of learning. Examples embrace leadership, teamwork, effective problem-solving, and reflective practice"

From Ewell, P.T., *Accreditation and Student Learning Outcomes: A Proposed Point of Departure*, Council for Higher Education Accreditation (CHEA) Occasional Paper, Washington, DC, September 2001

- A research-supportive curriculum will likely necessitate giving up some other requirements in the major
- Adding a research requirement to a packed schedule of instructional courses and laboratories will diminish the gains that can occur through research
- A research-supportive curriculum integrates research and research-like experiences throughout, and culminates in a capstone research experience

Creating Time for Students to Conduct Research

- Eliminate and integrate instructional labs
  - Remove the every-course-has-a-lab format
- Free up senior year of any instructional labs
  - Research becomes the senior "instructional" lab
- Reduce vertical/restrictive aspects of the curriculum

Creating Time for Students to Conduct Research

- Have fewer requirements and more electives
- Have students in instructional labs with courses undertake actual components of a faculty member's original research
  - Especially if contact hours too high

Research-Supportive Chemistry Curriculum at Bates

- Reduced the number of courses that had associated labs
- Created upper-level integrated labs
  -emphasis on research-like activities
  -advanced synthesis or measurement lab
  -corresponding elective courses
- Senior year free of instructional labs
- Thermodynamics or Physical Biochemistry
- Required senior thesis – most students do two semesters for two full course credits – 12 hours/week

My Individual Courses

- General Chemistry

"General Chemistry: Expanding the Learning Outcomes and Promoting Interdisciplinary Connections through the Use of a Semester-long Project," Wenzel, T. J., *Cell Biology Education*, **2006**, *5*, 76-84.

"General Chemistry: Expanding the Goals Beyond Content and Lab Skills," Wenzel, T. J.; in *Gender, Science and the Undergraduate Curriculum: Building Two Way Streets*, Association of American Colleges and Universities, **2001**, 29-46.

- Upper-level separations course

"The Teaching Learning Process in Analytical Chemistry," Wenzel, T. J.; *Microchimica Acta*, **2003**, *142*, 161-166.

"A New Approach to Undergraduate Analytical Chemistry," Wenzel, T.J.; *Analytical Chemistry*, **1995**, *67*, 470A-475A.

Cooperative Learning

- Class divided into small groups (3-5)
- Presented with a problem or question
  - I serve as a facilitator
  - If one student sees the point, she or he is to explain it to the others
  - When the groups appreciate the point, I call timeout and highlight the concept

Advantages of Cooperative Learning

- More "teacher" resources because the students are teachers as well
- Less formal
- Active learning – I know what they do/don't understand – they know what they do/don't understand
- Students spend more time on class material
- Cooperation, not competition
- Students learn more

Outcomes of Cooperative Learning from Prior Research Studies

- Statistically significant improvements in academic achievement
- Better reasoning and critical thinking skills
- Proposed more new ideas when presented with problems
- Transferred more of what was learned in prior situations to new problems
- Reduced levels of stress
- Promotes more positive attitudes toward subject and instructional experience – faculty get to know students better

- Decreased absenteeism
- Improved student commitment
- Greater motivation toward learning
- Better student retention (especially for women and minorities)

  -Socially involved

  -Academically involved

"Peer-Assessment and Self-Assessment of Group Activities," Wenzel, T. J., *Journal of Chemical Education*, **2007**, *84*, 182-186.

"Practical Tips for Cooperative Learning," Wenzel, T. J., *Analytical Chemistry*, **2000**, *72*, 359A-361A.

"Cooperative Student Activities as Learning Devices," Wenzel, T. J., *Analytical Chemistry*, **2000**, *72*, 293A-296A.

"Cooperative Group Learning in Undergraduate Analytical Chemistry," Wenzel, T.J., *Analytical Chemistry*, **1998**, *70*, 790A-795A.

Introductory Course

- Thematic version of general chemistry – fundamentals of chemistry related to the study of the environment
- Counts for the chemistry major
- Pre-requisite for all upper-level chemistry courses
- 60 students in class (20/lab)

Laboratory Project – Groups of 4

- Do plants grown in soil contaminated with lead take up more lead?
- Does the uptake of lead vary with the acidity of the rain water?

Some questions the students need to answer:

- What to grow?
- What soil to use?
- How to mimic acid rain?
- How much lead to add?
- What watering schedule?
- What to use as a control?

Some advantages of the project:

- Conduct a real investigation
- Ask/answer questions
- Design experiments
- Unanticipated problems
- Teamwork
- Communication – Informal/formal
- Opportunity for leadership

Uncertainty

- 26 of 29 contaminated samples had higher lead

  -other three?

- Acidity trend is inconclusive

Analytical Chemistry Course

- Analysis of methylbenzenes/terpenes in air
- Analysis of trihalomethanes in drinking water
- Amino acid content of foods (popcorn and beer)
- Caffeine, theophylline, and theobromine levels in chocolate
- Analysis of nitrate and nitrite in hot dogs/cured meats
- PAHs in burgers, oysters, diesel exhaust and wood smoke
- Toxic metals in sludges from waste-water treatment plants

THE GOAL

To design an undergraduate curriculum in which students begin scholarly-like activities in their first year and progress through to an original project by their senior year