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”

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


• Upper-level separations course


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


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.