Noyce Science Center Grinnell College

A Scenario

At Grinnell, students in an introductory chemistry course hear about global warming and greenhouse gasses in the classroom. They then go to the lab and measure the temperature difference between two beakers with a sun lamp shining on them, one filled with air and one with another gas, like carbon dioxide or oxygen. They repeat this for about eight different gasses. Pooling class data in a spreadsheet, they then note variation in measurements, seeing some clear trends: Some are clearly greenhouse gasses; others are not or have ambiguous results.

Students, following rudimentary instructions on drawing Lewis electron structures, look for structural similarities in those that are greenhouse gasses and differences for those that are not. Next week they measure the infrared (IR) spectra of the gasses and note which ones absorb lots of IR light and which do not. Moving on, they simulate the IR spectra using computational software, looking at molecular motions that correspond to their actual absorbance measurements, linking this information to their temperature measurements. Students then develop a theory for what structural features correspond to gasses being greenhouse gasses.

In doing this, they learn key chemical concepts not because they are in chapter six or that they might need to know for a later class, but because they are interested in answering an important question and know they need to understand concepts and models to address the question of interest. The added advantage of this learning experience is that it goes beyond learning content. More importantly, in the process of doing science, they become aware that advances in science rarely progress in a linear fashion to a single right answer.

So, what does this have to do with facilities planning?

Background

For over fifty years, Grinnell College has been recognized nationally as a pioneer in developing research-rich learning environments in the undergraduate setting. This culture was greatly enriched through a two-stage process of planning spaces for STEM learners that began in the mid-1990's.



Goals of the first stage were spaces that:

- Support the educational philosophy of the science departments, including provision for discovery-based learning in classrooms and for research by faculty and undergraduates, accommodating essential state-of-the art technologies and instrumentation.
- Prompted and supported a sense of community among STEM learners and faculty and that could be a living room for the campus.

Those years (at Grinnell) were about pushing myself. The most important thing that happened at Grinnell is that I met three or four mentors at Grinnell who helped me to push the boundaries of what I had done prior. — Student

Lessons Learned

Features of spaces that accomplish our goals included:

- Teaching labs designed more like research labs to promote research-type activities and provide summer research space.
- Classrooms designed to promote the engaged learning that is collaborative learning.
- Public spaces in corridors with tables and chairs for individual and group work and for poster sessions and other public community events.



- Tack boards scattered throughout for posting student research, making visible the process and results of the doing of science.
- Exterior glass to provide transparency into the building, spotlighting activity, together with windows within the building to bring natural light and energy into the interior spaces.

Findings from Research

With the completion of the first facilities phase and support from an NSF AIRE award, in 1998, David Lopatto, a member of Grinnell's Psychology Department, undertook a study of what and how undergraduates learn when engaged with faculty in research labs and in course-based research-like experiences.

Findings from this work, undertaken in collaboration with colleagues at other institutions, provided powerful organizing principles and goals for moving into the second stage of planning STEM spaces at Grinnell.

Major findings of their research included:

- Student-reported gains in disciplinary skills, research design, information or data collection and analysis, information literacy, communication, and a readiness for more demanding research.
- Student-reported gains in personal development, including the growth of selfconfidence, independence of work and thought, and a sense of accomplishment.
- Undergraduate researchers were more tolerant of obstacles faced in the research process.
- The quality of mentoring is a strong influence on student experience as it allows the instructor to break down the distinction between classroom learning and research.

In the process of his research, Lopatto designed the CURE (Classroom Undergraduate Research Experience) survey, seeking to document the impact of working as an undergraduate researcher in teams or with peer mentors. Lopatto has compared student learning gains over three types of experiences: dedicated summer research, traditional science



courses, and courses incorporating research-like experiences. He finds that students in research-like courses report gains close to a dedicated research experience.

The STEM community of learners at Grinnell, informed by Lopatto's work and on their own experiences in classroom and lab, has a communal understanding that research experiences, both within courses and stand alone, can be significant maturation times for students, where they can both learn and discover themselves, choosing and refining their beliefs. In this sense, expertise is defined both by cognitive capacity and by the self-knowledge and beliefs to which one is committed.



