Building Programs and Spaces at Hendrix College:
ATEC, an Integrated Junior Level Laboratory

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Anyone who has participated in a facilities project or a curricular revision is acutely aware of the myriad decisions necessary to bring the venture to fruition. The question of "what to put where?" holds a central focus in both processes. What may not be obvious is that facilities and curriculum are intimately tied together through the question of student learning. In both cases, a successful project depends on the primacy of the question, "what should students learn where?"

Hendrix College is a private liberal arts institution in central Arkansas with an enrollment of approximately 1100. The five-member Chemistry department, including a full time laboratory manager, educates over 200 students/year in the introductory sequences of General and Organic Chemistry. The department graduates between 10-20 majors per year that go on in equal proportions to further studies in medical school, graduate school, or the chemical industry within two years of graduation.

The Hendrix chemistry department is characterized by an emphasis on undergraduate research. Undergraduate research was officially initiated at Hendrix in 1978 and by 1982 the department was sending students to present research results at the spring American Chemical Society meeting. The department has now traveled a distance equal to the circumference of the globe by sending our students to research meetings. Further, the department has grown to include five research faculty. In 1997, our Chemistry Department initiated a new junior-level, project-based laboratory program, entitled Advanced Techniques in Experimental Chemistry (ATEC). In 2001, new science facilities were dedicated that, in part, were designed to support this program.

Previous to these curricular changes, the chemistry department offered a traditional set of segregated upper-level laboratory experiences. These included Physical Chemistry with a focus on measurement of energy and rate; Advanced Inorganic Chemistry with a focus on synthesis; and Advanced Analytical Chemistry centered on analyte analysis and instrument adaptation. Although each course had specific expectations for students, it had been years since the department programs had been evaluated for a unified understanding of the student learning goals.

Our curricular design process, along with the building project, began with an evaluation of the existing program. This included an assessment of students' needs, and an analysis of the departmental aims and goals. We found that the department's experience with undergraduate research reshaped our vision of student learning. We found that we wanted to create laboratory environments where the required student thinking was intellectually similar to the creativity required to execute research projects. For the upper-level laboratories, this realization expanded our student learning goals beyond the traditional skills. Our new learning goals for the junior level laboratory are develop synthesis, characterization, and analytical skills to:

- improve creative and critical thinking skills
- evaluate appropriate techniques and execute a plan
- participate in collaborative efforts that transcend traditional scientific divisions
- evaluate the implications of their work and the impact it has on the environment
- develop effective oral and written communication skills.

Once we settled on a set of student learning goals, we worked to develop the pedagogy that would deliver the facts and the skills, the curriculum to support it, and finally the facilities.

The task of deciding on a list of student learning goals is much larger and more important than it first appears. The learning goals are the cornerstone for all the decisions about pedagogy, curriculum, and facilities. Additionally, all the project shareholders must join in the final consensus. Despite the small size of our department, we found it was a challenge to work on substantive curriculum developments in hour-long meetings. Back and forth discussions between offices led to repetition of arguments, and the process stagnated, consensus required proximity, attention to the concerns, and distance from distractions. We found that the most productive model was to retreat to a faculty home in order to focus on the serious work of program building.

After tackling the student learning goals, we worked to design a pedagogy. In planning the junior level laboratory, we felt that compartmentalization of the course work at the junior-senior student level in the traditional program had led the students to intellectually segregate their thinking. We wanted to apply a research rich model, developed from our experience with faculty directed research programs. This has also been known as problem-based or discovery-based learning. These concerns led us to focus on an interdisciplinary, project-based laboratory program to remove artificial boundaries between courses. We expected students to use the scientific method and discovery-based laboratories to stimulate the thinking process of research.

The new laboratory program became known as ATEC. It is year-long, junior level laboratory course that meets twice a week concurrent with physical chemistry. Students participate in project-based tasks that involve sample development (typically synthesis), characterization, analysis, assessment, and reporting to faculty who act as consultants rather than directors. Herein the students participate in science in the same way that scientists do research – instruments and tools are used in context.

At present the course begins with workshops on instruments, data analysis treatment, technical writing, spectroscopy, and safety. During the course of the year students participate in five projects that give them experience with organometallic synthesis, characterization, kinetics, computer modeling, and environmental trace analysis. Ideally all three of the traditional laboratory courses, Physical, Advanced Inorganic, and Advanced Analytical Chemistry would be represented in each project. The original project ideas came from textbooks, journal articles, and faculty research. However, we customized many ideas to our specific needs. "Adopt and adapt" is an important credo to remember when creating new programs. In many cases, the projects constantly evolve since it is important to keep them unpredictable.

The year culminates in Individual Research Initiatives (IRI). In the IRI, each student is responsible for selecting a problem, creating and executing a timely plan, and assessing the results. This experience is designed to mimic the research experience by moving students from being acceptors of facts to being responsible creators of new information. All the department's resources are available to the students, with careful faculty oversight. This is where students begin to emerge as scientists. We have been delighted with the wide variety of projects the students have suggested and successfully completed during the IRI. We feel that this is in large part due to the training they receive in earlier projects.

After the course was designed we had the opportunity to create new spaces to support this curriculum. The building project recognized the need for the physical spaces to be tailored to the different tasks related to the ATEC laboratory, and yet flexible enough to support curricular changes in the future. We designed a suite of rooms that included a synthesis laboratory heavy with hood space, an adjacent characterization laboratory that has served as a central location for many of the department's equipment holdings, a laser laboratory, and a data analysis-library space. The data analysis room has served us well in many capacities. It holds the computers and software dedicated to the ATEC projects, the Department's library resources for upper level students, as well as serving as a conference and write-up room for informal cooperative groups fostered by these projects.

It is important to recognize that our programs and spaces grew out of an assessment of our students' learning goals. Program and facility development is a prolonged venture that builds slowly on the strengths of the department. This evolution is only occasionally punctuated by externally obvious departures from previous practices. One of these punctuation marks at Hendrix is the development of the ATEC laboratory for our junior-level students and the subsequent new spaces we developed. We have achieved our goal of moving students towards working and thinking as scientists during their undergraduate laboratory experiences.