



WHAT WORKS - A PKAL ESSAY

FACILITIES FOR THE RESEARCH-RICH LEARNING ENVIRONMENT

When Project Kaleidoscope (PKAL) was formed in 1989 with the mandate to study 'What Works' in undergraduate science education, few could have imagined the impact that this organization would have on both pedagogy and facilities in the ensuing decade and beyond. Hundreds of institutions and dozens of design professionals have participated in, and benefited from, the remarkable work of this grass-roots organization.

In order to elaborate on the attributes of 'facilities for the research-rich learning environment', it is appropriate to start by considering the broader trends in undergraduate sciences that have evolved over these past 15 years since PKAL was born.

Trends in undergraduate science facilities

Students as active participants

PKAL discovered 'what works' in science education is that students benefit from a hands-on, laboratory rich environment where students 'learn science' by 'doing science'. There is less emphasis on simply reading books, taking tests and being 'lectured-to', and a greater emphasis on collaborative group activities which more accurately replicate real world conditions. This phenomenon seems to be true not only within the laboratory environment, but also within the classroom. At many institutions, huge lecture rooms with a single row of fixed tablet arm chairs per tier are being replaced by smaller rooms featuring two rows of fixed tables and movable chairs per tier. This feature facilitates the incorporation of group activities by allowing students in the front row of each tier to turn around and work with students behind them across a common table.

Lectures in the laboratory

Just as group activities are now being accommodated within modern classrooms and lecture spaces, lecture activities are more frequently and successfully being integrated into the teaching laboratory environment. The careful consideration of laboratory bench design and appropriate room proportions facilitates better sightlines to the 'teaching wall' and better faculty/student interaction during lecture or pre-lab discussion activities. In fact, the increasing use of movable laboratory tables (where the need for piped services at student benches does not require fixed casework) has facilitated reconfiguration of the teaching laboratory as appropriate to support different courses or activities within the same room. (See discussion of movable tables under 'Alternative Teaching Laboratory Layouts' below.)

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TRENDS IN UNDERGRADUATE SCIENCE FACILITIES

- ◆ Learning science by doing science
- ◆ Lectures in the laboratory
- ◆ Integration of technology
- ◆ Scientific collaboration
- ◆ Science on display
- ◆ Celebration of science
- ◆ Sustainability



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Integration of technology

Another obvious trend in the undergraduate sciences has been the integration of technology into the laboratory environment. Computers are being used in laboratories of all types and laptops are becoming more prevalent. Multi-media audio-visual technologies are commonplace in both the laboratory and classroom with use of LCD projectors, DVD players, document cameras and 'Smart Boards' in addition to the more traditional slide projectors and overhead projectors.

Although the cost of technology sometimes dictates that such equipment be located on media carts to be shared by multiple rooms, flexibility dictates that provisions be made for future installation of such technology into all classrooms and teaching laboratories by providing structural capability in the ceiling and conduit pathways for cabling. Another form of technology integration is the increasing use of sophisticated laboratory instrumentation by both faculty and students.

Scientific Collaboration

Scientific collaboration is a major trend that is being accommodated in many different ways in modern undergraduate science facilities. Spaces for conducting faculty and student research are essential in promoting scientific collaboration and in maintaining the 'research-rich' learning environment.

Collaboration also takes place in how the building engages its occupants and visitors. Provision of spaces for faculty/student interaction, student study, and consumption of food/drinks outside of the laboratories and classrooms can promote a healthy collaborative environment.

Science on Display

Another trend in undergraduate science facilities is to put 'science on display'. The use of interior and exterior windows allows occupants and visitors to literally see what is going on in the laboratories, classrooms, and/or laboratory support spaces. Display cases are used to show off scientific artifacts, collections of old instruments or student projects. The provision of places to display student posters can activate the corridor experience and demonstrate vitality among the institution's scientific community.

Celebration of science

The 'celebration of science' through the incorporation of scientific art is another popular trend in undergraduate science facilities. There are many fine examples of scientific art in recent projects, such as the 3-story DNA mural in the atrium of the new science facility at Agnes Scott College (sequenced from a blood sample of a direct female descendant of the founder, Agnes Scott), or the popular Foucault pendulum at such institutions as Occidental College, St. John's University (MN), and Hendrix College.

Some state institutions are required by law to spend a certain percentage of construction cost on public art, resulting in such scientific art as the tile mosaic of bacteria on the atrium floor at Iowa State University's Molecular Biology Building, or the 3 Phases of Water in the Chemistry Building at the University of Southern Colorado. This 'celebration of science' through scientific art helps to energize these facilities, generating discussion about art and science, and helping to promote a more vital, interactive community.

Sustainability

A final, recent trend in undergraduate science facilities is the subject of 'sustainability'. While science buildings are typically energy hogs due to the abundance of fume hoods and heat-producing equipment, there is an increasing interest in being environmentally-sensitive in the design, construction and use of these facilities. Appropriate siting of the building to take advantage of natural lighting and ventilation, the use of sustainable materials, and the consideration of alternative building systems/technologies to reduce energy consumption are all examples of sustainability ideas being incorporated into the science facilities of today and tomorrow.

Students are becoming increasingly vocal about environmental awareness and encouraging their institutions to 'do the right thing'. Similarly, many institutions are looking at ways to 'market' their environmental sensitivity to donors and students through the incorporation of sustainability features in their facilities.



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Building Configurations and Functional Relationships

There are many variables to consider when developing a building design to support the research rich learning environment in an undergraduate science facility. The science departments must define their desired adjacencies and functional relationships between teaching laboratories, research laboratories, laboratory support spaces, classrooms, offices, and interaction spaces.

This can vary widely based on factors such as institutional preferences, intensity of mentored research programs, or degree of departmental support staff. Many faculty prefer to have their faculty/student research laboratory directly adjacent to their faculty office for ease of mentoring/monitoring their students.

Others prefer an adjacency between research and teaching laboratories for more convenient shared use of common equipment and support spaces, as well as the opportunity for research activities to ‘spill out’ into the teaching laboratories during non-academic periods.

Building configurations can also vary based on the degree to which an institution wishes to promote interdisciplinary collaboration between the departments. There can be a healthy ‘tension’ created by the competing interests of maintaining a departmental identity while leveraging the interdisciplinary programs that bring the different departments together.

Rather than simply organizing a building with each department on a different floor, interesting opportunities and benefits can result from mixing things up a bit.

For example, at Spelman College’s Science Center, General Chemistry and Physical Chemistry laboratories are located on the first floor along with all of the Physics space, with shared use of a common Laser/Optics teaching laboratory between the departments. The second floor features a shared Environmental Sciences teaching laboratory at the

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core of the building, along with portions of the Biology Department spaces. The third floor houses Organic Chemistry, Biochemistry and Cell/Molecular Biology teaching and research laboratories with specialized support spaces shared by Biology and Chemistry.

Faculty offices were purposely located at one end of the building away from the main entrance in order to force students and visitors to pass through the laboratory corridors and experience something about the activities going on within on their way to see a faculty member.

The campus context and building site can also have an impact on the configuration of the building. Consideration must be given to pedestrian, vehicular and service access as well as the massing of the building in the context of other campus buildings. The proportions of the selected building site can dictate building proportions and massing options.

Thus, it is necessary to look at building configuration issues both from the ‘inside out’ (i.e. the functional relationships desired by the faculty) and from the ‘outside in’ (i.e. issues dictated by the site and campus context). There is no single correct answer for all facilities. The only correct answer is the one that best fits the needs of a given institution.

Faculty/Student Research Spaces

As noted previously, accommodation of faculty/student research has become an increasingly important trend in undergraduate science facilities. Many institutions now require some sort of culminating research project or ‘capstone’ research experience for science majors prior to graduation. Students are motivated to seek out research opportunities to improve their viability as a candidate for graduate school admittance or employment in science related fields. Institutions are recognizing that the provision of faculty research space is an important issue in the recruitment and retention of the best faculty.



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While the importance of faculty/student research space is almost universally recognized, the options and solutions for accommodating such space vary widely. Whether an institution chooses to provide smaller laboratories dedicated to individual faculty working with their students or larger spaces shared by multiple faculty members within a given sub-discipline, it is important to have research space distinct from teaching laboratory space in order to support ongoing faculty and/or student projects. In either case, it is reasonable to consider an appropriate allocation of space per faculty.

An analysis of several recent RFD undergraduate science facility projects at public and private institutions reveals that the average net area of research space per faculty is approximately 400 to 450 square feet.

This area will accommodate one faculty member working with 3-4 students concurrently. Having multiple laboratories of this size in a cluster with inter-connecting doors provides the opportunity for collaboration between laboratories and for the potential expansion/contraction of research group sizes.

Another important component in the design of faculty/student research space is how to deal with student 'write-up' desks. Desks can be located within the research laboratory, immediately outside of the laboratory, or remote from the research laboratory.

It is generally desirable to have the desk areas proximate to the research laboratory for easy access and the ability to monitor on-going experiments.



The decision whether to locate desks within or outside of the laboratory is often related to the perceived hazards within the laboratory. One benefit of locating desks outside of the laboratory is the accommodation of food and drink at the student desks. In projects where the desks are located within the laboratories it is essential to provide appropriate interaction spaces outside of the laboratory environment where food and drink can be consumed safely.

An additional element related to faculty/student research is the provision of appropriate laboratory support space for specialized instrumentation (such as NMR, Electron Microscopy, Imaging, etc.), specialized procedures (such as Tissue Culture, Media Preparation, etc.) or specialized environments (such as Greenhouses, Animal Facilities, Cold rooms or Warm Rooms).

These types of spaces are essential in supporting a range of research and teaching activities, and allow the laboratory spaces themselves to be somewhat more generic as a result.

Conclusions

The undergraduate science facilities of tomorrow will likely need to handle greater and more diverse demands than ever before. While the solutions will vary widely among different institutions, the most successful of these facilities will arguably be the ones that best support the 'research-rich learning environment' in a manner most appropriate to that unique institutional setting. Are you ready for the challenge on your campus? ■