WHAT WORKS - STORIES FROM THE COMMUNITY

NOTRE DAME'S JORDAN HALL OF SCIENCE

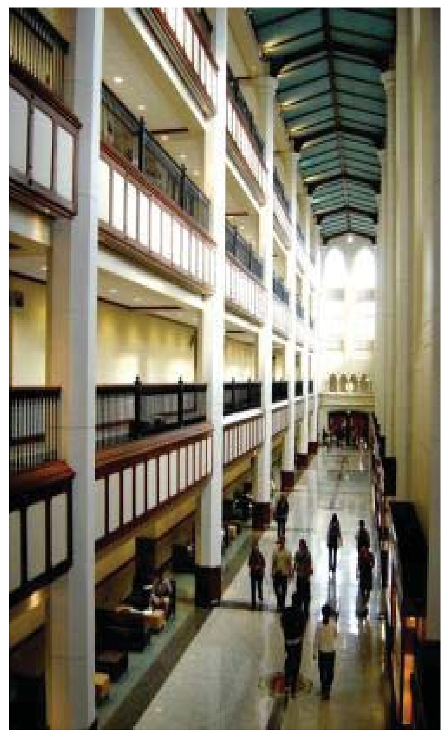
"What will the science of future be like?" This was one of the questions driving the planning of Jordan Hall of Science, the new facility for undergraduate science in biology, chemistry and physics at Notre Dame. Their recognition that "...imaging was becoming important in all of the sciences, that new technologies were making it possible to image everything from individual atoms to galaxies..." gave faculty a metaphor for their planning, one that influenced how they designed and equipped classrooms, hallways, laboratories, and Jordan's digital visualization theatre. But those planning these spaces also asked, "How do the students of today learn?" Their answers to that question are visible throughout— from the design of the large-enrollment classrooms to that of the lounges.

Dennis C. Jacobs
Vice President
Associate Provost
University of Notre Dame

Jeanne L. Narum
Director
Project Kaleidoscope

Jeanne L. Narum: You served in the role of what PKAL calls the "project shepherd" in the process of shaping the new spaces at Notre Dame— Jordan Hall, which serves undergraduate programs in chemistry, physics, and biology.

As you know, the PKAL planning premise starts with an understanding of how and what the students are to learn in the spaces to be realized. Tell us something about what happens in your classrooms.



Dennis C. Jacobs: I've been teaching chemistry at the University of Notre Dame for eighteen years. My area of specialty in physical chemistry involves looking at how reactions occur on surfaces. Right now, for example, we have experiments flying on the international space station to understand how materials erode in that environment.

In addition to my research, I really enjoy teaching— that's why I became a faculty member. I treasure that undergraduate education is very important to Notre Dame and that our students are committed to learning. This is a wonderful environment in which to work.

After seven years here, I began teaching general chemistry. Like at many research universities, this is a large enrollment class, with sections of about 250 students each. This was the most challenging teaching environment I have experienced, and it wasn't until I began teaching gen chem that I realized the deficiencies in the way I was teaching.

To that point, I had always judged my performance in the classroom by asking myself, "Did I get it right? Was I accurate in what I was trying to express in terms of content? Did I answer questions clearly?" If I could answer 'yes' to all of those questions, I would pat myself on the back and say, "That was a good class."

But, once I began teaching first-year students, I recognized many were having a very tough transition from high school to college. Notre Dame's demands and expectations for their performance were very different from what they had experienced in high school, where memorization and regurgitation of information seemed to be adequate.

NOTRE DAME'S JORDAN HALL OF SCIENCE

Where, when asked to figure out problems, they had only to memorize and reproduce algorithms, recipes, procedures. What we were doing here at Notre Dame was challenging these first-year students to think through new systems and applications, to apply concepts in ways that were very foreign to them.

So, in their first six weeks of the first semester of college an alarming number of students were failing or dropping out of my gen chem course. As my office hours seemed to be filled with students who were struggling, I felt that there was something that these students were not doing.

Soon, however, I realized I was not helping them make the transition into a different mind-set about learning science, and thus began rethinking how I teach. The challenge was how to change my style of teaching in a space that was constrained, with theater-seating, when I was trying to get students to think about and apply what they are learning, receive accurate feedback, and have opportunities to discuss, voice their ideas, conceptions, misconceptions, etc.

So I went in a few different directions. One is to make the course more interactive— using a lot of concept questions in class, building those around demonstrations so that students are challenged to apply the concepts we have learned in order to make accurate predictions about what will occur in experimental demonstrations.

To simultaneously engage all 250 students in the process, I began using wireless clickers, á la Eric Mazur. These alternative approaches transformed both the way I teach and the way I use learning spaces.

Narum: So when the planning team was thinking about what kind of learning was to happen inside your new spaces, were you alone in thinking about these new ways of teaching? Were others comfortable with staying in theater-style, faculty-centered teaching spaces?

Jacobs: No, there was actually a great deal of support across all the departments involved. Cooperative learning had spread to other classes in chemistry; the physics department adapted it extensively for their introductory physics courses; Biological Sciences is using the clickers in the teaching of genetics.

We all agreed that our plans for the two 250-student capacity lecture halls in Jordan would have to support various cooperative learning approaches.

In these two lecture halls, the floor is gradually sloped, with only five levels of seating, and just two rows of tables and chairs on each level.

Although the tables are built-in, it is easy for students in each odd row to turn and interact with students in the even row behind them on the same level; teams of two or four can be formed very easily.

Narum: Chairs on wheels?

Jacobs: Yes, all chairs are on wheels. If you remember how I integrate demonstrations into my teaching— as do many of my colleagues, we wanted to make certain that these lecture halls supported demonstrations.

So, the lecture halls are well-equipped with full glass fume hoods, but the most important thing to mention is the integrated system of cameras and projection screens that allow for different types of imaging and projection simultaneously— with three independent large projection screens on the front end of the room, we can be projecting live demos, images from PowerPoint, and 2-D or 3-D objects through a document camera, all at the same time.

In summary, the faculty recognized the value of different pedagogical approaches and wanted to ensure that the space was flexible enough to support a wide variety of teaching and learning styles within our large enrollment courses.

Narum: What other kinds of pedagogies are you and your colleagues experimenting with?

NOTRE DAME'S JORDAN HALL OF SCIENCE

Jacobs: There are lots of different types of experimentation in all departments: guided inquiry; Just-in-time Teaching; etc. This diversity of approaches is good, and Notre Dame has a Center for Teaching and Learning that helps facilitate conversations and communications around different modes of teaching. This is a very supportive place for a variety of modes of teaching.

Narum: Talk to me about the planning process.

Jacobs: The departments of physics, biological sciences, and chemistry/biochemistry each contributed three or four faculty to an advisory group, which also included a representative from the provost's office and the university architect.

We worked for two years, meeting probably every two weeks. We started with 'programming' what we needed to put into the space, what we needed to accomplish in the space, and from there laying out the kinds of spaces in the building that would facilitate the kind of learning we wanted to foster.

Early in the process, the architectural firm S/L/A/M was engaged, bringing in consultants as needed. Because our campus policy states that all the money has to be in hand before construction can begin, after two years of aggressive planning, the project was put 'on hold' for about 18 months before we could break ground.

Construction lasted approximately 2½ years. We moved into the building in summer 2006 and were ready for the first day of classes on August 22, 2006.

Narum: What questions did you ask about how science is changing, how did you bring the future into the present planning?

Jacobs: Through all our planning conversations, we began to recognize that imaging was becoming important across all the sciences, that new technologies were making it possible to image everything from individual atoms to galaxies.

All of us— chemists, biologists and physicists— realized that imaging kept coming up, again and again, at the cutting edge in their field.

So, the jewel in Jordan Hall is what we are calling the Digital Visualization Theater. It is a 136-seat capacity room with a 360-degree domed ceiling, like you would see at a planetarium.

But the reason we call it the Digital Visualization Theater rather than a planetarium is because it is intended to serve all the sciences and even Notre Dame students in fields outside of science.

Students will be able to experience what it is like to be inside a cell, or see the transcription of DNA to messenger RNA, or to experience what it would be like to visit King Tut's tomb, etc.

It is an all digital system built around a pair of Sony SRX-S110 projectors, a new level of very sharp, very bright projectors used in IMAX theaters, combined with a new lens system to project the two images seamlessly onto the 50-foot diameter dome. Notre Dame has the first full installation of this technology in the United States.

Let me illustrate the power and versatility of the software driving the Digital Visualization Theater. A chemist might say, "here's a target molecule we're trying to develop for cancer therapy," then electronically transfer the graphics file to the master computer. A cluster of microprocessors then performs a real-time 3-D rendering of the target molecule and projects it on the dome.

As the enormous molecule rotates or moves across the dome at the instructor's command, students feel as if they have been transported into the molecule's universe.

They can begin to appreciate how subtle changes in the linkages between a few atoms can impact the molecule's three-dimensional structure and its subsequent reactivity.

NOTRE DAME'S JORDAN HALL OF SCIENCE

The astrophysics faculty are ecstatic that they now can have their students fly through space and visit any corner of the galaxy. These astronomical journeys can be scripted in advance or driven in real time at the whim of the instructor. The Digital Visualization Theater leaves students with an indelible image of the intricacies of nature.

This visualization facility is an example of faculty coming together across departments and disciplines with a vision of the future.

We tried to think of using spaces with greater synergy and collaboration, rather than just carving the building into thirds. We tried to create spaces like the Digital Visualization Theater and the lecture halls that we all could take advantage of.

Of course there are also highly specialized labs in the building. You can easily identify the organic chemistry lab, because of the way it is configured, and nobody else will use it but organic chemists. But, there are other places that are intentionally flexible enough for many different kinds of uses.

Interdisciplinary courses are becoming increasingly important; therefore, the biochemistry lab is adjacent to the cell biology/genetics lab, and analytical chemistry is adjacent to ecology, for example.

By locating certain lab spaces in close proximity, the College of Science is well positioned to innovate its curriculum in ways we cannot currently imagine, without being constrained by the building layout.

Narum: Talk a little bit about the psychology of the space. Was there a vision for fostering community in the science building?

Jacobs: There was. We designed a lot of common space throughout the building, including a coffee bar area. The study lounges within Jordan Hall are arguably the most attractive space on campus for students to hang out. They are carpeted and well lit with very comfortable furniture. When we designed the space and selected the furniture our goal was to develop lounge spaces that were inviting to students, where students could easily congregate spontaneously in small groups, and where students and faculty could follow up on conversations that began in class or lab. Portable white boards on casters can be rolled up to a cluster of seats if students want to write or draw on a surface.

The building is "cathedral gothic" on the outside, consistent with the rest of the Notre Dame campus. The dominant interior feature is the north-south galleria standing four stories high.

Lining the western side of the galleria are balconies through which students access the labs on the upper levels. The eastern wall is filled with cathedral style windows, illuminating all floors of the building.

The galleria further captures our vision of imaging; the first floor is lined with display cases, starting at the southern end with the microscopic (what's inside a nucleus), then moving up to atoms, molecules, cells, organisms, and by the time you make it to the opposite end of the hallway, you are up to galaxies.

NOTRE DAME'S JORDAN HALL OF SCIENCE

The display, which integrates all the disciplines, is organized by scale. Halfway down the hallway is the museum of biodiversity, a unique collection of 600,000 plant, insect, and vertebrae specimens. When you arrive at the north end of the galleria, you are at the entrance to the Digital Visualization Theater!

There is a greenhouse with four independent climate zones with computer controlled lighting, temperature, and humidity settings.

On the rooftop is an observatory deck with a dozen portable telescopes and one large fixed telescope with CCD imagery; students can remotely point the telescope and capture images in real time for projection anywhere in the building.

We are also working with a firm to produce a video, probably about a fifteen-minute repeating reel, that captures undergraduates engaged in cutting-edge research at Notre Dame.

The video will be projected on a wall in the building, a way of sending a message to students that what they are learning in Jordan Hall connects with research at the frontiers of science and technology.

Narum: Any lessons learned?

Jacobs: Two come to mind. From the beginning, this project was to be solely for undergraduate education. There was a conscious decision to make it interdisciplinary, put all the sciences together, and I think that was a good decision.

But the existing spaces for our departments are separate buildings, and so we have effectively created a place for teaching that is apart from faculty offices and research. So the plus side is that it is 202,000 square feet designed completely for undergraduate education.

The minus side is that there are only twenty faculty offices in the building, with the majority of the faculty, research labs and graduate students housed elsewhere.

So we needed to compensate by making the space very inviting for faculty and graduate students so they would want to spend time here even when they were not scheduled to be here (one reason for the attention to the lounges).

It remains to be seen as to whether we can develop a satellite community of science in a space that is physically separate from where most faculty spend the majority of their time, in their office and their research lab.

But this was a compromise in siting, because there just was not a footprint surrounding our existing science buildings to expand them in ways that would have allowed us to put the teaching and research together.

However, the building is adjacent to the athletic complex, an important site for our campus, so although we did not have a lot of options for where to put the building, we think we've designed a first floor space that even one passing through can't help but be exposed to all kinds of science and to feel welcome to join our community of science.

The second challenge in terms of the planning is that this committee of ten faculty, architects, etc. focused entirely on the facility and on the kind of teaching and learning we wanted the space to enable.

There was not a similar amount of planning about the resources we will need to fill and utilize the space. What kinds of scientific instrumentation will we need to purchase, and how much will it cost? How many additional staff and teaching assistants will be needed to provide and support instruction in the newly designed space?

Everybody on the planning committee focused on the budget for the building— the "project" as we say— the one time cost of the building, but what was not included in that discussion was a thorough analysis of the implications of certain architectural designs on the recurring expenses needed to staff and supply the instructional space.

In part, this omission was a result of leadership changes during the project planning, which meant we didn't have some of the difficult discussions we really should have had about where and how to compromise on the building design to lessen the impact that the new space will have on the operating budget.

The faculty were there to inform the design process from the perspective of how and what we wanted students to learn, but the administrative voice expressing potential concerns about the long-term impact of using this new space was largely absent.

NOTRE DAME'S JORDAN HALL OF SCIENCE

Narum: Does that mean issues of sustainability and greenness were also off the table?

Jacobs: The issues that are coming back to challenge us are not so much energy efficiency, which was built into the building, we were very mindful of waste emissions, for example. In landscaping, students and faculty made it into a living classroom, with native species from Indiana.

The piece that was missing though is really that in order to fully utilize the space we would need to add how many staff, how many graduate students, etc.— personnel issues.

There wasn't a full anticipation of the equipment and instrumentation needs because that was not considered part of the project; only after the designs were all completed and the building was under construction did it become known to the administration that we have to raise additional funding in order to fill the building with the appropriate instrumentation to make it all work.

Narum: When you walk into the building what does your heart say to you?

Jacobs: I think Jordan Hall is a visually striking building because of the magnificence of the galleria, the large amount of natural light, the attractive display of science everywhere, and the comfortable way in which the public spaces foster community. It just jumps out and draws you in.

The majority of space within the building is allocated to undergraduate teaching laboratories. In terms of classroom space, the building is relatively modest: two 250-seat lecture rooms; one 136-seat Digital Visualization Theater; and two 40-seat classrooms.

On the other hand, there are forty specialized teaching laboratories within the building, an observatory, a greenhouse, and a museum of biological diversity. I should point out that there are some interesting hybrid spaces.

For example, all of the labs used for first- and second-year chemistry courses are connected to "data analysis rooms," which look and function like classrooms.

The notion is that we want students to move fluidly back and forth from the laboratory space, in which students must wear lab aprons and goggles in accordance with safety protocol, and a comfortable carpeted space with movable chairs where students can sit down with their laptops and lab partners to analyze and discuss the data they just collected or plan out the procedure that they want to try next in lab.

The data analysis rooms can be used for pre-lab lectures or post-lab discussions, so there is adjoining space next to these labs that allows for a different kind of learning experience.

Overall, Jordan Hall stands out as a beautiful, creative, well-designed, and technologically advanced space that invites students and faculty to explore nature together. I am eager to see the clever ways in which students and faculty make use of the space to advance scientific understanding and to develop the scientific leaders of tomorrow. ■