The 21st Century will be Engineered.

The 21st Century is being engineered in university and college classrooms right now.

Our world has become so complex that nearly every aspect of our lives is now engineered. What’s more, scientific phenomena and feats – and the engineering behind them – have become a large part of pop culture and thus, our common dialogue. Scientists are being interviewed on morning news programs like *The Today Show*, innovators are being profiled in A-list magazines like *Time*, and talk show programs like *The Daily Show with Jon Stewart* are shining the light on the profession as cool and relevant.

This heightened status of the engineering profession – not to mention its impact on our world – brings with it a huge responsibility. We’ve now come to expect that engineers will help lead us to a more balanced global condition in this century. And while conferred degrees in engineering have continued to increase, as much 12 percent in the last decade to meet the demand, there is still much to be done.

We need new kinds of spaces to support new ways of learning. We need to create physical environments that foster collaboration. And we need buildings that tell the story of the groundbreaking work of the profession.

**Teaching The 21st Century Engineer**

The 21st Century engineer needs to exhibit a broader range of skills to succeed in the global market. He or she needs to be a creative problem solver. He or she needs to exhibit leadership and business savvy. Engineering students need to be “T-Shaped” thinkers, experts in their field able to conceptualize how their knowledge connects with other systems. This kind of training demands new kinds of spaces.

**Collaboration Between Disciplines**

We must also make spaces that foster collaboration between disciplines as well as between graduates and undergraduates. While the desire is there, the traditional campus boundaries have long been an impediment. Smart facility planning can break down those barriers.

**Telling the Story**

Lastly, the fierce competition for students and faculty makes the ability to showcase who you are a priority. The work you do may be largely hidden away today. If others can see your innovations, they will invest. If future students see others succeeding, they will want to be part of it.

Supporting these necessary changes in your facilities will have profound impacts on your mission. The following pages highlight some more specific ways these ideas can be translated into your campus.
Make Space for the 21st Century Engineer

Most people think of a stereotypical engineering student as someone who is quiet, reserved and prefers to work independently. But this stereotype doesn’t take into account the needs of the 21st century engineer. Studies documented by The Carnegie Foundation, PKAL and The National Academy of Engineering have all recommended that engineer education move rapidly to a system that prepares students to work collaboratively to solve real-world problems. These recommendations have sparked a shift to greater hands-on learning opportunities and an increase in team-based projects. The physical learning space must adapt to support this change.

Hands-on Learning

While upper-level engineering coursework has always had a strong lab component, the first-year engineering education curriculum has been more instructor-centric. The advantage to exposing students to more hands-on learning early not only promotes greater conceptual retention, but also promotes greater retention of students in the program.

Purdue University’s Ideas to Innovation Learning Laboratory, commonly referred to as the i2i Learning Lab, is designed specifically to enhance the first-year engineering experience. The project-based curriculum is supported by a series of spaces specifically designed to follow the student’s progress through the engineering design cycle. Rooms are equipped with moveable storage carts and enough containers to allow student teams to work on something up to the size and weight of a lawnmower engine. Tables wired to personal computers, tablets, projectors and floor-to-ceiling dry erase boards all encourage group interaction. A team-oriented design lab, a team lecture space, small group discussion rooms and a fabrication shop are all part of the i2i space.

Team-based Learning

For the next generation of engineers, being able to work as part of a team is a necessary skill; however, most classrooms are not designed to facilitate this type of learning due to fixed furniture, inadequate size or deficient technology.

Looking Forward

At Rose-Hulman Institute of Technology, faculty advocated for five existing underutilized classrooms to be transformed into team-based environments. Now complete, groups of four students can alternate between team-oriented discussions to entire-class discussions while an instructor moves freely about the space. Flat-screens TVs and whiteboards wallpaper the rooms, allowing information to be created and shared seamlessly.

Looking Forward

As more faculty embrace a highly collaborative learning model, the demand for spaces that promote intentional collaboration will explode. Unlike traditional labs, these spaces are quite simple to create in new buildings or retro-fit existing conditions. The cost is quickly decreasing as visualization becomes less expensive and wireless technologies become more robust.

LEARNING RETENTION RATES

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Lecture</td>
<td>5%</td>
</tr>
<tr>
<td>Reading</td>
<td>10%</td>
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<tr>
<td>A/V</td>
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<tr>
<td>Demonstration</td>
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</tr>
<tr>
<td>Discussion</td>
<td>50%</td>
</tr>
<tr>
<td>Practice by Doing</td>
<td>75%</td>
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</tbody>
</table>

LEFT: Fabrication Lab / Purdue University
BELOW: Team-Based Classrooms / Rose-Hulman Institute of Technology
During the two semesters the i2i lab has been open, attendance for first-year engineering students jumped almost 20 percentage points to 98 percent. And the number of students withdrawing or earning non-passing grades fell from 10 percent to 5 percent.
Make Interdisciplinary Collaboration Easy

The lines between engineering disciplines are blurring. This trend has been largely led by faculty whose research topics have demanded a more interdisciplinary approach. In fact, entirely new fields of engineering such as bio- and nano-engineering have been born out of these conditions.

This blended landscape where disciplines overlap reflects the environment in which engineering students will operate throughout their careers. While there will always be a need to develop specialties within a discipline-based curriculum, students will also benefit from the opportunities to apply that knowledge across the vast spectrum of problem-based engineering.

A Vessel for Collaboration

Colorado State University’s College of Engineering strategically decided to focus its mission on providing a hands-on, interdisciplinary education focused on the research areas of energy, health and the environment.

To support that mission, its new 122,000 sq. ft. engineering research building brings together five departments: Atmospheric Science, Biomedical Engineering, Chemical & Biological Engineering, Civil & Environmental Engineering, Electrical & Computer Engineering, Mechanical Engineering and the School of Biomedical Engineering.

During the process of making the building, researchers collaborated with the design team to balance their specific needs with the needs of other groups. The result is flexible space, smartly organized enough to meet today’s needs and flexible enough to adapt to new focuses over time.

The Collaboration Shop

South Dakota State University also recognized an opportunity to enhance collaboration among its departments. In particular, the School of Engineering wanted to see the interdisciplinary, learn-by-doing methodology become a pervasive force within its campus.

In their newly-planned expansion to their oldest engineering building, a 12,000 sq. ft. fabrication studio will house all the equipment and layout space needed by this precinct of campus. These labs will be used by each department within the College of Engineering, as well as by the College of Architecture. As such, the final product will be an open, flexible, project-centered environment that will prepare students to work collaboratively — an environment that mirrors the professional world into which they will soon enter.

Looking Forward. Interdisciplinary collaboration will continue to grow. Presently, it’s most evident in research and graduate level work; however, there will be a time in the not-to-distant future where it will permeate the undergraduate experience. Reconnecting research and undergraduate facilities could supplement the undergraduate educational needs for space and also offer greater financial flexibility in capital expenditures towards facilities — not restricting them to “research only” buildings. It can also affect a school’s ability to recruit its undergraduates into its graduate programs.

A campus where the walls are truly broken down will be the most effective use of space and the most aligned with the goals of a 21st century engineering education.
Bringing together graduate and undergraduate facilities not only better leverages physical resources, it can also more easily recruit undergraduates to pursue their graduate work on campus.
The more complex a problem — the more exciting the solution. But if no one ever sees the work, selling the success of a program becomes very difficult. Furthermore, a vast majority of engineering facilities have suffered under deferred maintenance, closed doors and opaque walls. To an incoming student or donor, the program can appear underwhelming because of this. But with a little rethinking, the building can serve as one of the greatest recruitment tools.

Make the Invisible Visible
Dr. Brent Seales, head of the University of Kentucky Vis-Center, is a shining example of a 21st century engineer. His multidisciplinary global research is gripping. Additionally, he is a highly motivational leader who understands the power of marketing his research and clearly stating its value to the world. So when it was time to design a building to house the Vis-Center, showcasing the work of his pioneering faculty and students was a top priority.

The Vis-Center houses faculty from the schools of Computer Science, Electrical Engineering, Art, Architecture and Teaching. Working collaboratively, their work is focused on the applications of visualization technologies on everyday life and is very visually engaging. Because their work offers exceptional visual aids, translating the work into the physical environment was easy; the computer cluster is visible behind a glass wall, glass walled labs line the main corridors, and work is projected onto the exterior glass wall to showcase the research going on inside to the campus community.

Perhaps the greatest element used to showcase the department’s innovations is the Digital Theater. Part research lab and part movie theater, this 80-person presentation space is flexible enough to hold seminars, arts performances or act as a motion capture lab.

Looking Forward
As competition for resources on campus and between university departments increases, the importance of making your work stand out is imperative. Like Dr. Seales, university engineering departments must make a conscious effort to showcase their work through the building’s design. The question for many colleges is how to strategically transform their facilities in a time when funding is limited or nonexistent and often significant private support is required for any capital endeavor. This trend is likely to only accelerate. Therefore, colleges of engineering must leverage the work they are already doing by simply making it more visible.

Make Space for the 21st Century Engineer

Of the four most recent COE projects completed, nearly 75% of the funding came from sources other than direct state appropriations.

“Hardware Lab” / University of Kentucky

The building is a beacon at night / University of Kentucky

[Image of the building at night]

[Image of the Digital Theater]
The design of a space can be a vehicle to showcasing what you do and your value to the world. This impacts your outreach to a broader student demographic, your donor base, and the university as a whole.

The Digital Theater in “Presentation Mode” / University of Kentucky, VisCenter
Powering the Transformation

An engineering building’s design can fuel the creation of 21st century engineers. Architects can work with the educators to define some basic, shared criteria for incorporating new ways of teaching into the building’s design, thereby helping students develop the best technological skills possible, as well as the business savvy and leadership skills required of this generation of engineers. Smart planning can also help make the most effective use of space by crafting spaces that are not only highly flexible today but also adaptable over the next one hundred years. And perhaps equally important, the building’s design can become an outward expression of how the institution is helping to lead the way in 21st Century Engineering Education.