

Perspectives from Industry

The *Journal of Engineering Education* gratefully acknowledges our corporate partners for their support of this special issue. Their generosity made it possible to distribute complimentary copies of this issue to U.S. engineering faculty members and to many other stakeholders worldwide. Their continued commitment to assure global engineering excellence is greatly appreciated. We are pleased to share with you their thoughts and comments on the future of global engineering education.



THE TWENTY-FIRST CENTURY GRAND ENGINEERING EDUCATION CHALLENGE

XAVIER FOUGER

Director

Global Learning and PLM Academy

Engineers have enabled globalization, a transformation with planetary impact. Not just in the way humans interact with the planet but also in the way the planet “works”. As a consequence, engineers now have a challenge of global magnitude: *how to make globalization sustainable*. The U.S. National Academy of Engineering recently published the “21st Century’s Grand Engineering Challenges,” a set of ambitious challenges for engineers that reflects this new reality. These grand challenges will equally challenge engineering education, whose task must be to prepare the next generation of engineers to further prosperity within the complex system of an interconnected planet. This will not be easy.

Many stakeholders in academia, policy making, and business are already involved in the transformation of global engineering education. Among them is Dassault Systemes, a global supplier of technologies to help transform engineering in many businesses.¹ However, what has been achieved thus far is still infinitesimal in view of the considerable impact necessary to transform the global engineering education system. This special issue provides a perfect framework to review how industry and academia can collaborate on the “who, what, and how” to improve engineering education.

Who are today’s and tomorrow’s engineering students? The need to educate more engineers will help drive the desired diversification in engineering students. Recent experiences have shown successes in three areas of collaboration: *recruitment* by increasing the attractiveness of engineering by defining, testing, sharing, and enabling

best practices and collaborative initiatives to attract underrepresented populations, and reach families with little or no awareness of engineering; *retention* by jointly inventing and deploying ways of sustaining student commitment to, and enthusiasm and energy for engineering learning; and *volume* by sharing visibility, ideas, and efforts in defining locations and disciplines where an increase in capacity is justified by employment opportunities.

What do engineering students need to know? Tomorrow’s engineering practices are not to be found in books written ten years ago. We need to rapidly develop the right *mix* of conceptual and procedural knowledge required to articulate and execute solutions to our planetary challenges. This requires infusing several characteristics within curriculum. Among them is *agility*, where industry can help faculty understand skills and practices that emerge or become standard in engineering jobs, including skills resulting from globalization and virtualization of the engineering profession, aptitudes and attitudes required in sustainable development, or discipline-mixing, experience-based innovation. Instruments to that end include fellowships, sabbaticals, and industry conferences. Another is *scalability* where industry can help transfer new engineering methods practiced by innovative businesses into curriculum through such means as faculty training by industry, educational content distribution, and educator/student internships in industry with educational scopes of work.

How can we help engineering students learn better? Businesses have been exposed very early to powerful forces resulting from globalization. To increase their competitiveness or to simply survive, they recognized that learning is a key response to these pressures. This drove significant innovation in distance- and blended-learning, high speed knowledge updates, knowledge certification within partner and stakeholders networks, and affordability of large-scale education programs, to name a few. Sharing understanding, co-inventing new techniques, and transferring know-how about these innovations can greatly benefit from collaborative work between businesses and academia.

Only if many more in industry and academia join forces will the global engineering education community succeed in the “21st century grand engineering education challenge.” We commend the *Journal of Engineering Education*; it is a remarkable tool to that end.



A MORE EXPERIENTIAL EDUCATION

RAY ALMGREN

Vice President

Product Marketing and Academic Relations

What top three experiences define the ideal engineering education in today’s world? First, and foremost, is the integration of

¹Technologies include CATIA, SolidWorks, SIMULIA (Abaqus), Dymola, ENOVIA, DELMIA, Vtools, and 3DViaComposer (Seemage).

hands-on, experiential learning with classroom-taught theory. It is critical that students experience the opportunity to work on exciting projects in order to fully ground the theories they are taught in a classroom. Second, if the experiential learning involves collaborative, socially-relevant projects, students will also develop the professional skills of teamwork, communication, and leadership while they hone their technical skills. In a world where no engineer is an island and products are likely to be co-designed with someone in another country, these skills are more important than ever. Finally, it is no longer acceptable for engineers to just analyze problems or mathematically derive models of problems; they must experience design, creativity, and innovation. They must be able to synthesize unique and innovative designs using their knowledge. Here again, hands-on learning is critical to developing these skills.

When engineers graduate, they will encounter two challenges particular to this day and age. The first, and biggest, is the converging complexity of devices and systems, for example, automobile telematics. Just a few years ago, this system included a radio and a CD player. Today, the system not only incorporates the standard radio and CD player, but a cell phone, wireless Internet, a GPS navigation system, a DVD player, communication to handsets and PDAs via Bluetooth technology, and remote diagnostics. No single engineer can understand each of these technologies, but he or she must be capable of designing, prototyping, and deploying this system in a few months.

The second challenge is globalization. The product they design will probably be co-designed with someone in another region of the world, and then very likely be produced at yet another location. Today's engineers must be technically competent and skilled at working on and managing teams of engineers with diverse cultural backgrounds.

We ask a lot of engineering students, and it is evident in the United States that students are deciding not to pursue science and engineering degrees because they can make a good living doing something else. We must excite and inspire them to become the world's future heroes—the scientists and engineers that will cure disease, create sustainable energy for all of us, and create safe drinking water in every country.

At National Instruments, we believe that graphical system design offers students an easy-to-learn approach to science and engineering education that lets them quickly jump into exciting projects and explore how they can make the world a better place. Our unique approach is to tightly integrate our software and hardware into a low-cost, computer-based platform that maximizes system performance while lowering the overall system cost. Because each of our products is tightly integrated with the computer and the computer software architecture, the user enjoys high development productivity.

So how does graphical system design assist with hands-on learning? Take a look at the evolution of programming tools over the past 50 years. As semiconductor technology has advanced, so has programming technology. It would take years to design devices at the transistor level. Today, we use advanced design tools that synthesize complex systems on a chip.

Similarly, software engineers no longer must program at the lowest levels of assembly, or even with the programming language C. The systems are so complex that they must approach them at a system design level. It is with system design tools that engineers can take advantage of the latest computing technology without having to be low-level expert embedded programmers.

Graphical system design is so intuitive, in fact, that even elementary school students can program with it. For example, LEGO MINDSTORMS NXT robots use graphical programming software, and children as young as five years old are building and programming robots. These are highly sophisticated, 32-bit embedded systems. It would be impossible to teach a young child to do this in C. Instead of playing a video game, children are designing and building their own game, using the same tools engineers use to put robots on Mars.

These are the engineers of the future. This is how hands-on learning is invaluable to engineering education, and graphical system design tools can help deliver that hands-on experience in an exciting, cost-effective manner that inspires the heroes of the next generation.



EMPOWERING THE NEXT GENERATION OF ENGINEERS

KRIS GOPALAKRISHNAN
Chief Executive Officer and Managing Director

I believe that major changes in education must take place for the economy to grow and bring harmony and peace to the world. With the unhindered exploitation of natural resources, it is time for education systems to focus on green engineering for sustainable growth. Five factors deserve our attention.

Recruiting the students of tomorrow. Of late, due to the increasing convenience in our lifestyles, it has become challenging to keep students engaged in the process of learning. This has only been made more complex due to changes in what society deems as success or failure. Material success seems to get the most recognition, thus drawing attention away from studies. This has also added to the complexity of keeping students engaged. It is not enough to discuss student engagement in isolation; the issue has to be treated alongside the quality and commitment of faculty members.

Diversifying the engineering workforce. With a huge shortage of personpower in engineering and continuous emergence of new problems, it is imperative to convince able people to opt for engineering. If not, these pressing problems will be left unattended, and as a result we may continue to use older technologies that are not optimal for energy efficiency. For example, in India, the problem stems from parental and societal pressures, which result in uninterested students joining engineering colleges and, thereafter, the workforce. In other geographies, particularly the West, the fear of math and science has dissuaded children from taking up engineering.

Breaking the mold using technology. From our knowledge of how engineering education systems have grown across the world, it is clear that they are localized in perspective. However, in today's completely connected world enabled by high technology, the importance of borderless collaboration has become critical. Without this, future research and innovation will suffer from a shortage of people who can successfully pursue advanced studies. Fortunately,

the information and collaboration technology infrastructure and virtualized classrooms can allow the world's best faculty to interact seamlessly with international classrooms. For this to happen, new financial models have to be found in education services, just as with any other service. Collaboration must be envisaged on a scale much larger than it is today.

Better student engagement. Solving the pedagogy puzzle—it is a time for introspection when it comes to engineering education and methods. Today, both are far removed from the workshop where answers to current problems troubling society are to be found. While sound knowledge of math and science behind engineering is important, it should not become an obsession. The education system must take a closer look at the learning needs of students, pay attention to their learning styles, and develop the capabilities to address these needs in innovative ways. It is only when students experience the insight-driven 'Aha' approach to learning and problem-solving that they will be immersed in the learning process. It is only then that they will feel that they can contribute to society, and develop a sense of pride in doing so. Can we achieve this effect in every class and for every student? The success of engineering education lies in solving this puzzle.

Designing engineering education for the future, not the past. For reasons inexplicable to me, I feel that our education system is too steeped in the past. How apt it would be for our lessons to project a view of the future and indicate unsolved problems, and touch upon the problems of material, energy, water, privacy, etc. For faculty, it would be interesting to teach students about how riddles were solved in the past, and contrast them with how they are solved today. This approach would open the minds of students to new areas of invention and encourage them to become innovators. It may also be important to instill in students the awareness that more likely than ever, the collaborating teams of the future may come from anywhere in a 'flat world.'

Taking into account these factors, the three questions posed in this special issue, "who, what, and how," seem particularly apt, and the inclusion of authors from diverse areas of scholarship including engineering, the sciences, education, and the learning sciences seems quite *apropos*. I wish the *Journal of Engineering Education* the very best in achieving the objectives for the good of engineering education and for the sustainable growth of a balanced world.

Autodesk

RETHINKING ENGINEERING EDUCATION

PAUL MAILHOT

Senior Director

Worldwide Education Programs

As companies struggle with macroeconomic forces and trends in their respective industries, increasingly they are seeking employees with a holistic education experience. With this consideration shaping the way in which organizations look to the future of their talent pool, there are clear ramifications for post-secondary engineering education today: conventional instruction

may not provide students with the kinds of experiences that they need to build a successful career. Colleges and universities are beginning to align instruction with this future workplace demand. They are bringing real-world engineering requirements, experiences and tools into the classroom to prepare students for professional practice, with a view toward defining problems more broadly and solving them in a more holistic fashion. For example—

Virginia Tech aims to help its civil engineering students become the best engineers they can be. Sophomores learn the basics of working with CAD software and how to interpret civil engineering drawings such as site plans, cross sections, and profiles. That foundation is followed by "Civil and Environmental Engineering Measurements," a required, four-credit course in which students gather field survey data and use software to create 3D surface models. In their senior year, students may elect to take "Land Development Design," in which they work closely with engineering firms to address such issues as site grading, storm water management, and erosion and sediment control—the kinds of situations that students might encounter in developing infrastructure to accommodate urban growth. The engineering companies participating in the course are rewarded with students' understanding of real-world conditions and constraints, and many of these firms hire students directly from this senior elective class.

The Humanitarian Engineering (HE) minor offered by the *Colorado School of Mines* is breaking new ground. It is one of just a few programs worldwide—and the only undergraduate minor—created to address the issues that arise in the construction of infrastructure in developing parts of the world. The program was launched in 2003 by an interdisciplinary team of faculty in response to "The Engineer of 2020," a National Academy of Engineering (NAE) Committee on Engineering Education (CEE) initiative that calls for engineers of the future to see themselves more broadly as global citizens, leaders in business, and ethically grounded in their work. In the HE program, students' aptitude for using CAD software and engineering calculations evolves into experiences focused on solving design problems that span cultural and societal issues, such as design and construction of a water system for a village in Honduras. In the short time since the program was launched, nearly 200 students have completed senior design projects designated as humanitarian engineering, with more than 25 students enrolled in the minor.

The Construction Management program at *Brigham Young University* (BYU) is designed to expose students to multiple disciplines that factor into the management of construction projects. Ultimately, it may prepare students for solving problems under circumstances that are changing due to project conditions or macroeconomic forces, or both. Early reports from students following graduation or a stint in the professional world suggest they benefit from the experience of considering multiple aspects of a project. This ability to consider aesthetics, function, and process at the same time

helps BYU's future construction managers and engineers understand how to manage the cost, schedule, scope, and risks associated with design and construction.

There is no question that the nature of work is changing and the imperative to prepare students for the future has never been more pressing. In order to cultivate the nation's next generation of engineers and innovators, universities face two significant

challenges: inspiring and retaining students who enroll in their programs, and preparing these students for successful careers. From early reports, it appears that educational institutions that align instruction with real-world needs and that provide opportunities for practical, contextual learning experiences are finding the students who enroll in their programs are highly engaged in learning, and their graduates are well prepared for success as professionals.