Tsinghua University Prepares Students for a Global Workforce

To best prepare students for an evolving global workforce, Tsinghua University has partnered with NI to standardize labs in its Department of Automation. Through this collaboration, graduating students are better equipped to identify real problems and design engineering solutions. Tsinghua University is a leading educational institution in China and has been named Best Global University for Engineering by *U.S. News & World Report*.

NATIONAL INSTRUMENTS

Challenge

Tsinghua University sought new ways to develop future engineering students in both graduate and undergraduate tracks to prepare for the ever-changing industrial landscape.

Solution

The faculty began a comprehensive change of not only individual courses, but also the complete curriculum. The university partnered with NI to explore technological solutions and ways to bring an industrial voice to support the pedagogy.

Embracing Global Change

Tsinghua University, founded in 1911, is one of China's most highly recognized institutions for higher education. It was recently named the Best Global University for Engineering by *U.S. News & World Report*. For over 100 years, Tsinghua has been a leader in graduating engineers that excel in undergraduate studies, research, and industry impact. This earned the school the chance to participate in two funding opportunities from China, Project 211 and Project 985, which target universities with a goal of raising the research standard among schools in the country. Through specialized curriculum, training programs, and renowned faculty, Tsinghua has established an educational model that is being used as a new standard for world-class engineering institutions.

Tsinghua has developed an enviable reputation globally for its leadership in engineering literacy, which shows through the international impact of its graduates. In maintaining this global standing, we have embraced continuous change. In 2012, as technology continued to accelerate, our school faced an increasing need to maintain both relevancy and impact in the engineering discipline and also establish ourselves as a leader among universities globally. This required finding new ways to develop future students in both graduate and undergraduate tracks to prepare for the ever-changing industrial landscape. China challenged us with addressing this task within five years. This new, daunting challenge required that both faculty and administration rethink how the program could continue to graduate students that could immediately impact industry. Rather than make small incremental changes to existing foundational courses (such as electronics and controls), we placed an emphasis on student outcomes around problem solving, communication skills, critical thinking, and understanding modern multidisciplinary engineering systems. To deliver such resounding reform, our faculty began a comprehensive change of not only individual courses, but also the complete curriculum.

Customer Profile

Tsinghua University was founded in 1911. It comprises numerous schools and departments offering programs in areas such as engineering, medicine, science, and art. The university has more than 300 research institutions and awards more than 4,000 master's degrees and 3,500 bachelor's degrees a year.

In 2012 the Ministry of Education in China assessed departments for control science and engineering, including at Tsinghua. Schools were ranked across four core areas of evaluation: quality of faculty, research outcomes, education, and overall academic reputation. The Tsinghua University Department of Automation Engineering was ranked first in China across each of these areas. To maintain these results, we focused on the undergraduate experience and investigating more effective ways to cultivate a student's practical skills to further differentiate them in the professional work environment.

Students are introduced to myRIO in their second-year controls course.

Another challenge the educators confronted was the continued change in both the educational and industrial landscapes. Trends like an increasingly automated environment evolved the workplace in China, which in turn changed the expectations for students. We sought to address some key areas to ensure we maintained a student-centric focus:

- Develop students that can handle complex design projects, thereby developing engineers that can integrate directly into industry
- Ensure that students learn hands-on skills with industry-relevant, up-to-date technology
- Cultivate a global vision in students so they can address problems that span multiple countries and communities

A Goal-Centered Partnership

To partner in redesigning the curriculum, we chose NI to explore technological solutions and ways to bring an industrial voice to support the pedagogy. The first step in the process was clearly defining the critical learning outcomes for each laboratory course throughout the complete automation curriculum. Central to our goal was to expose first-year students to practical design concepts using robotics. Through a controlled experience of exercises and laboratories, these first-year students focused on learning about sensors and actuators on a real-world robotic system. In the subsequent electronics courses, the faculty and NI saw a clear need to build a strong foundation by combining simulation and real-world laboratories. This would ensure students built clear engineering intuition in a space where they traditionally struggle in non-electrical engineering curriculum. For classes in controls, students must not only understand foundational areas such as PID, but also develop programming skills to advance critical intuition in algorithm development and analysis for real hardware. Finally, these various courses need to culminate so students can apply their various skills into the design of mechatronics systems through deep knowledge in electrical and mechanical components.

To further aid in reducing challenges experienced by faculty, we chose to look for consistency in the tools used throughout the student experiences to create a cohesive program in which students are focused more on the engineering topics, and not having to learn new technology each term.

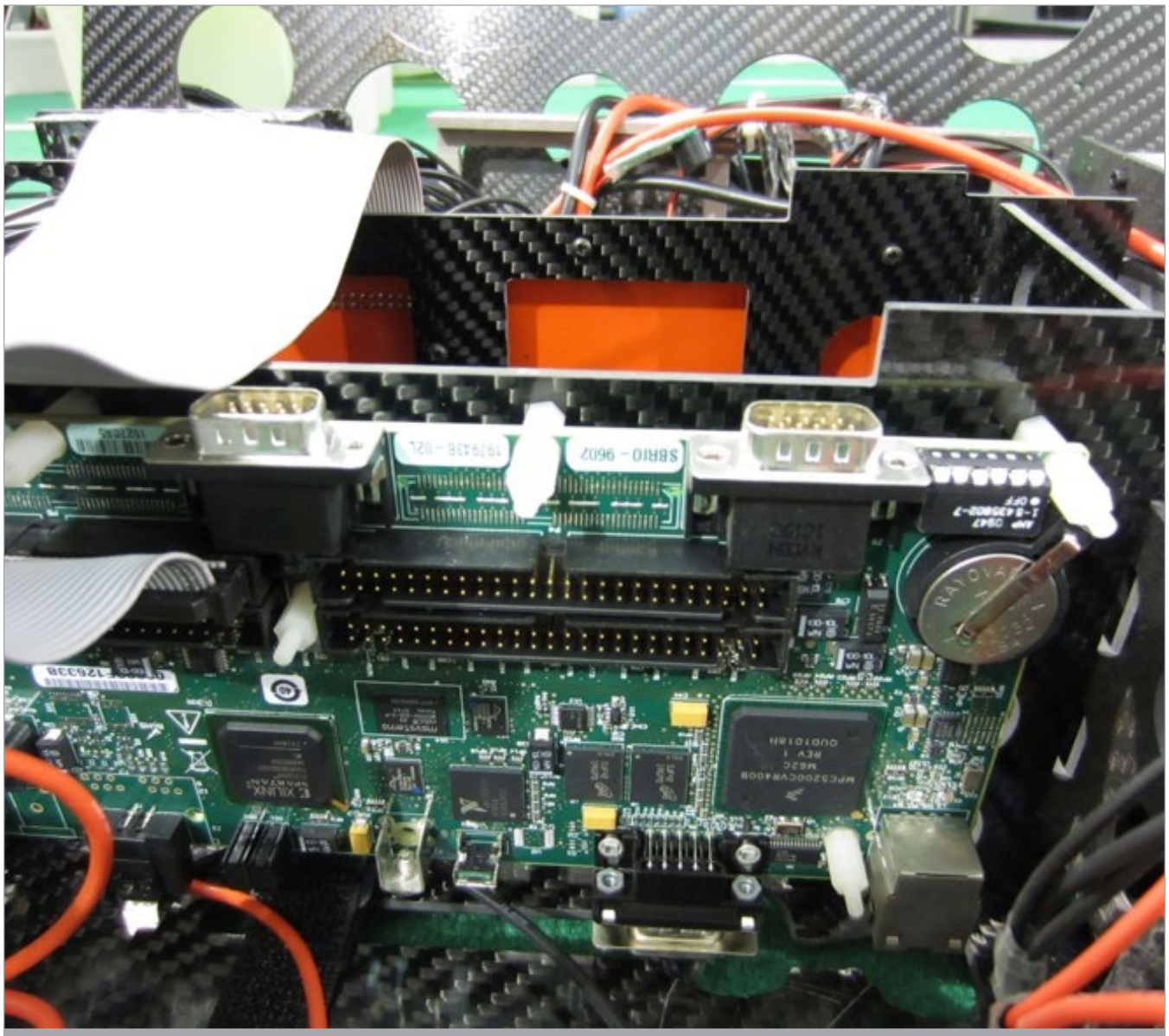
Students design solutions for real-world applications such as self balancing robots.

In tackling this final goal of consistency, we adopted LabVIEW graphical programming for a singular, powerful approach to measure, control, and design across each course. We could use a single software-based platform that could extend through all areas of the automation engineering department so educators can focus on building more challenging, yet rewarding, student laboratories and projects instead of losing valuable class time in transitioning students to other technology. Ultimately, faculty saw gains when students gained practical exposure to different design principles, while transcending to more complex system design.

We paired the LabVIEW software with specialized, pedagogical platforms built on the latest industry-standard DAQ and embedded platforms. The solutions, which included the NI myRIO student embedded device, the NI myDAQ student measurement device, the NI Educational Laboratory Virtual Instrumentation Suite (NI ELVIS), the Multisim circuit teaching and SPICE environment, and controls plants from Quanser, helped us rapidly build and reform curriculum in just one year. We built each solution through the LabVIEW environment for consistency.

The final implementation included students introduced to engineering through robotic execution tasked on a system programmed with LabVIEW. In the second-year circuits course, students use Multisim to simulate complex electronics behavior and then correlate measurements through the integration with the myDAQ measurement device. Using the same myDAQ, as well as the myRIO, students build additional engineering intuition in signal processing through a concept that we call "pocket labs" because they can use the smaller, portable form factor of the devices to learn anytime, anywhere.

Using the NI ELVIS, and its expandable ecosystem and controls plants from Quanser, students had a robust, low-maintenance, high-accuracy platform to see controls behavior, which exactly matches the theory, while already building their own algorithms.



NI Products Used:

- LabVIEW
- myRIO
- myDAQ
- Multisim
- Single-Board RIO

Industries:

- Industrial Automation
- Automotive
- Robotics

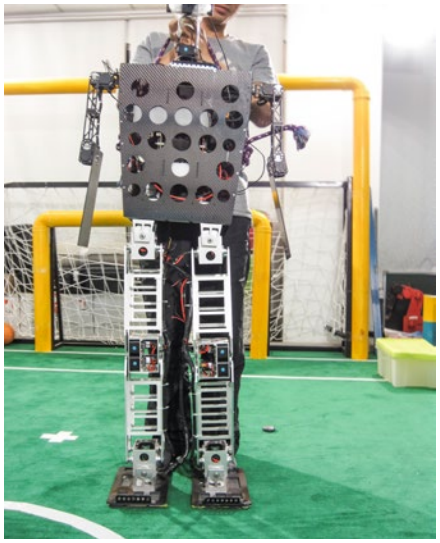
Application Areas:

- System Simulation
- Control of Complex Systems
- Artificial Intelligence

Accelerating Discovery

This approach rapidly changed student experiences. Students had more time to use cumulative knowledge of the technology to build hands-on knowledge of engineering, rather than the more traditional simulation and theoretical courses they had seen in the past.

Our partnership with NI not only focused on curriculum change, but also on building a greater community for engineering students to apply their knowledge and increase engagement. Students were encouraged to participate in clubs and, through NI, also developed skills to mentor younger students as they transitioned throughout the program at Tsinghua. The result was to pair an inventive approach to teaching with a fun and friendly environment to grow and innovate. The impact even went further than undergraduate students, with the development of a pipeline of students prepared for research in areas such as the Internet of Things and cyber-physical systems, all developed using LabVIEW and the NI platform.



Student teams develop robots to compete in National RoboCup Challenge.

Increasing Impact

One of the key outcomes from the new approach has been the ability for faculty to encourage students to move into more challenging applications, including a non-linear systems course with a project to build a two-wheeled, self-balancing robot. The robotic system integrates all the knowledge students have gained in electronics, sensors, system simulation, mechanical, and electrical system design.

Due to the overall complexity and the sheer number of subsystems involved, students prior to the curriculum reform would only have the ability and bandwidth to focus on the low-level design of a few components. By simplifying some areas of the system through the incorporation of the myRIO device and through the graphical nature of LabVIEW programming, students could accelerate their design through quick simulations, rapid prototyping, and instrumentation of each component to test and iterate toward a working robot. Students can accomplish what previous students found difficult, if not impossible, to complete.

An outcome of this course has been the ability for an increasing number of Tsinghua students to participate in global competitions and projects such as the Baidu Bike. The Baidu self-balancing bike was a top three finalist in the global NI Student Design Competition in 2015. The bike can autonomously drive in complex rugged environments while handling the intervention of people and obstacles through a fusion of

sensors and cloud-based resources. The competition highlighted the ingenuity of these Chinese engineering students on a global scale and empowered them to both compete and network with students from schools such as MIT in the United States as well as the University of Manchester in the United Kingdom.

Single-Board RIO is an example of an industrial version of the tools students worked with from their first year.

The international recognition of our students has enabled Tsinghua to continue to occupy a position on the global stage as a pre-eminent institution of learning. The automation department continues to travel the world to promote both the critical nature and importance of integrating engineering systems into curriculum. Since the reform, we have worked to ensure that we can collaborate with other global leaders in engineering to deepen relationships, improve the international success of students, and pilot more innovative curriculum.

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