



# Saving the world one student at a time

A Guidebook for Engineering and Science Educators



Do Engineering

## **Introduction**

Effective educators motivate students not just to learn but also to dream. They help students stay disciplined during the challenges of their curricula. These educators share something that often goes unspoken: the moment they progressed from inspiring individual students to inspiring entire classrooms full of them.

We asked top engineering educators from around the globe to tell us about the turning points that changed their classrooms. Join us as we unveil the findings.

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*Educators worldwide have joined the movement to challenge students to go beyond theory and simulation to “do engineering.”*

## UK Students Call for Educational Reform, School Responds

**Who:** Danielle George, PhD, Senior Lecturer, The University of Manchester, United Kingdom

The cry for reform was deafening. Students gave the School of Electrical and Electronic Engineering (EEE) at The University of Manchester alarmingly low marks on teaching and learning in the 2009 UK National Student Survey (NSS). With overall satisfaction at 67 percent, the School ranked 34<sup>th</sup> out of 36 schools in the survey that year.

School leadership knew exactly where the dissatisfaction was coming from. The course material was all theory and featured very little application. Students couldn't understand the relevance of what they were learning, and they had grown tired of taking it on faith that they would one day use those concepts.

"The situation was precarious. Discontent was only going to build if we didn't change our curriculum quickly," said Head of School Andrew Gibson. "Moreover, there were murmurings of tuition fee increases across the UK, and since students vote with their feet, we were in danger of losing them not just to other universities, but to other countries as well."

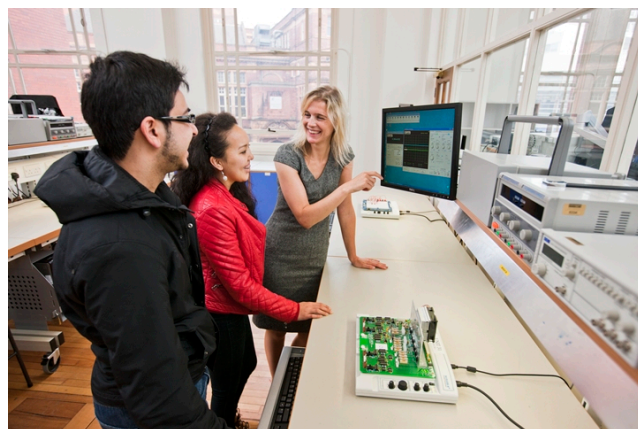
### Designing a Ripple Effect

"The need for change wasn't news to us. It wasn't that we were ignoring it, but a complete curriculum overhaul always seemed impossible," Gibson said. "The survey gave us no choice but to start taking some risks to improve the situation."

The school enlisted Senior Lecturer Danielle George, PhD, to improve the laboratory experience for students and add real-world relevance to the theory-heavy curriculum. The challenge was implementing her strategies within time and budget constraints.

"The impact needed to be immediate," George said. "But the changes had to be palatable. We couldn't just scrap everything. We had to use the same things in new ways. A small change had to create a ripple effect through the rest of the curriculum."

George added new lab tools that worked alongside existing equipment while exposing students to technologies they will use in their careers. She revised exercises so that equations from textbooks translated directly into computer simulations. In turn, students used those simulations to more deftly experiment on the equipment. They began to see that by grasping the theory, their experiments were better and their ideas actually came to life.



**Figure 1. George demonstrates the relevance of theoretical concepts through hands-on projects to undergraduate students.**

With the first laboratory course revised, the school began to notice a change.

"I was frequently told by Dr. George's students that the once 'cryptic' concepts were now making sense. They seemed more confident in their abilities because they were actually using that knowledge to solve real problems," Gibson said.

Based on the momentum of this success and student demand for the changes in other courses, George and her colleagues continued the reform across the entire curriculum. Because she had chosen tools that could scale into other labs quickly and affordably, they remained within time and budget constraints.

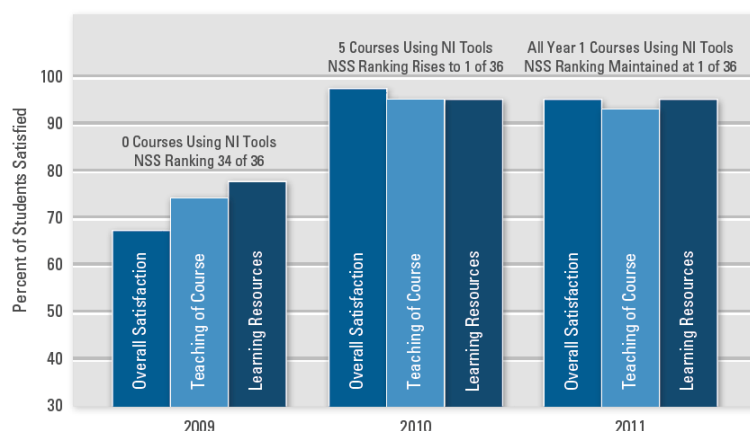
### The Tide Turns

After just one year, the students ratified the reform's impact on the next NSS. Satisfaction with teaching and learning lifted, and overall satisfaction rose dramatically to 98 percent. The school rank rose to first of 36.

"For us, it was more than just numbers,"

George said. "Motivation and understanding go hand in hand for students,

and seeing those results pushes us to operate with a constant sense of urgency. When it comes to educating our future innovators, there are some big problems out there that we need them to solve, and we can't wait any longer."



**Figure 2. UK National Student Survey Results 2009-2011**

*National Instruments tools for teaching scale from the fundamentals of education all the way to cancer research and rocket science. Start the ripple effect by downloading the free starter kit at [ni.com/educators-guidebook](http://ni.com/educators-guidebook).*

## Former Imagineer Challenges Students to Engage, Overcomes 'Blank Stare' Syndrome

**Who:** Dave Barrett, PhD, Professor of Mechanical Engineering, Olin College, Massachusetts, USA

Dave Barrett was not accustomed to the blank stares he was getting from students during his first few weeks of teaching Capstone Design at Olin College.

"Working at Disney, I was used to kids' undivided attention," he said. "They couldn't wait to see what would happen next."

When Barrett, former director of the Walt Disney Imagineering corporation, solicited advice, he was told that students were lazy by nature, and that the smart ones would eventually emerge after two quizzes and a final exam.

"This didn't sit well with me," Barrett said. "I went into teaching to help improve education for these students, not to just keep doing the things that didn't seem to be working."

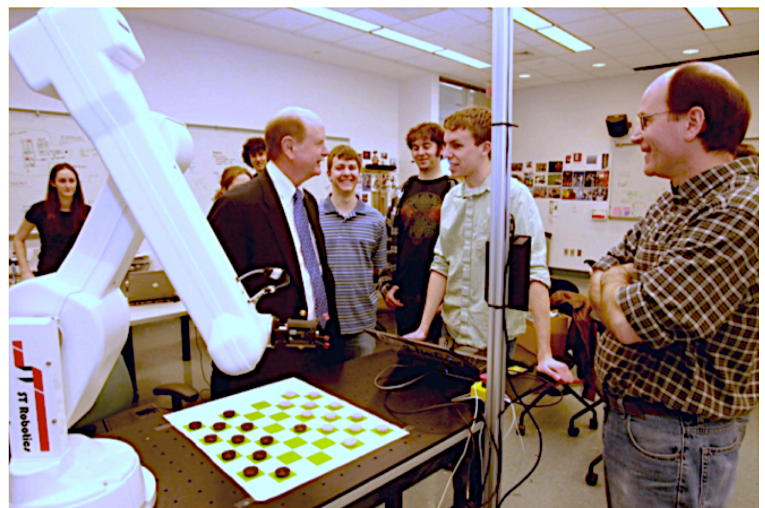
### The Science of "Brain Building"

Barrett decided to do some research into the science of learning. He defined education as "brain-building" and determined that understanding how the brain works is a fundamental part of improving education.

He found that past generations had learned to absorb information by sitting and listening, but the new generations of students gathered insight from the world in a more dynamic, networked way. The lecture-and-test structure of the traditional classroom once worked well for those who learned by listening, but it was no longer suited for students who needed to interact, ask questions, challenge assumptions, and ultimately apply concepts to truly understand them.

Barrett immediately applied his findings to his teaching. He moved the course from a lecture hall to a lab and assigned students to teams that were given the responsibility of an industry-sponsored project. This way, students could simultaneously learn textbook theory while applying it to real-world situations.

"There was one problem," Barrett said. "This was their final year. By the time I got them, they'd already forgotten all the theory that was going to actually make these systems work."



**Figure 1. Barrett (right) and his students demonstrate a checkers-playing robot for their industry project sponsor.**

## Making Brain Building a Business

Barrett knew that for students to be successful in their careers, for which their ability to build working systems would be nonnegotiable, he had to introduce the realistic constraints of business into the classroom. Thus, similar to on-the-job training, he developed a just-in-time approach to reteach concepts to students as they continued with their projects. He helped students manage the real-world requirements of feasibility, time, and maintaining strong client relationships. He also found that instead of testing his students on paper, he could gauge their performance and thus their understanding by whether their systems actually worked.

“There’s nothing like watching the airplane you’ve spent hours building crash to the ground,” Barrett said. “After that, you’ll never accidentally make a number in an equation negative when it was supposed to be positive.”

The results spoke for themselves. Olin students have worked with more than 50 companies on projects ranging from creating medical devices for Boston Scientific to automating an agricultural sprayer for AGCO. Olin College has since gained a reputation in the community for graduating creative students capable of solving any problem.

“I don’t know what they put in the water at Olin,” said Sorin Grama, CEO of Boston company Promethean Power Systems. “But those graduates are exactly what we need. These are the people who will solve the biggest engineering and science problems facing our society.”



**Figure 2. Barrett (right) supports his students as they present an autonomous sailboat to thousands of professional engineers at NIWeek 2012 in Austin, Texas.**

*Transforming a course does not have to mean ripping out the lecture hall right away. National Instruments teaching tools are modular and multi-disciplinary to help educators introduce project-based learning into courses over time. Download the free starter kit at [ni.com/educators-guidebook](http://ni.com/educators-guidebook).*



## Professor Puts the Future of the Japanese Workforce Into Students' Hands

**Who:** Motohiko Kimura, PhD, Professor, Shizuoka University, Japan

The Japanese workforce faced a serious problem: the generation of baby boomers who had helped build a thriving manufacturing economy was beginning to retire en masse. At the same time, students were turning away from engineering as a field of study because they believed it did not encourage the creative problem-solving and teamwork that they found in other disciplines. They wanted to work in fields that would impact society, but they did not see engineering as one of them. This led to a shortage of skilled workers in science and engineering.

"As a biomedical engineer, my interest in helping to solve the crisis was twofold," said Motohiko Kimura, PhD, a professor at Shizuoka University. "First, we wanted students to pursue studies in biomedical engineering because this was where we needed skilled workers to develop our economy. But also, their discoveries would become more critical in supporting the healthcare needs of an aging population."

However, the challenge was more complex than just showing students that engineering could help them make an impact, test their creative limits, and work with others. For students to truly believe that they could make a difference with engineering, they had to experience success and build real working systems.

### Helping Science Keep Up With Technology

Kimura's task to give his students hands-on experience with the systems they would create in their careers was further complicated by the multiple disciplines involved in biomedical engineering.

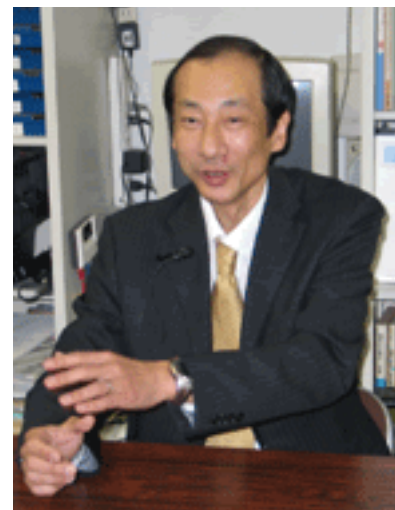
"Traditionally, the business of measurement and control was dominated by masters of the electrical system. They had experience working with hardware and software and could easily use computer-based technologies. But it was very challenging for chemists and biologists to make use of the same tools," Kimura said. "Combine that with the mechanical element, and it seemed impossible for even the most experienced biomedical engineer to keep up with advances in technology."

So Kimura sought tools that would help his students use the experience they already had to build biomedical systems. He found that NI LabVIEW system design software and data acquisition devices helped to unify software and hardware so that students could see immediate results. With the graphical software, students could program visually in a way more intuitive to them, which made the learning process easier.

"All 160 students in the first years of the course could use the tools on their own. They completed projects previously impossible because they had equipment that integrated the mechanical and electrical elements for them, so they could focus on the science," Kimura said.

### A Community Effort

Shortly after introducing projects into the curriculum, the number of students who expressed an interest in studying engineering grew in the university. Still, overall awareness of the field remained



**Figure 1. Motohiko Kimura , PhD, explains the impact of the retirement of skilled workers on the Japanese manufacturing economy.**



low in the community. Incoming students were not aware of their study and career opportunities, and local companies needed a larger pool of qualified graduates to hire.

Thus, the Faculty of Engineering collaborated with local educational authorities and government on a systematic approach to bookend their existing efforts. They toured high schools throughout the region and conducted hands-on activities during classes to encourage students to pursue engineering. The next year, the faculty taught training workshops on business fundamentals for their upper-level students and partnered them with local companies to fulfill the transfer of skilled students to industry.



**Figure 2. Shizuoka University students test a medical device prototype during one of Kimura's classes.**

"Through these efforts, we've seen students become excited about engineering," Kimura said. "What's more, our community now knows it can take control of the situation. With the right technology, the only barrier is our willingness to equip our students so we can entrust them with the direction of the economy."

*National Instruments teaching tools integrate hardware and software seamlessly so students can focus on taking ownership of their learning and discovery. Download the free starter kit at [ni.com/educators-guidebook](http://ni.com/educators-guidebook).*

# Students Use Music, Everyday Routine to Challenge Perceptions of Electrical Engineering

**Who:** Mathias Chr. Mathiesen, Assistant Professor, Høgskolen i Bergen, Norway

On a Tuesday morning in October, sleepy engineering students stumbled onto campus to find that their average staircases had been transformed into pianos. Some were even rigged to play the familiar childhood tune from Super Mario video games.

It was all a part of Professor Mathias Mathiesen's plan to challenge perceptions of electrical engineering.

"Electrical engineers are thought of as analytical people who compartmentalize the personal from the practical," Mathiesen said. "But many of us are musicians, artists, athletes, and businessmen, and often the best innovations happen when we embrace both sides of our brain. In fact, Ada Lovelace, the world's first computer programmer, got her inspiration for the first algorithm from the 'relations of pitched sounds in the science of harmony and musical composition.'"



**Figure 1. Surprised undergraduates examine the piano staircase created by Mathiesen's students.**

## When Art Met Science

Mathiesen first noticed misconceptions among his own electrical engineering students at Høgskolen i Bergen in Norway. Many seemed to believe that hands-on projects were a waste of time and that the focus should be on theory in lectures instead.

"On the contrary, technicians are among the most skilled workers because they have to understand theory well enough to put it to the test. We therefore needed to show students the creativity and skill required to make something real and innovative," Mathiesen said.

Mathiesen decided to issue a challenge to his first-year students: combine art and science in a project that would compel the engineering students in other disciplines to rethink their perceptions of electrical engineering. He gave teams of students access to hardware, software, and 50 euros each to make their ideas a reality.

To his surprise, the students converged on the piano staircase idea and united their efforts. Their vision was to create a moment of surprise to break up the early morning ritual of those on their way to classes across the whole college. The students designed their pianos from wood, tape, paint, and wiring. To give students practical skills, Mathiesen had them use industry-grade tools to program the piano with the NI myDAQ hardware device and NI LabVIEW system design software.

## No Ordinary Tuesday

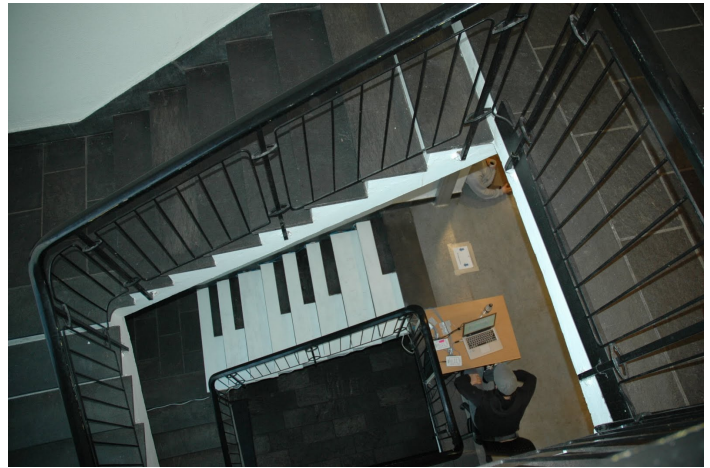
"It was fun to watch other students react to the staircases. We stood at the top so we could explain how we'd programmed the pianos with computers and could teach them the connection between programming and music. You'd be amazed at what 50 euros can do to teach people about electrical engineering," said student Lars-Erik N. Borge.

But the project did more than surprise the engineering students: national news came to film the students experiencing the staircases and shared coverage with the public.

“The teams succeeded in informing perceptions not just of the students but also of those seeing the news coverage, and even of the lab instructors,” said Per Eilif Thorvaldsen, head of the Electrical Engineering Department. “They helped show us how the tools they’d used to program their projects were portable enough for us to make a ‘lab in a bag’ for students to use throughout the curriculum. The instructors were excited because rather than worrying about outfitting and monitoring lab equipment, they could focus on mentorship.”

The addition of Mathiesen’s course to the curriculum ensured that incoming students could see how creative engineering could be. Hands-on projects proved key to the experience.

“We can’t make piano staircases every year if we want to keep the element of surprise,” Mathiesen said. “I’ve thought about making an automated nanobrewery next year. Brewing 50 liters of fine ale while learning temperature measurement, data logging, and PID control seems like a good idea to me.”



**Figure 2. Mathiesen’s students explained to passersby how programming and engineering powered their pianos.**

*Surprise your students with projects that let them be innovative. National Instruments teaching tools are affordable and accessible so students can get creative. Download the free starter kit at [ni.com/educators-guidebook](https://ni.com/educators-guidebook).*

## 5G Researcher and 12-Year-Olds Challenge Each Other to Make Waves in the RF Industry

**Who:** Jan Dohl, Vodafone Chair, Technische Universität Dresden, Germany

Jan Dohl did not subscribe to the belief that one had to have a doctorate to understand RF.

"I was told that I would bore young students with complex theory if I tried to teach them RF. But I think the real reason they lose interest is because they can't see the relevance of that theory. They are capable of understanding difficult topics like wireless communications and RF, provided they are given a reason to stay motivated," Dohl said. "Given the shortage of engineers qualified to work in this discipline, it was time to challenge those assumptions."

Dohl, the Vodafone Chair in the 5G research lab at Technische Universität Dresden (TU-Dresden), believed that experimentation with real tools played a key role in keeping young students interested in science and math.

"I remember how valuable it was for me to be able to break things apart on my own and explore when I was young. We needed to create an environment where kids could feel safe doing that, but still understand what they were seeing," Dohl said.



**Figure 1. Dohl, shown at right with National Instruments CEO James Truchard, was named a Graphical System Design Achievement Awards Finalist for his RF research.**

So, Dohl and TU-Dresden partnered with the Martin-Andersen-Nexö Gymnasium School to participate in its annual "project week" when the school's seventh- and eighth-graders work in small groups to conduct real, hands-on RF research.

### Opening the "Black Box"

Dohl tasked his team with building a radio receiver for Morse code using digital data transmission over radio waves. Dohl and his advisers designed the experiments so that students could have the same freedom to explore topics that he'd had when he was young. The adults intervened with hints only if the students veered too far from the right track.

"I was skeptical of the 'hands-off' approach," said School Headmaster Armin Asper. "And I questioned if students wouldn't get frustrated trying to solve problems where the solutions were not yet known. But this is how Jan learned, and now he was researching 5G. So we decided to try it."

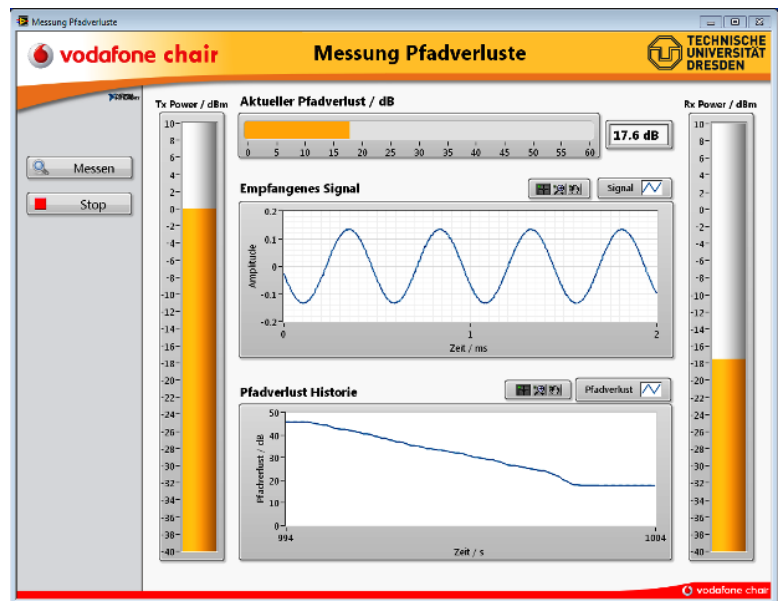
Because radio waves were invisible and technology had become so small and software-driven in recent years, it was impossible for students to break apart new wireless and RF devices and understand what they were seeing the way Dohl did. These "black boxes" made it seem like it was magic rather than engineering making the devices work. So, Dohl used the same technology that had made these advances invisible in the first place to bring them back to life for the students. He equipped students with computer-based technologies like the NI USRP™ (Universal Software Radio Peripheral) platform and LabVIEW system design software so they could visualize how the devices were behaving and how the radio waves were propagating through the air.

Equipped with these tools and a brief history of radio communications, the students worked on their receivers.

### Making Waves

"I couldn't believe how quickly the students picked up these complex topics to build working receivers," Asper said. "They told me how much they appreciated the chance to explore on their own with real radio waves. They especially liked that the adults didn't jump in to rescue them if they were challenged with unexpected results because it gave them a chance to find solutions themselves."

Dohl was also surprised by how capable the students proved to be. "Here I was, trying to prove to skeptics that we were underestimating these students," he said. "Meanwhile, they managed to surprise even me. I realized we are all guilty of underestimating young people. Someone believed in me when I was young, and that's what got me where I am today. We must assume that any student could be a future innovator. We just have to get out of their way."



**Figure 2. Dohl's students designed an interface for their Morse code receivers showing transmit and receive power levels and pathloss.**

*It's never too early for future innovators to start tackling complex problems. National Instruments teaching tools reach those as young as age 5 and span from LEGO® bricks to space travel. Download the free starter kit at [ni.com/educators-guidebook](http://ni.com/educators-guidebook).*



## Ford Engineer Turned Professor Manufactures Star Students

**Who:** William Kaiser, PhD, Professor, University of California, Los Angeles, USA

Professor William Kaiser already had experience in mass production. As a former member of the research staff at Ford Motor Co., his development of embedded system technology resulted in the ability to produce automotive sensors on a large scale. But he didn't know that this experience would help him mass-produce star students.

"Yes, you think that working in industry will help you as an educator," Kaiser said. "But only to the extent that you can show your students the relevance of theory to the real world. What I didn't know was that my knowledge of what it took to scale technology would also help me in teaching."

As a faculty member in the UCLA Electrical Engineering Department, Kaiser found that students' learning experiences were severely disjointed from the experience they would need as professional engineers. Moreover, projects were disjointed even between the first and last years of the curriculum. This disconnect began to look to him like a broken manufacturing process. He wondered if he could use the same principles that he would have used on the production line at Ford to fix it.

### Moving Students Through the Assembly Line

"Initially Bill and I resisted thinking about education as a manufacturing process," said Graduate Assistant Henrik Borgstrom. "Dehumanizing the students was the last thing we wanted to do, especially at a large school like UCLA. But the students weren't the issue. It was the process we were putting them through. The whole idea of an assembly line is that each step is supposed to add value, and we needed to make sure that our curriculum was doing this with the students."

Kaiser evaluated the teaching pipeline using production principles. He reviewed inputs to see if they were starting with the right raw material. He reviewed the process for bottlenecks and breakdowns. And he reviewed the final outcome to judge the process as a whole.

	Freshman	Sophomore	Junior	Senior	MS and PhD
Pipeline Design Experience	Foundation Projects	Platforms and Systems	Application	Project Capstone Design	R&D, Leadership, and Mentorship
2010 – 2011 Technology Tracks	<ul style="list-style-type: none"><li>• Analog and Digital Circuits and Systems</li><li>• Control Systems, Embedded Computing, and Robotics</li><li>• Wireless Health and Biomedical Engineering</li><li>• Sensor Network and Sustainability: Water and Energy Resource Monitoring</li></ul>				
Undergraduate and Graduate Student Mentors	Student Guidance, Leadership, and Mentorship		Product Development Experience		Research

**Figure 1. Kaiser designed an educational pipeline to ensure a hands-on design experience from freshman to doctorate courses.**

"The inefficiencies were the same that you'd see in industry. Our raw materials were inconsistent: we didn't account for how students came in with varying levels of knowledge of the fundamentals," Kaiser said. "And we could tell there was something off about our processing after that, because we were losing the engagement we started with. By the time we put final product out into the market, so to speak, we couldn't meet the needs of the employers who were going to hire our students."



Kaiser knew that much of the value added during the process was in laboratories where students gained real-world experience with the theory they were learning. But the constraints of laboratory time and space acted as a bottleneck, and, unlike industry, the school couldn't just expand to meet demand as a company would.

At this time, Borgstrom discovered the concept of personal laboratories—portable hardware devices students take home to complete projects outside the lab.

"Building physical intuition is very important for learning," Borgstrom said. "It can make all the difference between an engineer who is impactful on the job and an engineer who only knows theory. Bill and I agreed that using the personal lab to resolve our bottleneck could have a positive impact across all four years of the curriculum."

### **A Productive "Education Pipeline"**

With this knowledge, Kaiser redesigned the education pipeline. He used personal labs to give students in the first year a solid foundation with practical experience. Second-year projects became complex systems that were used in open-ended challenges in the third year. Finally, the curriculum culminated in projects with industry partners. Every step was designed to add value to the student's experience, all using the NI myDAQ portable hardware device and NI LabVIEW system design software so students could work off campus to experiment wherever inspiration struck.

"The response was overwhelmingly positive. Student evaluations were at a record high, and employers gave positive feedback," Kaiser said. "Quality education starts with the individual. If you can add value for just one person, you can begin to make an impact for everyone."



**Figure 2. Kaiser and Borgstrom developed personal laboratories for students to experiment with both on and off campus.**

*Each year adds value to the education pipeline. National Instruments has teaching tools for every step of the way. Download the free starter kit at [ni.com/educators-guidebook](https://ni.com/educators-guidebook).*

## Professor Gives Students and Robots a Common Language

**Who:** *Pedro Ponce, PhD, Professor, Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), Mexico*

"Imagine if every one of us spoke our own language," said Pedro Ponce, PhD, a professor at the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM) in Mexico City. "We'd never be able to share anything with one another. Imagine how slow our society's progress would be."

According to Ponce, this very problem is obstructing the progress of robotics.

"Today's machines have more computing power than humans, but they cannot communicate with each other. In that sense, they are rather primitive," he said.

Ponce, a renowned researcher in the field of intelligent control systems, experienced these language barriers firsthand when he attempted to share his own research findings with the scientific community. Although he won awards and acclaim for his invention of a wheelchair for quadriplegics that could be controlled with eye movements, he found that others couldn't make use of his algorithms if they were not programming in the same language.

"The misconception about inventors is that we are secretive about our work," Ponce said. "For me, the joy of invention is the idea of improving someone's life, and that possibility multiplies when the next inventor builds on your findings. But without a common robotics language, my ability to do that is limited."

### Taking the "Artificial" Out of "Artificial Intelligence"

Ponce began to notice similarities between his students' communication challenges and the communication challenges of robots.

"Effective teams collaborate to explore possible answers, share new information, and establish common goals. This is true for both humans and robots. A common language is required to do this. Students couldn't take the designs they'd created as a team and implement them because the computers spoke a different language, and the language changed for every task. They couldn't reverse-translate for each other, and they couldn't get their programs to communicate, so they became discouraged."

Ponce then decided to give the students a language that they and the robots could both speak. Using NI LabVIEW system design software, he created a platform for collaborative robot development. The platform unified in one software environment the tools robotics developers needed, such as those for implementing control algorithms, creating neural networks, and interfacing with sensors.

The students programmed in a visual language that directly translated the diagrams they drew on paper into something that the robots could understand. Additionally, with a shared platform, teams could break down complex tasks into more digestible subtasks, further accelerating their progress as they worked in parallel.



**Figure 1. Ponce and colleague Rafael Mendoza demonstrate control of a wheelchair using eye movements.**

Teams were tasked with building a community of robots that worked together to navigate a maze relay-style. Each robot had an assignment, which was completed only by each robot effectively communicating with the next. An “optimization algorithm” initialized the robots’ timing and helped to define the structure of the communication.

Together, the robots traversed the maze, some performing speed tasks, others following a given path, and others navigating curves and obstacles. All the while, the robots communicated through the optimization algorithm to share relevant information and notify the others when to start. The success of the robots’ collaboration reflected that of the students. Their motivation grew as they watched their visions come to life.



**Figure 2. Ponce's classes have grown full with demand from students wanting to learn how to program robots.**

### **The Language of Invention**

“We take teaching as seriously as we take research,” said ITESM graduate student Omar Mata. “We are the future researchers. Pedro understands this, and it pays off.”

Ponce continues to share the software and has authored several textbooks on programming for robotics and control. He has even taught elementary school students to program robots using the same language.

“We must do in education and research what the students’ robots did in the maze: communicate, share information, tell each other how to help,” Ponce said. “Language is a tool that we have yet to use to its fullest. That is, perhaps, until now.”

*Teach students the language of invention. LabVIEW is used in more than 35,000 companies worldwide. Download the free starter kit at [ni.com/educators-guidebook](https://ni.com/educators-guidebook).*

## Saving the World... Around the World

*Engineering educators worldwide have joined the movement to challenge students to go beyond theory and simulation to “do engineering.”*

**Author:** Dominik Osinski  
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In our course Sensor and Instrumentation Technology we began to use a setup that we call ‘lab in the bag.’ It is a plastic case containing NI myDAQ, a prototyping board, cables, and sensors. Because the setup is mobile, students no longer depend on lab room availability and can spend as much time learning hands-on with the equipment as they wish.

The lab tasks are organized as practical projects. Students are, to a high degree, independent in choosing the evaluation methodologies and experimental setups. This kind of course organization results in many creative approaches to the solutions of the defined problems. After the course we received very positive feedback from the students. They were interested in using the prepared lab setup for their own projects outside the scope of the course.

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With the Mexican educational system focusing more on practical skills, students need to devote more time to “doing.” This is where experimentation comes in. One of the main benefits of experimentation is that it joins together different application areas. When students integrate multiple areas and functions, they add to their ability to innovate. They can build applications of all levels, from small projects to ongoing projects that link with industry.

NI technology can be adapted to teaching multiple subjects. This is especially useful during these interdisciplinary projects. Thanks to NI LabVIEW software, we can assign students a single platform to incorporate several subjects in their projects. Students develop real working systems and gain confidence in their ability to compete with other graduates. If students can excel in the use of technology, they improve their ability to find a job and add prestige to the school. Many students have found jobs in major research institutes throughout Mexico as a result of these efforts.

**Author:** Piotr Maj, PhD  
Researcher  
AGH University of Science and Technology, Poland



One of the main aims of academia is to challenge new ideas through real projects. In the department of Measurement and Electronics, we specialize in designing application-specific integrated circuits (ASICs) for physics and neurobiology applications. The process of implementing a new ASIC consists of several stages such as design, prototype manufacturing and testing. Since we are dealing with new technology and new ideas, each chip revision requires a specific set of tests. Therefore, we knew that the future engineers working in this area would need to have the skills to quickly build dedicated software-based instruments that use a variety of different hardware to create appropriate input and output signals for custom testing.

To better prepare our students to work in this field, we introduced a series of five courses through our curriculum. The first two show applications of LabVIEW performing different measurements. During the fifth semester, students reach the Basics of Graphical Programming Environments subject, which has been certified as an official LabVIEW Academy. This gives them the background they need to be effective in future courses such as Design of Control-Measurement Systems and Advanced Programming, where they learn how to work with different hardware platforms and use advanced programming techniques. This all gives our students a set of skills to be able to quickly build virtual instrumentation-based systems for control and measurement application including and beyond the testing of ASICs.

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My university is one of the top private schools in Korea, and the quality of students is very high. They are well trained in both theoretical and practical ways. However, most of them did not have many chances to realize their knowledge gained through classes. Using NI LabVIEW, I found that many students naturally find their own (unique) way to express and realize their thoughts on the block diagram. Once their algorithms work, they are more motivated and realize that their ideas are unique.

With graphical programming, students are generally much more interested and motivated. In fact, many want to join my laboratory after my class, which makes me both happy and sad since I cannot accept all of them. So, we will be looking into opportunities to expand the laboratories out of class with take-home hardware and software so that more students have the opportunity to gain hands-on experience.

**Author:** Brecht Van Hooreweder  
Research Engineer  
KU Leuven, Belgium



During a period of three months, we helped 13 first-year master's students work together to electrify a conventional vehicle. With a limited budget and off-the-shelf components, the students transformed a Daewoo Matiz into a fully electrically driven vehicle. In total, they spent only 160 hours on this project (equivalent to 20 working days). This amount of time is impressive even for experts in industry.

During this project the students learned about teamwork, constructive communication, practical problem solving, and decision making. Furthermore they learned how to rapidly study and implement unknown topics such as battery and electromotor technology, electrical safety, solar cells, vehicle mechanics, and so on. At the heart of the system were NI CompactRIO and LabVIEW, which gave students the flexibility, versatility, and robustness they needed to complete the challenge in this amount of time.

Apart from the educational value, this project anticipates the subject of environmentally conscious transportation. The developed vehicle clearly shows the main advantages, disadvantages, and difficulties of electric cars in a comprehensive way.

**Author:** Gloria Mata-Hernández  
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Universidad Nacional Autónoma de México (UNAM)



Engineering curricula and the corresponding laboratories are a fundamental, formative part of the engineering experience. In the laboratory, students demonstrate theoretical concepts and the variables that arise from the real world. With practical knowledge, students can learn more easily and readily join the professional environment.

In this regard, NI LabVIEW, NI CompactRIO, NI Multisim, and the NI Educational Laboratory Virtual Instrumentation Suite (NI ELVIS) have contributed to our ability to train educators, who in turn teach our future engineers. By verifying the theoretical with the practical, students spend more time gaining experience with systems and the applications derived from them, and they feel the satisfaction of doing work on their own. We created a virtual instrumentation laboratory to make the teaching-learning process more dynamic for more than 200 students.



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In the past, we've had our students work on simple projects in small groups of four people each. The projects were very defined and the process very streamlined. Recently, however, we chose to increase the complexity and open-endedness of the projects as well as the size of the groups. We wanted the students to design a new system, not just re-create existing ones. So the students took a traditional package delivery system and redesigned it to be automated.

The students accomplished the challenge in just eight weeks. It would have been impossible without the abstraction of complexity provided by NI LabVIEW. They gave the new course a positive evaluation, and the teachers thought it worked well. The students appreciated that they had more freedom to design the project and interpret the given design specifications, which required them to do a lot more practical system integration. LabVIEW gave them the tools to integrate all of the parts of the system well.

In general, students were motivated and formed groups that worked well. We will definitely keep the concept of large groups and complex projects because it forces students to learn how to collaborate effectively, just as they will in their jobs. We hope to double the amount of students next year, at which point we'll have two projects running in parallel.

