ENDEAVOR: The Ultimate Engineering Playground

As industry drives the demand for design-oriented students that thrive in team settings, OSU needed to create a project-based learning environment. To achieve this, they designed an entirely undergraduate-based lab to altogether redefine what an engineering curriculum could look like.

NATIONAL INSTRUMENTS

Figure 1. CEAT ENDEAVOR Facility Main Entrance

ENDEAVOR is the centerpiece of a paradigm shift underway at Oklahoma State University to expand instruction beyond the classroom and increase undergraduate laboratory and exploratory time for interdisciplinary, hands-on, and industry-aligned learning.

The Questions that Built ENDEAVOR

How do we learn? We learn through experience and repetition. For example, we begin to walk by stumbling, falling, and trying again—and again. To ride a bike, we make repeated attempts that become increasingly successful until we're rewarded with complete success. Simply put, we are built to learn by doing. Why would engineering be any different? Wouldn't it be most effective for students to learn engineering by actually doing engineering?

During the nineteenth century, our society experienced an industrial revolution. Out of the need for a highly trained workforce—as efficiently and quickly as possible—came the classroom/lecture hall, in which a large student body could acquire information quickly from a single person. This venue satisfactorily facilitated knowledge dissemination, but relied heavily on repetition (mostly on the student's part).

Today's environment challenges that traditional model. Modern engineering students are bombarded with information—from everywhere, at all times. They have competitors vying for their attention, making the lecture structure of nearly a century ago less effective. Educators must get their attention, keep it, and encourage them to think for themselves. Students have to be in an environment where they cannot help but be exposed to engineering principles and inspired to lean into their own curiosity. They need a place that encourages them to experience lecture concepts by direct application—using cutting-edge industrial hardware, in multidisciplinary teams. Students also must be able to mimic potential career experiences to build their understanding of what it means to be an engineer. Our team felt confident that we could make such a space a reality.

We also asked ourselves, "Can we accommodate technologies in such a way to improve retention?" To answer this, we turned to a source that we (and, likely, you) use all the time: YouTube. YouTube how-to videos provide the opportunity to learn by imitating a master. When students have a question, they simply rewind and watch a particular task over and over, until they understand. To provide a YouTube-equivalent number of instructors for thousands of students is cost-prohibitive, but it's certainly achievable to build and outfit a facility that utilizes such tools.

Cementing the Vision

The idea of an immersive, project- and experiment-based undergraduate experience is simultaneously compelling and easy to dismiss. The transformation requires both an investment in materials/labor/infrastructure

and a (perhaps challenging) change in culture. Instructors and departments must reexamine teaching methods that they've used since their University was founded. They need to rethink and restructure degree plans, course structures, new/old/redundant courses, number of hours for graduation, and accreditation to effectively provide an immersive learning environment for all students.

To fulfill the infrastructure portion of this transformation, we focused on these key concepts: A centralized location that could serve more than 8,000 undergraduate students; a set of advanced industrial tools that undergraduate students could operate; interdisciplinary use (the facility and equipment belonged to the college versus individual departments); and a modern and relatable curriculum. These formed the basis for the partnerships that we would eventually pursue and the proposals that we would make to educational and industrial partners to bring holistic improvement to education at OSU.

The transformation of education at CEAT is a monumental and ongoing undertaking. Not only are we bringing together all CEAT departments, we also are including other colleges such as Arts and Sciences, Agriculture, and Business. Dean Paul Tikalsky, who spearheads our endeavor, provides a constant direction and drive critical to making it work.

Figure 2. Sophmore and Junior Students Running the Communications Lab

Figure 3. Electrical Engineering Lab Equipped with an NI ELVIS III at Each Station

ENDEAVOR's Innovative Foundations

The ENDEAVOR lab is a 72,000-square-foot discovery environment filled with prototyping, test, and measurement equipment, run by a small team of professors and undergraduate students. Because everything in the building's foundation is meant to be explored, we incorporated thoughtful details, such as exposing sections of wall to reveal inner workings—everything from how the facility is insulated to how the elevators work. From measurement systems embedded in the stairs, to sensors lining a room for thermodynamic tests, to equations built into the floors, students are immersed in engineering the moment they enter.

Equipment and NI Partnerships

Because ENDEAVOR needed to service several engineering disciplines as well as students from other colleges, we required a seamless communication infrastructure between departments and tools that would easily span a wide breadth of course topics. National Instruments, upon hearing our challenge, partnered with us to equip ENDEAVOR with state-of-the-art test and measurement equipment. We immediately benefitted from how easily their industrial products (such as CompactRIO and CompactDAQ) transitioned between thermodynamics, fluids and mechanics, and materials labs. Their NI ELVIS III solution integrated into a wealth of courses, from circuits to wireless communications. OSU admits more than 1,500 undergraduate freshmen into the department yearly, and we have confidence that they are building the engineering intuition to set up real-world experiments and get relevant data from day one.

We offer ENDEAVOR equipment to all students, so it needed to be low-cost, durable, and easy to get started with. NI ELVIS III has completely changed how we approach our entire lab scheme. Not only does it integrate several box instruments, such as power supplies, function generators, and analyzers, into one workstation, but it includes the measurementslive.ni.com environment. This made the solution a must-have. These features, combined with the ability to prototype with the embedded onboard processor, means that we can begin preparing students for design work in their first year and have them transition to full designs using the more compact myRIO platform later. We found value in the NI platform because we could scale throughout the education experience, establishing foundational

lessons on NI ELVIS III and reinforcing those ideas on larger industrial equipment. With students already competent using NI technology, we reduce reteaching and spend more time learning engineering concepts.

Curriculum

ENDEAVOR is much more than a building—it is a catalyst for mindset change. Our faculty is embracing new ways of teaching fundamental courses, leaning heavily on project-based and experiential learning opportunities. This has changed a number of courses taught at OSU:

- **Circuit Fundamentals:** Students test theories in the classroom by connecting their laptops to NI ELVIS III and taking measurement data using Measurements Live. This procedure truly bridges the gap between theory and real world.
- **Digital Design:** This course challenges students to build a state machine on NI ELVIS III to mimic 1967 Thunderbird car taillights. They are given requirements for timing and user interaction and are graded on how well they meet those requirements in a final product.
- **Embedded Computers:** Students are able to rapidly develop using the NI Digital Systems Development Board and enhance theory with real, hands-on applied exercises. In one case, students used this system in combination with the NI ELVIS III to develop a fully operational NES Classic Edition, that was able to run Super Mario Brothers on an FPGA environment.
- **Measurement and Instrumentation:** Integrating biomedical sensors with Nerf guns is a surefire way to get students engaged! In this course, students connect analog sensors to an embedded controller. Then, they collect EKG data from NI ELVIS III and build a model to fire a NERF gun when an individual flexes their ring finger.
- **Wireless Communications:** Previously, OSU never offered a wireless communications laboratory for undergrad students. Now, through our partnership with National Instruments, we have a course that begins with NI ELVIS III and the Emona Communications Board for NI ELVIS III, as well as a more complex track that takes advantage of research-ready solutions such as USRP (Universal Software Radio Peripheral). There are only approximately four laboratories in the country that can compare to ENDEAVOR's RF/COM lab, and none dedicated solely to undergraduate education.
- **Design Courses:** Adopting NI gear and software has advanced student achievement. From building more advanced industrial prototypes, to ENDEAVOR systems, to autonomous vehicles, NI provides a common platform and a fast learning curve. Perhaps most impressively is how students are taking initiative: One team is building an autonomous BB-8 robot using cutting-edge drive systems. Another is using LabVIEW and myRIO to collect and fuse sensor data while interfacing with NVIDIA for artificial-intelligence processing. Their goal is to create an autonomous car that self-learns an obstacle course.
- **Leapfrog Capability:** Using NI gear with LabVIEW software is helping our college leapfrog the slow traditional curriculum in current industry-driven topics. NI products reduce to DAYS tasks that typically took weeks—or even months—to develop. Simply by reducing required effort, we can shift more advanced courses and concepts from graduate-level students to juniors. While this advancement is already occurring in design classes, we intend to build very advanced applied courses around lessons that we are currently learning, so stay tuned!

Figure 4. Student Lab Manager Configuring a Flume in the ENDEAVOR Fluids Lab

Figure 5. Sophomore Student Finishing a Tracking Robot Prototype Using myRIO

A Growth Story

Already, the facility, equipment, and revamped curriculum are driving engagement, reducing costs, and growing partnerships with adjacent departments. Currently, there are 60 NI ELVIS III units throughout the facility, and we plan to expand with more units and other NI tools for all CEAT departments. We have completed the first round of teaching with the new curriculum, and 60% of the students have become mentors, lab managers, or ambassadors to other departments. The School of Business is investing in a program to nurture entrepreneurial students, wherein they create product pitches and "hire" student resources to prototype their ideas in ENDEAVOR. Students of varied disciplines—from (currently) Physics to (next semester) Theater—are enrolling in ENDEAVOR-specific courses. We support STEM student outreach and teacher training for CEAT and the College of Agriculture. Culturally, we provide support and encouragement for CEAT student organizations as well as community outreach. The spirit, or essence, that people feel with they walk through the door to ENDEAVOR reaches beyond a building or facility: It has naturally become an extension of the OSU Cowboy way.

National Instruments is truly a partner in our efforts. Not only did they provide the impact of a single solution, but their global platform amplifies our message to reach a larger network. Together, we are pushing the limits of technology to galvanize innovation. Our joint presentations at NIWeek and the American Society for Engineering Education provoked new conversations with The Open University in the UK on what a global, connected approach to teaching could look like.

ENDEAVOR is much more than a building; it is a chance for engineering to be embraced as an innovative and creative discipline. While our doors have only been open since August 2018, we have seen students' excitement when they discover that ENDEAVOR meets them where they want to be. Our aim is to engage a global audience and bring the spirit of ENDEAVOR to any student who wants to engineer.

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