



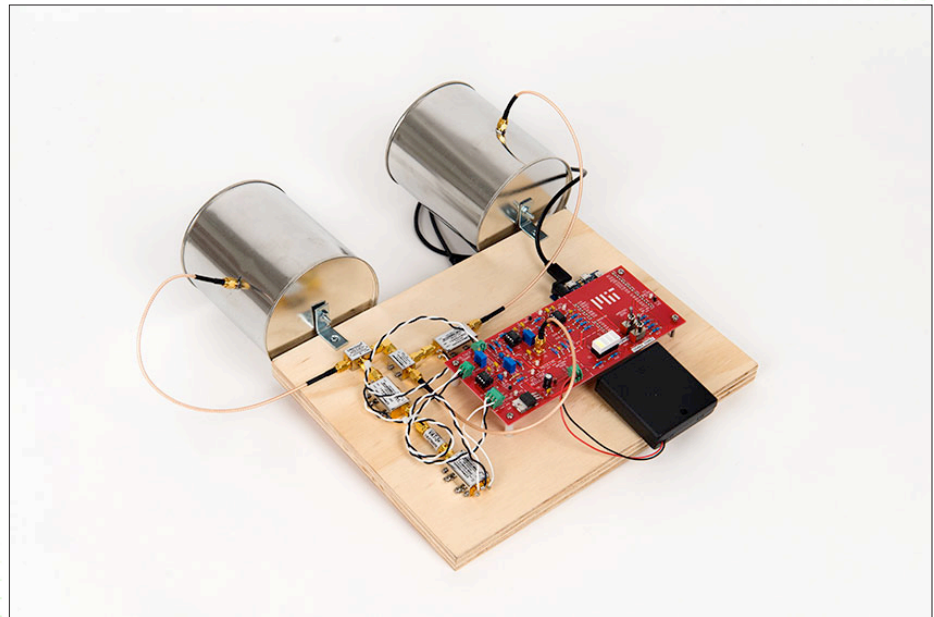
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## LLx Project Seeks to Improve Online Hands-On Learning

Division 5: Cyber Security and Information Sciences

Online learning has been around for decades, but educators still struggle to adapt certain hands-on subjects to the web. For example, electrical engineering requires both theoretical and practical knowledge because understanding how to build a system is not the same as actually building one. When students first attempt to assemble a physical system, they often need access to instructors or experts who can answer questions and help troubleshoot issues. In an online environment, where instructors may not be readily available, guiding students as they translate their theoretical knowledge into practice is a difficult task.

At the Laboratory, a team of researchers has been working on ways to close this practical learning gap through the Lincoln Laboratory Online Courses (LLx) project. The project was born from a desire to adapt the Laboratory's internal course offerings for a wider audience. Its goal is to identify best practices for online hands-on learning in order to provide unique Laboratory classes to sponsors, students, and the general public as self-paced, massively open online courses (MOOCs).



The Build a Radar course, one of the classes offered on the Laboratory's education course platform (called LLx), aims to give students hands-on experience in an online setting.

The program currently has courses that are offered internally and externally, including a course where students learn how to build a radar. Additionally, the project supports the online portion of the Beaver Works Summer Institute by providing material that prepares rising seniors for the four-week program.

Dr. Julia Mullen, Supercomputing Center (LLSC), leads the LLx program and believes that helping students

build intuition about a subject is essential for successful learning: "If learning is defined as being able to transfer knowledge and apply theory to new applications, then building intuition about a subject matter is key to understanding how to transfer knowledge to new applications and cross-disciplinary projects."

In academia, intuition is built within a laboratory setting, where instructors can demonstrate

## LLx Project Seeks to Improve Online Hands-On Learning (continued)

troubleshooting techniques and guide students through the engineering process by asking a series of questions. The challenge in an online environment, particularly in self-paced courses, is to replicate this one-on-one help. Traditionally, online courses have provided theoretical material, while practical applications have been left for in-person sessions. The Laboratory is unique in developing techniques for bridging the physical-digital learning gap for online, self-paced courses.

Following standard best practices for online learning, the courses are designed to present theoretical content in modular blocks that break down difficult topics into small pieces and incorporate exercises and checks for understanding. To help develop intuition for the hands-on portion of the courses, the team has designed the build, test, and experiments sections using a collection of high-resolution, clearly annotated images of the final system. Students can use these while building their own system.

To help students get an idea of the type of results they should be seeing, the team has included simulations of experiments that include good and bad results. “At every stage, there’s a check. Does it work? Great, go to the next step. If doesn’t work, then here are things to try,” said Mullen. “The goal is help learners develop troubleshooting skills, learn how to design good tests for their system or program, and develop confidence in their ability to track down and rectify issues as they arise.”

The first course developed in the LLx program was the High Performance Computing class for users of the LLSC systems—offered both internally and externally in MOOC format. The success of this course prompted the team to consider other Laboratory courses that would interest a wider audience. A prime candidate was the Build a Radar course.

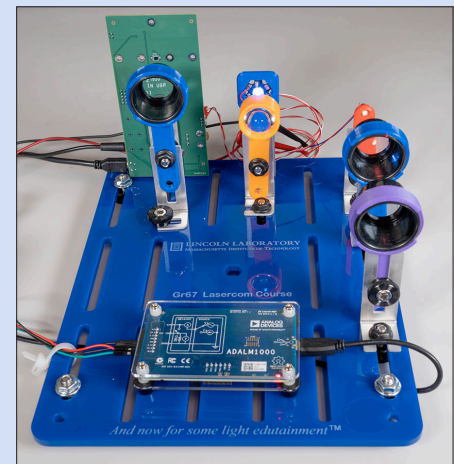
“We have been running various versions of the Build a Radar course since 2011, and since it has gained a lot of interest, it has consumed a lot of staff hours teaching it to different student and sponsor groups,” said Kenneth Kolodziej, Radio Frequency Technology, Group 86, who is the current lead of the Build a Radar course. “The MOOC version helps us drastically reduce the amount of staff time for each course we offer, and it has even opened the opportunity for others to take it remotely with only the online instruction.”

The LLx team is currently working with Laboratory staff to develop a new Build a Lasercom System course, which will be launched on campus for students next month and internally in the spring.

Robert Schulein, Optical Communications Technology, Group 67, who is leading development of the Build a Lasercom System course, said that he hopes the course will help onboard new staff and deepen sponsor interactions. “One of the goals is to hold the course for folks with less background in the

technology area. After introducing the technology through the course, a relationship is established that can translate over to demonstrating real Laboratory technology.”

The team is also adapting the LLSC Practical Machine Learning



As government, business, and personal users increasingly rely on the internet task for researchers. Supercomputing is an untapped resource that can help them in this endeavour.

Course and using it to explore methods of personalizing course content and activities. The end goal is to allow students to begin courses with whatever module best fits their experience level or pick and choose which modules to complete based on their experience and goals.