The Freshman Experience Workshop: A Modular Approach to Experiential Learning

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Abstract

In the summer of 2015, I was asked to teach an Introduction to Engineering course for the VCU School of Engineering Electrical and Computer Engineering department. The course was for the fall, 2015 semester. I had not taught Intro in quite a few years, and its format had changed significantly. With that in mind, I decided to redesign the course to be comprised of lab modules that led instruction rather than deciding on the instructional goals and developing labs around that. It was important that the students actually make something in the lab and that each exercise provide opportunities to learn new concepts, build skills, exercise good study habits and review relevant material. This course is now in its third semester and it is proving to provide an effective way to teach students fundamental engineering concepts while engaging their attention and stoking their enthusiasm for the engineering profession.

Keywords

Introduction to Engineering, Engagement, STEM.

Introduction

In the fall of 2015, the course "Introduction to Engineering" taught to Electrical and Computer Engineering students was fundamentally changed to accommodate the need to introduce a wider range of electrical engineering concepts in a more engaging way. Prior intro courses used mock robotics competitions to engage students but the learning objectives, such as fundamental circuit analysis, Excel® and MATLAB® projects and others, were disconnected from the experiential part of the class. In the new course, the plan was to use projects to drive learning and to develop projects that would allow a wide range of topics to be covered in class. In addition, most of the projects provided opportunities for overlapping concepts to be taught so that a natural rhythm of repetition and review of concepts was established.

Program description

The labs and a summary of their learning objectives can be found in Table 1. Students used Arduinos as a microcontroller platform for the digital Theremin and the Color to Sound projects. In 2016, the school purchased a site license for MATLAB®, including the Fundamentals courses. This was also heavily utilized in the course. All homework and some quizzes were programmed on LONCAPA, an open-source learning content management system.

Table 1: Lab projects leading to learning objectives.

Lab	Implementation and learning objectives
Ethics	Case studies taken from ethics.tamu.edu; students have breakout sessions and prepare for mock debates on predefined case studies.
Motor	Students learn about electricity and magnetism, and how they interact. They also learn about back-emf and observe the phenomenon on an oscilloscope. Also provides an opportunity to discuss rotational motion, angular velocity and torque. Simple circuit analysis; KVL and KCL. In studying all the above topics, students practice their math skills.
Coilgun	Magnetic field induced by a current; forces on a ferromagnetic material because of the current coil; linear motion; capacitor charging and discharging problems; math problems containing ln and exp functions.
Theremin (Analog)	Ring oscillators, voltage division, simple circuits. Electromagnetism. Simple integral equations.
Theremin (Digital)	Arduino; sensors and how they work; linear transformations to translate distance into frequency and amplitude; signals and systems; math.
Color to Sound	How LED and light sensors work; the vidible and audible spectrum; programming a microcontroller; math and the composition of sound.

The students thrived under this new learning environment. The second semester was taught to a wider audience that included non-engineering students. Of those, about half converted to engineering or started the process of converting to engineering by the end of the semester. In the third semester, the course really hit its stride. Anecdotally, electrical and computer engineering students who are now seniors and juniors openly admire the new Introduction to Engineering course. Student feedback in the course evaluations is almost uniformly excellent, with only a few comments dealing with organization, but only at a level that is natural in what is effectively a new course.

A very important aspect of this course is the use of LONCAPA to assign practice and homework problems and even give quizzes online. While there is some effort involved in programming the problems, the benefit of being able to assign as many problems as we want and to have them be graded automatically is worth it. LONCAPA allows us a full range of possible problem types and flexibility in how we assign and grade these problems. In terms of helping us build skills and reduce fluency illusion [1] in our students, this has been a very useful tool. In fact, it is so easy to use, we have assigned this task to undergraduate teaching assistants.

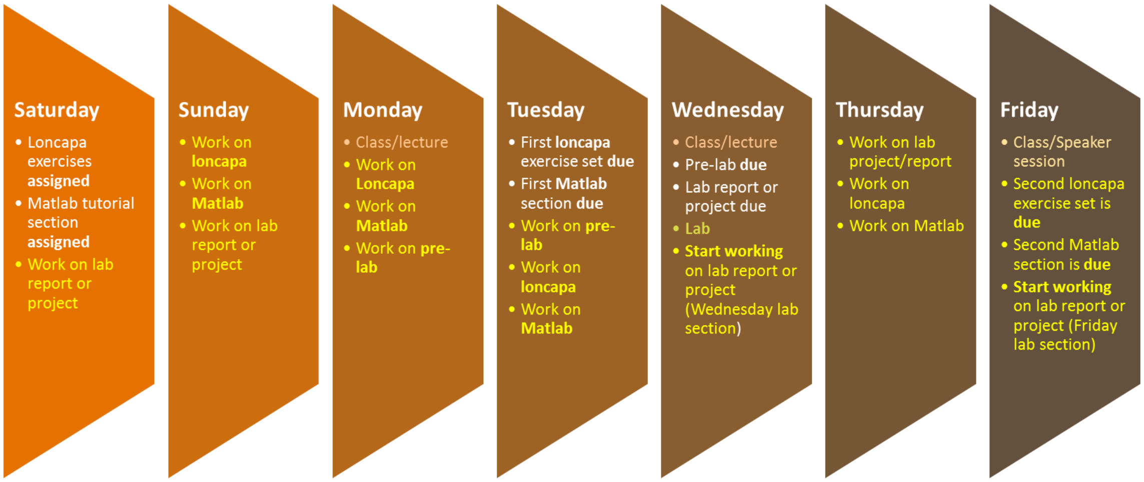

Figure 1: Typical week in the life of an ECE Introduction to Engineering student.

Program

1. ½ hour – Philosophy of "Modular" or lab-driven course work – starting on the road to developing 21st century skills.
2. ½ hour – The coilgun: the learning opportunities that arise from this one simple lab.
3. ½ hour – breakout sessions: develop problems and lesson plans associated with the coilgun lab
4. ½ hour – Theremin lab – analog and digital
5. ½ hour – develop problems and lesson plans associated with the Theremin lab
6. ½ hour – introduce and demonstrate LONCAPA: Practice problems, homework problems and exams – how LONCAPA is used to build skills and teach good study habits.
7. ½ hour – choose a few of the easier problems and have participants program them into LONCAPA.
8. ½ hour – wrap-up: round-table discussions – can we come up with another lab and mind-map its lesson plan?

Look up the course online – https://rampages.us/vcuengineering/

References

[1] B. Carey, How we learn: the surprising truth about when, where, and why it happens, New York: Random House, 2014.

Afroditi Filippas

Dr. Filippas received her B.S. in Electrical Engineering from the University of Patras, Greece. After earning her M. S. and Ph. D. from UT Austin, she completed post-doctoral research with the Institute of Accelerating Systems and Applications in Athens, Greece. Dr. Filippas is currently the Associate Dean of Undergraduate Studies at the VCU School of Engineering. She provides vision and leadership in achieving the School's objectives for substantial growth in the size and quality of its undergraduate enrollment while maintaining its commitment to excellence. Focus areas include contemporary teaching and learning technologies, special degree programs with partnering academic institutions, and K-12 outreach.

Umar Hasni

Umar Hasni, currently a graduate student in the Department of Electrical and Computer Engineering, graduated with a degree in electrical engineering from Virginia Commonwealth University. Mr. Hasni is currently researching optical filters for novel particle detection applications, microwave applications for 3D printing technology, medical applications for radar based systems and mentoring an undergraduate vertically integrated projects lab.

Alen Docef

Alen Docef received his Engineering Diploma from the Polytechnic Institute of Bucharest in 1991 and his Ph.D. degree in electrical engineering in from the Georgia Institute of Technology in 1998. From 1998 to 1999 he worked as a research engineer in the Signal Processing and Multimedia Group at the University of British Columbia. Since 2000 he has been with the Department of Electrical and Computer Engineering at Virginia Commonwealth University. His research interests are in medical image processing, efficient and embedded implementations of signal processing algorithms, and engineering education.

Georgios Bakirtzis

Mr. Bakirtzis received his B.S. in Electrical Engineering from the VCU School of Engineering. He is currently a second year graduate student in the Department of Electrical and Computer Engineering at Virginia Commonwealth University. His interests include cyber-vulnerability assessment modelling in embedded systems. He is broadly interested in formal methods, resiliency, graph theory, evolutionary game theory, and higher order logic. As an undergraduate at VCU, he was an officer of IEEE and was involved in the establishment of the Autonomous Robotics Group. He has worked in navigation algorithms for flight control systems, hardware in the loop flight simulators, and wireless mesh networks for collaborative missions.

Angelica Sunga

Born in Virginia, U.S., in 1996. She is currently a sophomore student at the Department of Electrical and Computer Engineering at Virginia Commonwealth University, Richmond, Virginia, for the B.S. degree in electrical engineering. Angelica has served as a tutor and lab assistant in the “Introduction to Engineering” courses and is an active participant in the “Vertically Integrated Projects” research endeavor at the VCU School of Engineering.

Hiba Nabi

Hiba Nabi grew up in New Jersey, and completed her high school in the Middle East. Currently she’s a sophomore, pursuing a B.S. in EE at VCU. In her freshman year, she worked as an UG Researcher in the Medical Device Development and Prototyping Lab. After taking Intro to Engineering during her freshman year, she realized the significance of this course for incoming freshmen, and decided to aid in developing it further. She is a member of the UG Student Advisory board for ECE, and VCU’s Engineering Ambassadors Program. Through these organizations, she volunteers at events to promote Electrical Engineering to the community. In addition, she’s also serving as the Secretary for IEEE’s VCU branch.

Arthur French

Arthur French received his B.S. in Electrical Engineering from and is currently a doctoral student in the VCU School of Engineering where he is also a teaching assistant. His research includes applications for dielectric sensors, specifically focused on biomedical devices.