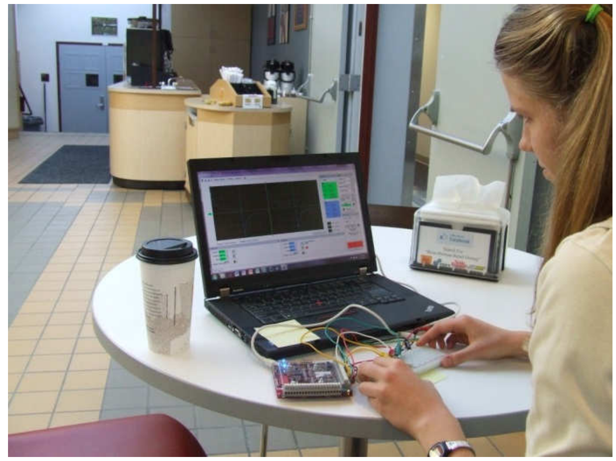
2014 ACC WORKSHOP

Ubiquitous Hands-On Learning: The Future of Engineering Education

Organized by the Center for Mobile Hands-On STEM
Endorsed by the IEEE Control Systems Society Technical Committee on Education

Rationale: Studies have demonstrated that concrete experimentation improves student understanding of abstract concepts and motivates students by providing examples of theory in practice. The model of having traditional, centralized laboratories requires expensive equipment and personnel; furthermore, students have limited access to these resources. Development of inexpensive and portable USB-powered oscilloscopes, function generators, microcontroller boards, and other portable electronic equipment has facilitated a new model of engineering education where hands-on experiences can be done ubiquitously anytime anywhere. Students can explore the theoretical concepts introduced in lectures with hands-on activities either immediately in the classroom or at home rather than waiting for a scheduled laboratory time.



Student ownership means that students can work on experiments anytime anywhere.

Benefits to Students: tools immediately and readily available for design projects, design competitions, and to just tinker and follow their own creativity to new areas of discovery. Online and distance learning students have equal access to hands-on activities as do on-campus students.

Benefits to Instructors: new way to facilitate inquiry-based learning through hands-on activities. They can develop course content anywhere and anytime; new ideas for labs, activities, and projects can be easily tried out at home rather than waiting until lab classrooms and technical staff are available. With minimum resources, teachers can easily integrate mobile hands-on activities into their courses.

Benefits to Institutions: new options for incorporating practical lab experiences into their curriculum without the need for expensive equipment and dedicated lab space since students have their own equipment.

Target Audience:

Who should come to the workshop? Engineering administrators, instructors, laboratory staff, graduate students and post-docs interested in academic careers in all engineering disciplines.

Why should you come? Learn different models for the effective implementation of hands-on learning: 1) hands-on experiences in traditional lecture-based courses; 2) lab courses where students own their own equipment and do the labs at home; 3) studio classes; 4) flipped classes; and 5) online lab courses. Experience the use of several different mobile learning platforms for measuring and analyzing physical phenomena, designing circuits, and learning programming. Participants will use a selection of low-cost electronic boards and portable instruments, which include the **National Instruments**' myDAQ,

Digilent's Analog Discovery board, and ARM's **mbed** microcontroller platform to carry out a number of experiments during the workshop. The experiments will demonstrate the range of hands-on activities and some of the diverse theoretical concepts that can be taught via active hands-on learning. Participants will leave the workshop with a set of tested experimental procedures and other instructional resources.

Presenters:

The presenters of the workshop, **Bonnie Ferri** and **Al Ferri** (TESSAL Center, Georgia Tech), and **Deborah Walter** (Rose-Hulman) have been engaged in pedagogical research on active learning and have designed, implemented, and assessed hands-on activities in numerous courses during their academic careers. In addition, the workshop organizers include Kathleen Meehan (University of Glasgow) and Jim Hamblen (Georgia Tech), who have collaborated as part of the multi-institutional Center for Hands-On STEM, along with colleagues from Howard, Morgan State, and Albany to present this material to facilitate the development of the common themes that have developed from their research. This workshop is partially supported by an NSF TUES Grant (Award 0817102) and technical support from Digilent.

ACTIVE LEARNING: Students working on hands-on activities at their desks during a regular lecture period in a regular lecture room.

Half-Day Schedule:

Models of Ubiquitous Hands-On Education (30 Min)

myDAQ Platform Hand-On Activities and Demonstrations (1 hour)

- Hands-on activities showing the time response and frequency response of underdamped and overdamped second-order circuits.
- Demonstration of PID motor control experiment
- Demonstration and presentation of the impulse response, frequency response, and initial condition response of a vibratory system (guitar string)

Break (15 Min)

Mbed microcontroller Platform Hands-On Activities and Demonstrations (45 min)

- Demonstration of a temperature controller built with an mbed kit
- Hands-on activity where participants build a very simple code and implement it on the mbed

Pedagogical Discussion: Models of Learners (15 Minutes)

Discovery Board Platform Hands-On Activities and Demonstrations (1 hour)

- Hands-on activity to run a filtering experiment to remove 60 Hz noise
- Demonstration of the use of MATLAB to control the Discovery Board

Summary and Discussion (15 Minutes)

Logistics

Participants will be given free software ahead of time to download to their computers. During the hands-on activities, the participants will work in groups of 2-3 on experimental activities that are related to systems and controls topics using an mbed kit, myDAQ boards, and Digilent Discover Boards. This hands-on exposure will give the participants an understanding of the potential impact on student learning from the use of the mobile, student-owned platforms. Additional hardware will be brought for demonstrations of other experiments that students do on their own.

Abstracts:

Models of Ubiquitous Hands-On Education (30 Min)

This section discusses three particular models of implementing hands-on activities in a curriculum: small in-class activities in lecture-based courses, student-owned equipment in lab courses for students to complete at home or at school, and mobile studios where the hands-on activity is fully integrated into a lecture class. These three models use different strategies and take different levels of commitment from universities and from instructors. The first one, in-class experiments on a small-scale level, aims at targeted intervention and has the lowest threshold for instructors, students, and administrations. The mobile studios model has the highest threshold but may have the largest impact by fully integrating classes with hands-on activities. The model where regular, full-scale labs are done by students using student-owned equipment can serve to replace the centralized laboratory model, which is costly to universities, with a mobile version where students have more time to explore the lab activities. Assessment results on how well these methods work will be included in the presentation.

Ref: Kenneth Connor, Bonnie Ferri, and Kathleen Meehan, " Models of Mobile Hands-On STEM Education," proceedings of the ASEE Annual Exposition and Conference, June 2013, Atlanta.

myDAQ Platform Demonstrations and Hands-On Activities

Software coupled with the myDAQ board converts a laptop into a suite of instruments including a function generator, oscilloscope, dynamic spectrum analyzer, automated Bode plot generator, and digital I/O interfaces. Georgia Tech now requires all ECE students and all students taking the circuits course for non-majors to purchase the myDAQ board and a small parts kit. The price for this unit is about the same as a textbook. This is a total of 1000 students per term using these devices in one of several lecture-based core courses: ECE2020 Fundamentals of Digital Design, ECE2040 Circuits, ECE 3084 Signals and Systems, ECE 3710 Circuits and Electronics (for nonmajors). The overview of the logistics and the impact on learning of using hands-on activities in lecture-based courses will be presented in the first session (above), but the real impact will be felt here where the participants will see for themselves what students experience.

This session will give a hands-on demo of the platform by having participants experiment with an series RLC circuit where a potentiometer is used in place of a static circuit. The potentiometer allows for students to adjust the resistance to get underdamped, critically damped, and overdamped behavior. The participants will see how to use the board for both time domain and frequency domain measurements. The two demos will feature a small, inexpensive PID motor control experiment that works with the myDAQ unit and a guitar string experiment. The guitar string is an engaging system for students to use because of the tie to music. The model of the system will be shown along with how that model can be used for students to learn about transfer functions, controllability and observability, light damping, initial condition responses, impulse responses, and frequency responses.

Mbed microcontroller Platform Hands-On Activities and Demonstrations

The mbed is a low-cost microcontroller built by ARM that has a very large community providing a large library of online resources and very easy to use support. Embedded computers make up about 90% of all computer applications, so exposure early to these devices is beneficial to all engineering students. Many of the applications of embedded computers include system monitoring and control. Georgia Tech teaches two sophomore-level courses involving programming, both of which require students to purchase an mbed kit (cost of $95). This session will feature a demonstration of a temperature controller project that was given to students in the C++ programming class. As part of the project, students build the temperature controller from parts in their mbed kit and then program it. This is a nice illustration of crossover technology from the controls domain into a programming class. A hands-on activity is planned for the workshop participants to implement a very simple program on the microcontroller to see how easy it is for students and faculty to use in courses.

Pedagogical Discussion: Models of Learners

Discovery Board Platform Hands-On Activities and Demonstrations

- Hands-on activity to run a filtering experiment to remove 60 Hz noise
- Demonstration of the use of MATLAB to control the Discovery Board (Kathleen suggested this)

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