



## **Collaborative Research: Center for Mobile Hands-On STEM**

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## Collaborative Research: Center for Mobile Hands-On STEM

Remarkable progress has been made in the development and implementation of hands-on learning in STEM education. The mantra of *See One, Do One, Teach One* overly simplifies the idea but does provide a helpful structure to understand how many engineering educators are attempting to change the learning experience of our students. Until recently, this effort has been faced with a major limitation. While we can easily incorporate traditional paper and pencil and numerical analysis, synthesis, and simulation in our classrooms, the remaining key aspect of *doing the job of an engineer* – experimentation – has only been included through the use of expensive and limited-access lab facilities. Small, low-cost Mobile Hands-On STEM (MHOS) learning platforms (e.g., myDAQ, Analog Discovery, and Circuit Gear Mini) provide almost unlimited opportunities to solve this remaining problem in engineering courses. Pedagogy based on these tools has been implemented and studied in several NSF funded projects and has been successfully transferred to other institutions in the US and in other countries. As these new learning platforms are the price of a textbook or less, thousands of students each year are being given the opportunity to learn in this exciting new pedagogical environment. In all cases in which hands-on learning has been studied, the pedagogy has been successfully implemented, even in traditionally theory-only based courses, with more engaged students and instructors hands-on learning as one of the results. Although the initial assessments of this new approach to STEM education argue for broad application, the definitive case for its adoption has yet to be documented so that all STEM educators can fully appreciate its merit. Thus, the most effective approach to STEM education is still in question in the broader community and best practice methods of dissemination of the MHOS pedagogy to the entire STEM community have not yet been identified.

Mobile hands-on pedagogy in science, technology, engineering, and mathematics (STEM) is a relatively recent innovation in the teaching of electrical engineering. Three of the universities that have been involved in the development of this pedagogical approach for the past decade are Rensselaer Polytechnic Institute (RPI), Virginia Tech (VT), and Georgia Institute of Technology (Georgia Tech) [1-18]. Colleagues at Rose-Hulman Institute of Technology (RHIT), Howard University (HU), Morgan State University (MSU), and Virginia Western Community College (VWCC) were early adopters and have contributed significantly to the refinement of the approach [19-24]. The expansion of this pedagogical approach has the support of the National Science Foundation as well as the involvement of several major manufacturers of electronics components, instruments, and circuit simulation software. The number of institutions of higher education that have incorporated the mobile hands-on pedagogical approach in teaching concepts in electrical engineering in their curriculum has exploded, coinciding with the growing number of inexpensive USB-powered oscilloscopes, educational parts kits designed for low-power applications, and the availability of free instructional materials [references]. To further promote its adoption, a number of workshops have been held to demonstrate how the hands-on pedagogical approach has been inserted into electrical engineering courses and the curriculum along with the improvements observed in student learning and engagement.

There remain a number of issues that must be addressed to validate that the mobile hands-on pedagogical approach has significant impact on learning of introductory and complex theoretical concepts in electrical engineering by students who are majoring in electrical engineering as well as by students outside of the major who take service courses in the discipline. While notable increases in interest in the discipline and comprehension of theory have been measured by faculty who have been extensively involved in the development of the pedagogical approach, it has yet to be determined if the improvements observed are universal for students at all institutions that adopt the pedagogical approach. Furthermore, a generic guide that addresses

common concerns about adoption of mobile hands-on pedagogy that describes the models of implementation and the resource required for success must be available for others who are considering the pedagogical approach. Lastly, the hands-on pedagogical approach need not be limited to courses in electrical engineering as engineers and scientists in a rapidly growing number of disciplines rely on electronic instrumentation in their daily work. Thus, students in all STEM fields should become familiar and comfortable with experimental practices that involve electronics and can benefit from the learning of concepts in their fields by seeing the concepts in action. Therefore, the development, documentation, and dissemination of mobile hands-on pedagogy beyond the field of electrical engineering could enhance student learning and interest in all STEM disciplines.

The Center for Mobile Hands-On STEM is pursuing activities that support the following goals:

- I. gather strong evidence of the effectiveness of Mobile Hands-On STEM (MHOS) pedagogy on student learning
- II. develop an effective and pro-active dissemination strategy for the entire STEM educational community.

To achieve these goals, we are:

- documenting evidence already available at MHOS partner institutions on mobile hands-on learning.
- developing standardized assessment tools for the MHOS partner institutions.
- creating and implementing new assessment tools that measure student learning, including the development of new concept inventories, as well as measure ease of adoption by instructors.
- identifying implementation barriers for wide-spread adoption and how these might be overcome by engaging potential new adopters in workshops, working with faculty who have recently received funding to implement the mobile pedagogy, and holding focus groups among different constituencies.
- holding a practitioners' best practices workshop to build a community of users to pool expertise.
- conducting a series of mini workshops to introduce mobile hands-on learning to instructors from these different constituencies and will pilot a full-scale workshop for new instructors to mobile hands-on learning near the end of the proposed program.

The Center for Mobile Hands-On STEM has accomplished the following during its first year of funding from the National Science Foundation.

The collaborative research team has developed a set of common assessment tools that will be used in the second year of this project to evaluate the impact of the hands-on pedagogical approach on student learning. The targeted student populations for this study are lower division electrical engineering students and non-major engineering students, both of which are enrolled in introductory circuits courses. The electrical engineering students in upper division courses that have a few select hands-on activities distributed throughout the semester will also be studied where a comparison between depth of learning of topics with a hands-on component and topics that are taught in a traditional theoretical lecture format will be carried out. An assessment tool to determine the concerns and insights of faculty who are responsible for courses in which hands-on learning activities have been integrated and courses that have a mobile hands-on companion lab course is under development. The goal is to determine the set of resources and support that are necessary to assist engineering faculty members to adopt hands-on learning and to sustain it.

A workshop organized by Bonnie Ferri (Georgia Tech) was hosted at Georgia Tech during the week

of the ASEE 2013 Annual Conference with presentations made by Ken Connor (RPI), James Hamblen (Georgia Tech), Bonnie and Aldo Ferri (Georgia Tech) and Kathleen Meehan (VT). Approximately 30 participants attended the workshop, which provided an overview of activities that are conducted at Georgia Tech, RPI, and VT. A survey will be carried out to solicit the concerns of these faculty as they considered adopting the pedagogical approach, the barriers that they have encountered, and their evaluation of the successes achieved and remaining challenges as they incorporated mobile hands-on learning into their courses.

Deborah Walter (RHIT) and Kathleen Meehan (VT) have initiated the development of a concept inventory for non-ECE majors who are enrolled in circuits classes with either hands-on activities in the classroom or laboratory exercises conducted outside of the classroom, both facilitated by portable electronic instruments. Co-PI Ella Ingram (RHIT) has studied the existing literature on teaching circuits, examined circuits concept inventories developed by others in the field, and participated in the learning of basic concepts in circuits and use of lab equipment along with students enrolled in circuits classes for non-majors. The plan is to present a draft of the concept inventory at the 2014 workshop to obtain input from other faculty members who are actively engaged in hands-on pedagogical activities.

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