Workshop - Elementary Engineering Education: Engineering Teaching Kits for K-5 Students

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Abstract - Engineering education interventions are increasingly commonplace at the middle and high school levels; witness the popularity of activities such as FIRST Lego League, FIRST Robotics, and Project Lead the Way. Less common, though, are interventions at the elementary school level, and we offer a promising one in this workshop: Engineering Teaching Kits (ETKs). Currently, ETKs provide age-appropriate engineering activities at the middle school level, and are overwhelming popular among middle school math and science instructors for two reasons: the kits are based on relevant Virginia Standards of Learning, and are self-contained units built on the principles of guided inquiry and active learning. In this workshop, participants will be introduced to ETKs; work through activities from two ETKs scaled for elementary grades, Buoyancy (Archimedes’ Law) and Simple Machines; and design their own ETKs for K-5 students.

Index Terms – K–5 engineering education, Engineering Teaching Kits, pre-college outreach, educational/learning standards.

INTRODUCTION

For years, engineering schools have engaged in extensive outreach programs to attract students to science, technology, engineering, and math (STEM) programs. The outreach is in response to several trends that pose a threat to the United States’ ability to remain globally competitive, such as stagnant or declining college enrollments in these fields while the need for trained professionals increases; and the under-representation of females, African Americans, Hispanic Americans, and Native Americans in STEM fields. These outreach programs seek to educate, engage, and empower students with respect to STEM.

Initially, outreach programs focused on high school students because they seemed to be the most logical candidates for recruitment. However, many students were not academically prepared to enroll in college STEM studies; one reason is that previous curriculum choices resulted in limited and/or too low a level of math and science in these students’ courses of study. Other obstacles to overcome include student unawareness of engineering as a possible career because of unfamiliarity with the profession. [1] The natural extension, then, was to focus projects at the middle school level, where timely interventions would lead to enrollment in classes that would better prepare students for the rigors of college STEM studies. Recently, it’s become clear that contact must begin as early as possible for the best intervention outcome; therefore, several groups have begun to target elementary students for outreach. [1] – [3] This workshop is designed to introduce participants to Engineering Teaching Kits (ETKs), an intervention strategy proven to be successful at the middle school level [4] – [6] and now modified for use at the elementary school level.

This workshop covers one approach to K-12 engineering education. There are many other ways to reach out to potential students and attract them to engineering and technology. The K-12 Engineering Education and Outreach Division of ASEE has many papers at the annual conference, and K-12 engineering has been a track at FIE for the past several years.

BACKGROUND ON ETKS

Since 2002, teams of students and faculty at the University of Virginia (U.Va.) have developed, tested, and distributed ETKs for use in middle school science and math classes. [4], [6] An ETK is a set of lesson plans and materials designed to teach math and science concepts in the context of engineering design. ETK activities are structured as challenges that students solve through application of selected concepts to design and build a device, structure, or system that addresses a problem or meets a need. In addition to instructor and peer review, each ETK is reviewed by middle school teachers and graduate students from U.Va.’s Curry School of Education for content and pedagogic effectiveness. The kits are piloted in local middle schools as time permits. Once tested and validated, a kit is available for distribution. [5], [7]

The theoretical bases for ETKs are the pedagogical philosophy of constructivism [8], [9] and the methods of directed inquiry and active learning [10]. Students learn by actively engaging with the relevant concepts and methods through hands-on experimentation and investigation. Lessons are structured to develop understanding of key concepts at both abstract and concrete levels. The content of an ETK is tied to the educational/learning standards for the grade level and school system.

ETKs are also designed to encourage tie-ins with other subjects in the curriculum. For example, an interdisciplinary team of eighth-grade teachers of math,
Session W3B

A summary of key common standards will serve as the context for developing the multidisciplinary ETKs. Each team will report out at the close of this activity.

The instructors will also provide discussion notes and activity materials. Participants will receive a copy of the activities developed in the workshop.

REFERENCES


AUTHOR INFORMATION

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The workshop begins with background on current and previous elementary school outreach initiatives and programs in order to situate the participants on what’s been done and how successful the programs have been. The programs covered include Engineering Is Elementary, the Boston Museum of Science and its National Center for Technological Literacy [13], Children’s Discovery Museums, and the Virginia Museum of Science.

Next, we will review existing national and state standards for science and math instruction in elementary school. In particular, we will discuss the standards proposed by AAAS, NSTA, NCTM, and ITEA; and learning standards with respect to elementary engineering, math, and science education from “best practices” states: California, Massachusetts, New Hampshire, New Jersey, New York, and Texas. We will also have standards from the states of pre-registered participants available for reference.

After a brief introduction to ETKs, workshop participants will work through activities from two ETKs, scaled by age and cognitive developmental milestones: Buoyancy (Archimedes’ Law) and Simple Machines. Participants will observe how the activities are adapted to be age-appropriate for each grade while still presenting a challenge.

Working in teams, participants will brainstorm ideas for multidisciplinary ETKs. Each team will be assigned a different grade and topic. Disciplines to consider include math, science, English, and history. Reference materials, such as standards and representative texts, will be available. A summary of key common standards will serve as the context for developing the multidisciplinary ETKs. Each team will report out at the close of this activity.

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W3B-2