



Using Engineering Design Challenges to Foster Integrative STEM Education

Dr. Larry G. Richards, University of Virginia

Larry G Richards is a Professor in the Department of Mechanical and Aerospace Engineering at the University of Virginia. He leads the Virginia Middle School Engineering Education Initiative, and is active in K 12 outreach and professional development activities locally and nationally. Larry's research interests include creativity, entrepreneurship, engineering design, innovation, and K-12 engineering education. He is a founding member of the K-12 Division and is a Fellow of ASEE.

WORKSHOP PROPOSAL FORM

2015 Annual ASEE K-12 Workshop on Engineering Education
“Authentic Engineering: Representing & Emphasizing the E in STEM”
Presented by Dassault Systems

Saturday, June 13, 2015
8:00 A.M. – 5:00 P.M.
Sheraton Seattle | Seattle | WA

Please complete this form, save it as a PDF file *only* and upload it through the ASEE Paper Management system as shown in the K12 Workshop Presenter’s Kit.

All notifications will be by email from the ASEE Paper Management system.

NOTE: To ensure that emails are not obstructed by spam blockers, please make sure to WHITELIST the email addresses: monolith@asee.org and conferences@asee.org and s.harrington-hurd@asee.org.

Direct questions to Stephanie Harrington-Hurd, ASEE K-12 Activities Manager, at s.harrington-hurd@asee.org. Additional workshop details are available at: <http://www.asee.org/K12Workshop>. Thank you!

Deadline

Friday, January 23, 2015 by 5:00PM EST

Presenters will be notified of acceptance status by March 14.

Late submissions will not be accepted.

Advanced Workshop Registration will open December 6, 2013.

SUBMISSION INFORMATION

Provide the first and last name of each presenter, including affiliations. If there is more than one presenter, designate one person as the organizer and provide only that person’s contact information. The organizer is responsible for communicating to co-presenters.

Number of Presenters: 2

Presenter Name(s):

1) Last Richards First Larry Affiliation University of Virginia

Contact Person’s Name: Larry G. Richards

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Please provide a one-paragraph bio for each presenter (in the order listed above). The bio should not exceed 70 words and should be written as you would want it to appear on the ASEE website and program materials.

- 1) Larry Richards is a Professor in the Department of Mechanical and Aerospace Engineering at the University of Virginia. He leads the Virginia Middle School Engineering Education Initiative, and is active in K 12 outreach and professional development activities locally and nationally. Larry’s research interests include creativity, entrepreneurship, engineering design, innovation, and K-12 engineering education. He is a founding member of the K-12 Division and is a Fellow of ASEE.
- 2) Susan Donohue is a lecturer in the School of Engineering and Applied Science at the University of Virginia. She works with the Virginia Middle School Engineering Education Initiative on developing and disseminating Engineering Teaching Kits, with a focus on P-5 and developing engineering challenge materials for parents and teachers who do not have an engineering background. She was the K-12 and Pre-College Division's Program Chair for ASEE 2013.

WORKSHOP INFORMATION

Proposed Title:

Using Engineering Design Challenges to Foster Integrative STEM Education

Abstract: Please provide a concise description that includes the workshop’s learning objectives (maximum 750 characters). The abstract is used on the ASEE website, program materials, and other K-12 Workshop promotional activities.

We will emphasize the "E" in STEM by demonstrating the inherently integrative nature of engineering design and how that nature promotes learning in science and mathematics while developing man-made artifacts, the core process of technology. By working through design challenges from several popular Engineering Teaching Kits, participants will gain experience with the engineering design process, observe how the design challenges incorporate learning of relevant scientific and mathematics principles, and learn the concepts and tools that will enable them to develop and incorporate engineering design challenges into their own curriculum. These learning objectives will be addressed through team-based design activities. While appropriate for K-12, the focus will be on grades 6 – 8 (middle school).

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Workshop Description. Please provide a detailed description of the proposed workshop that, at minimum, explicitly addresses the following (maximum 4,000 characters):

- a. Learning objectives
- b. Hands-on activities and interactive exercises
- c. Materials that participants can take with them
- d. Practical application for teachers and outreach staff

The primary goal of this workshop is to introduce participants to pedagogies for creating truly integrative STEM curricula for K 12 students through hands-on, participatory exercises and activities based in the engineering design process. The interdisciplinary design activities are based on Engineering Teaching Kits (ETKs), self-contained standards-based units grounded in the constructivist philosophy of education and the principles of guided inquiry and active learning. ETKs were initially developed in conjunction with the Virginia Middle School Engineering Education Initiative (VMSEEI) for students in grades 6 – 8, but have been proven scalable for use by students throughout the pre-K – 12 pipelines. Over 60 ETKs have been developed and used in classrooms throughout the US and abroad.

By the end of the workshop, participants will be introduced to engineering habits of mind, the engineering design process, and the educational promise and strength found in an interdisciplinary approach to STEM subjects; be able to identify methods for integrating engineering design, social science, and humanities into STEM studies; and gain experience in using interdisciplinary design activities to promote the development of creativity, systems thinking, collaboration, and communication. Participants will have the opportunity to work through design activities from *Surf's Up* and *Movers and Shakers* ETKs. The activities include stories from the Northwest Tribes regarding their responses to tsunami and earthquakes, and will address diversity and inclusiveness in engineering education and practice. Participants will design and build structures that can withstand the forces of tsunami and earthquakes.

The instructors will provide discussion notes, appropriate references, and materials. Participants will be registered with the ETK Collaborative web site and *The Engineer's Way* Facebook page to facilitate access to additional materials. They will be able to take home ETK teacher/parent guides for the ETKs used in the workshop.

This workshop will be of interest to faculty and program staff involved in P-12 outreach activities. It will also be of interest to P-12 teachers who use, or would like to use, hands-on engineering design activities in their classroom. The interdisciplinary nature of engineering design, with its emphasis on critical thinking and problem solving, results in an experience that will be appealing to teachers in all fields.

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The workshop is structured as follows:

- **Welcome and Introductions**

A reverse engineering exercise will kick off the workshop, energize participants, and provide an introduction to the engineering habits of mind, especially systems thinking and creativity, targeted in this workshop.

- **ETK introduction and activities**

After a brief introduction to Engineering Teaching Kits, participants will work in groups on several engineering design challenges and activities. Periodically, we will hold status checks incorporating discussions on how the activities can be adapted to various grade levels. This discussion will include a review of expectations as to cognitive development and skill levels for students in those grades. Teams will report out on their experiences at the end of the workshop.

- **Concluding activities and discussions**

Participants will reflect on how these activities and materials can be used in their classes. We will review "engineering habits of mind" and 21st Century skills; how the engineering design process can integrate topics from science, math, history, and communication arts, and engage students via project-based learning.

Standards

Applicable national standards for the selected ETKs appear at the end of this application as per communication with Ms. Hurd. Please note that all of the ETKs are grounded in Virginia's Standards of Learning in math and science; many also match to standards in other states (Massachusetts), national initiatives (i.e., NextGen and Common Core), and national organizations (i.e., ITEEA, NCTM, and NSTA)

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Authentic Engineering Connection. Identify and describe how you will explicitly address the ways in which your lesson or activity is representative of the processes, habits of mind and practices used by engineers, or is demonstrative of work in specific engineering fields. At least one of those must be within the first four listed, below; i.e., do not only check “other”. Check all that apply:

- Use of an engineering design process that has at least one iteration/improvement
- Attention to specific engineering habits of mind
- Attention to engineering practices (as described in the NGSS/Framework and as practiced by engineers)
- Attention to specific engineering careers or fields related to the lesson/activity
- Other (please describe below)

Provide a description of how you will explicitly address these aspects of authentic engineering in your workshop (maximum 2,000 characters):

We will explicitly address the authentic engineering experience in our workshop in the following ways:

Iterative nature of engineering design: we will have at least two design-build-test cycles in the design challenge. Participants will be asked to debrief each other on their experiences, lessons learned, and what they will do during the next cycle.

Specific engineering habits of mind: strategies for the discovery and nurturing of a creative frame of mind that embraces innovation and recognizes both states of natural and manufactured interdependence will be introduced in the design challenges. Participants will also be introduced to pedagogies for nurturing critical "engineering habits of mind" - creativity, systems thinking, collaboration, and communication as well as practice these habits of mind during the workshop.

Attention to engineering practices: Design is the core activity of engineering; William Wulf, former president of the National Academy of Engineering and Professor Emeritus at University of Virginia, characterizes engineering as ‘design under constraints’. Technical learning will be promoted through testing the participants' structures, with an emphasis on the various types of stresses, forces, and loads engineering designers take into account when designing and building a structure.

Attention to specific engineering careers: the design challenges incorporate learning about and exposure to civil, mechanical, and systems engineering and materials science.

Examples of prominent engineers: participants will learn about diverse engineers and their major accomplishments.

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Diversity. This year is the American Society for Engineering Education’s “Year of Action on Diversity.” It is essential that we have a diverse engineering workforce to solve diverse problems. To do that and to have an engineering-literate public, it is essential that we reach *every* preK-12 student with high-quality engineering education, drawing on issues of access and equity in the classroom and in the curriculum. Reviewers would like to know how your proposed workshop will address diversity.

Provide a description of how you will explicitly address diversity – e.g., diversity with respect to gender/sex, ethnicity or race, special education inclusion, socio-economic status, or LGBT status – in your workshop (maximum 2,000 characters):

Since design is not performed in a vacuum and student knowledge and experience often are constraints, it is important to provide sufficient background to provide a non-judgmental comfort zone for students to design. This zone will support design work from students of all ethnic and socio-economic backgrounds. Also important to the development of the comfort zone is the fostering of resilience and creativity among students to help prepare them for the design challenges through carefully structured exercises. The materials provided to build the structures will be very varied so that there will be something that everyone can use. This variety of materials will take into account different motor and spatial abilities.

Our ETKs have been used by students from all ethnic backgrounds. They have been designed to appeal to diverse audiences and have been successfully used in a variety of contexts (public and private schools, regular classrooms during school, after school Boys and Girls club, summer enrichment programs for minority students, and summer camps for students from around Virginia). We have worked with schools covering the range of socioeconomic levels, mixed and single gender schools, ELS classes, and ability levels.

As a unique feature for the workshop in Seattle, we will use stories from the Northwest Tribes that explain tsunamis and earthquakes in easily understandable terms as part of the background introducing the design challenges.

Our examples of significant engineers represent diverse backgrounds, ethnicities, gender and sexual orientation, and mobility status.

Are there any online components to the proposal or presentation? (Note that these online components may only be available to presenters or those who have their wireless subscriptions, since wireless may not be available during the workshop sessions.)

- No
 Yes

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Please describe:

Although we have a website and a Facebook page, all the activities and materials for this workshop will be loaded on our personal computers.

Grade Level Target Audience (check all that apply):

- Primary (EC–2)
- Elementary (3–5)
- Middle School (6-8)
- High School (9-12)

Maximum Number of Participants:

25

If this number is greater than 25, please describe how your workshop will equally engage all participants.

n/a

All Seating is Classroom (tables and chairs).

Audio Visual Equipment Requests:

Note: An LCD projector, screen and podium with attached microphone are provided. Requests for additional equipment or resources (e.g., internet connection or laptops) will incur extra charges. If you do not have additional requests, please indicate with “Not applicable.”

Not applicable

Reminder:

Presenters must register and pay the registration fee to support their workshop attendance and audio/video costs.

Thank you for completing this proposal form!

Please review this document prior to submitting it to ensure that all items are complete.

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Since ETKs cover a wide range of topics, we can provide, in general, a list of standards that are addressed by ETK core and common activities.

Applicable ITEEA Standards are:

1. Students will develop an understanding of the characteristics and scope of technology
2. Students will develop an understanding of the core concepts of technology
4. Students will develop an understanding of the cultural, social, economic, and political effects of technology
5. Students will develop an understanding of the effects of technology on the environment
8. Students will develop an understanding of the attributes of design
9. Students will develop an understanding of engineering design
10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving
11. Students will develop the abilities to apply the design process
13. Students will develop the abilities to assess the impact of products and systems.

The applicability of ITEEA standards 14 - 20 depends on the ETK topic.

Applicable NCTM Standards are:

Geometry (use visualization, spatial reasoning, and geometric modeling to solve problems)

Measurement (understand measurable attributes of objects and the units, systems, and processes of measurements; apply appropriate techniques, tools, and formulas to determine measurements)

Process/Problem Solving (build new mathematical knowledge through problem solving; solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems; and monitor and reflect on the process of mathematical problem solving).

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Applicable Next Generation Science Standards:

Engineering Design (3 - 5 and Middle School)

- 3-5-ETS1-1.** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.