



Reinforcing K-12 Math Education through Engineering Applications

Dr. Cristian Gaedicke, California State University, East Bay

Dr. Cristian Gaedicke earned the Ph.D. in civil engineering from the University of Illinois at Urbana-Champaign in 2009 and is a licensed professional engineer (Civil). His research interests include connecting STEM education to engineering practice, sustainable construction materials, infrastructure, and construction engineering. Dr. Gaedicke has participated in engineering education projects sponsored by the NSF and Chevron and has served as co-PI on projects with MESA and Project Lead the Way.

Dr. Saeid Motavalli, California State University, East Bay

Dr. Saeid Motavalli completed the Ph.D. in industrial engineering from the University of Pittsburgh. Dr. Motavalli has spent the past ten years as the founding Department Chair/Graduate Coordinator of the Department of Engineering at California State University, East Bay. He has authored or co-authored about fifty journal and conference proceeding publications and served as PI or co-PI of several federal, state, and industry grants totaling more than \$2

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 K-12 Workshop Presenter’s Kit.

All notifications will be by e-mail from the ASEE Paper Management System.

NOTE: To ensure that e-mails are not obstructed by spam blockers, please make sure to WHITELIST the e-mail addresses monolith@asee.org, 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, 2014.

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 with co-presenters.

Number of Presenters: 2

Presenter Name(s):

- 1) Last Gaedicke First Cristian Affiliation California State University, East Bay
- 2) Last Motavalli First Saeid Affiliation California State University, East Bay

Contact Person’s Name: Cristian Gaedicke

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Contact Person’s Phone: 217-417-5039

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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.

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WORKSHOP INFORMATION

Proposed Title:

Reinforcing K-12 Math Education through Engineering Applications

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.

This session will present three engineering case studies that use math and science concepts applied to civil, electrical, and industrial engineering designs. Teaching math as an abstract subject has been the main turn-off for students in K-12, as they do not fully realize why they are learning math equations and relationships. The learning objective of this session is to present practical cases that enhance students' learning of algebra concepts through practical applications in engineering. Projects comprise a combination of design theory and hands-on implementation.

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

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The objective of the proposed workshop is to facilitate the teaching of math concepts through engineering applications. Teachers will use case studies that describe how an algebra concept is applied to electrical, civil, and industrial engineering. Each case study will include a hands-on activity, which will promote student engagement and active learning of the math concept through engineering experimentation.

The following case studies and activities are proposed:

a) Electrical Engineering

Students will use *fractions and rational expressions* to calculate electric circuits’ resistance and power consumption and will build series and parallel electrical circuits. The lesson will ask students to imagine that they are an electrical engineer in charge of designing the lighting for the San Francisco Christmas tree at Union Square.

The lesson will include an introduction to parallel and series circuits, where fractions will be used to calculate the overall resistance of the system.

Hands-on-Activity

Students will then create a series and parallel circuit using LEDs, batteries, and a bread-board.

b) Civil Engineering

Students will use *equations* to calculate the moment on a cantilever bridge and will design a bridge using straws and tape. Students will learn about different types of bridges and will experience some of the challenges that civil and structural engineers face when designing and building a bridge. The description of the hands-on activity is included below:

Hands-on Activity

In this activity you will explore how to design a cantilever bridge using straws and experience how the weight of construction equipment during construction can be a factor in bridge design.

You will need:

- *Straws*
- *Tape*
- *Scissors*
- *Rocks*
- *A cup*
- *A ruler*

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You will:

Using the straws, scissors, and tape, build a cantilever bridge off the edge of your desk. Recall that a cantilever bridge “hangs” off one fixed support. Now place the cup at the edge of the bridge and measure with the ruler how much the bridge deflects downward from the horizontal. Repeat the measurements as you add one rock at a time to the cup until the bridge fails. Explain what you think went wrong.

c) Industrial Engineering

Students will analyze *linear graphs* and write *linear equations* to predict the time that is necessary to improve the design of a paper aircraft as they repeat the process. Students will learn about the principles of time studies, learning curves, and work measurement and apply it to a hands-on activity in which they will need to make paper airplanes. Each student will be timed on how long it takes to build a paper airplane in repeated trails. Then, students will plot their learning curves (task time vs. trials graph) and qualitatively and quantitatively analyze them. Students will primarily use their knowledge of linear functions and average rate of change to quantitatively analyze their results. Students will figure out if the time to build a paper airplane decreases as the number of trials increases.

The hands-on activity will comprise groups of 2-3 students that will complete the following steps:

1. **Review the assembly rules.** Each team member will complete 10 trials. Note that the number of trials can be changed to a minimum of 7 trials.
2. **Record the team’s results.**
3. **Plot the task times.**
4. **Analyze the graph.** Here, students’ graphs should most likely be decreasing.
5. **Discuss.** Students will reflect on their results and brainstorm on how to improve the paper-folding task to be more efficient.

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The materials for each team are:

- 50 sheets of 8.5” x 11” paper
- An electronic stopwatch
- The instructions may be downloaded from <http://www.funpaperairplanes.com/>.
 - Students can decide which design to use depending on how much time they have for the activity and how many students are participating. The “Arrow,” “Delta,” and “Condor” designs are suggested.
 - Students should only print the instructions, not the templates.
 - Students may use another airplane design from another source if they wish as long as everyone in the class uses the same design.
- Suggested materials: pencils, tape, scissors, and rulers.

Participants will be allowed to take the devices that they create (circuits, straw bridge, and planes) during the workshop with them. This will facilitate the implementation of these activities with students in their school district.

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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.¹ 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):

All proposed case studies in the workshop use experimentation and the engineering design process to develop a product. In particular, the industrial engineering case study fully focuses on the improvement of an engineering design (e.g., paper airplane) and measurement of the learning curve.

The case studies place special emphasis on engineering habits of mind such as creativity (create different devices), collaboration (work in teams), and communication (present findings to the class). The ethical implications of engineering decisions are discussed when testing the straw and tape bridges.

The proposed workshop explicitly includes cases of three different engineering disciplines to facilitate discussion about the different career paths that engineering can offer.

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 that end, 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):

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The proposed curriculum originated as part of a project for the Math, Engineering, and Science Achievement Program (MESA). MESA targets school districts that have predominantly students of minority and economically disadvantaged groups.

The case studies will emphasize the importance of diversity and how the engineering offers great opportunities for a diverse population. We will discuss engineering work, which typically involves teams of engineers from diverse backgrounds and countries working on a product design. We will place special emphasis on the contributions of women and engineers from underrepresented groups to the engineering profession. We will also discuss the fact that in engineering diversity is a plus.

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

Please describe:

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:

24

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

All Seating is Classroom (tables and chairs).

Audio Visual Equipment Requests:

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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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Date Received:

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