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Engineering Design: A Water Wheel Challenge for 3-8 Educators

Dr. Adam Kirn, University of Nevada, Reno
Prof. David T Crowther, University of Nevada, Reno
Dr. Melissa Ann Jurkiewicz, University of Nevada

Melissa Jurkiewicz is an Assistant Professor of Secondary Science Education at UNR. Her research focuses on teachers' formative assessment practices in a variety of contexts within science classrooms. Her education includes a B.S. in Biology and a M.A.T. in secondary science education from the University of South Carolina and a Ph.D. in Science Education from the University of Georgia.

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.

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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: 3

Presenter Name(s):

1) Last Kirn First Adam Affiliation University of Nevada, Reno (UNR)

2) Last Jurkiewicz First Melissa Affiliation University of Nevada, Reno

3) Last Crowther First David Affiliation University of Nevada, Reno

Contact Person's Name: Adam Kirn

Contact Person's Email: akirn@unr.edu

Contact Person's Phone: 775-682-7567

Contact Person's Alternate Phone: 864-508-1644

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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1) Adam Kirn is an Assistant Professor of Engineering Education at UNR. His research focuses on the interactions between engineering cultures, student motivation, and learning experiences. His projects involve studying student perceptions, beliefs and attitudes towards becoming engineers, problem solving processes, and cultural fit. His education includes a B.S. in Biomedical Engineering from Rose-Hulman Institute of Technology, a M.S. in Bioengineering and Ph.D. in Engineering and Science Education from Clemson University.

2) Melissa Jurkiewicz is an Assistant Professor of Secondary Science Education at UNR. Her research focuses on teachers' formative assessment practices in a variety of contexts within science classrooms. Her education includes a B.S. in Biology and a M.A.T. in secondary science education from the University of South Carolina and a Ph.D. in Science Education from the University of Georgia.

3) David Crowther is the Executive Director for the Raggio Research Center for STEM Education and Professor of Science Education at UNR. Dr. Crowther has research interests in STEM Education, Inquiry based teaching / learning, and using science for English Language Learners to develop academic language. Dr Crowther has a B.S. and MEd in Education from Brigham Young University and a PhD in Science Education from the University of Nebraska-Lincoln.

WORKSHOP INFORMATION

Proposed Title:

Engineering Design: A Water Wheel Challenge for 3-8 Educators

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 otherK-12 Workshop promotional activities.

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Participants of this workshop will identify myths related to who can be an engineer and who can teach about engineering. Then, participants will engage in an interactive lesson that can be implemented in a 3-8 setting. The interactive lesson will engage participants in the engineering design process in order to solve a design challenge. The participants will explore potential and kinetic energy while working in a team to design and build an interactive water wheel that lifts the most weight.

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

This workshop will engage science and engineering educators with an integrated STEM lesson that will support the development of science and mathematics content using the Engineering Design Process (EDP) and related Science and Engineering practices for elementary and middle school students.

This workshop has two learning objectives:

- Participants will examine data in order to dispel myths related to the field of engineering.
- Participants will be exposed to an effective 3-8 grade lesson on engineering design through engaging in the Water Wheel Challenge.

The presentation team will begin by facilitating a group discussion aimed at identifying persistent myths about who can be an engineer and/or implement engineering lessons. This activity is described in detail in the diversity section below.

Then, the Water Wheel Challenge lesson will be modeled for the participants. The lesson has three learning objectives for elementary and middle school students:

- Students will explore the conversion of potential to kinetic energy.
- Students will design and build an interactive water wheel that will lift weight.
- Students will engage in the engineering design process to solve the design challenge.

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During the lesson, the presentation team will begin by discussing the Engineering Design Process as applicable to this challenge. The participants will also learn about the history, use, and function of water wheels. Then, they will work in teams to brainstorm, design, and build a water wheel that is capable of lifting the most weight when rice is poured across the water wheel and keep to a materials budget as outlined in the challenge. Metal washers will be used as weights. They will be instructed to draw both their initial design concept and their final construction, as well as any and all modifications throughout the design process. A tarp will be spread across the floor and rice will be used instead of water in order to prevent making a mess. They will utilize various inexpensive household items including paper plates, paper cups, drinking straws, plastic spoons, string, and masking tape. Once the groups have completed their water wheels, they will be tested and the amount of weight that each wheel can lift will be measured on a scale. The participants will examine the science behind the water wheel and in particular, focus on potential and kinetic energy and will participate in general mathematics for a project budget and graphing success of weight lifted per iteration. Lastly, the teams will revise their water wheel designs. The teams will test their water wheels one final time and attempt to lift more weight than before. The presentation team will conclude the water wheel activity with a discussion of potential variations to the lesson. For example, a teacher could attach nominal costs to each material and require each team to build a water wheel within a specific budget.

The participants will receive a hard copy of the water wheel lesson plan aligned to the Next Generation Science Standards and participants will be able to keep their own water wheel design.

The practical application for teachers and outreach staff is that they will learn to implement engineering design in the classroom using effective science teaching pedagogies that align with the Next Generation Science Standards. In addition, the workshop will provide teachers with a means to foster the development of problem solving and critical thinking skills while meeting other state standards related to kinetic and potential energy.

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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.[i] 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):

The initial design and construction of the water wheel is geared toward construction of an object that will lift the most weight. This initial foray through process will be guided by the presentation team. After this initial design participants will be asked to improve on the efficiency of their water wheel in a less guided manner such that teachers develop self-confidence and ownership of the engineering design process. Once teams have reached a point where they are satisfied with their designs the presentation team has five variations on this lesson that may be implemented, if time allows, for another revision of the product given new information. These variations include creating a cost for materials and having participants purchase their materials; having participants design the most inexpensive water wheel that lifts the most weight; having

participants design a water wheel for under a set amount that lifts the most; giving all teams the same materials and all students to buy or trade/barter maters from/with other teams; and giving some teams bags with missing materials, other teams receive bags with extra materials, and teams must trade or purchase materials from other teams in order to build a water wheel.

This work will address explicitly address the following two standards from the NGSS:

Engineering Design (Grades 3-5)
- ETS1-1. Define a simple design problem reflecting a need or want that includes specific criteria for success and constraints on materials, time, and cost.

Engineering Design (Middle School)
- 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.

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):

To address diversity in engineering, the research team will leverage the funded NSF projects related to students with non-normative identities in the cultures of engineering. This work

focuses on how students who do not fall within in the dominant cultures of engineering navigate these cultures and either succeed or decide to leave. The team has previously asked pre-service and in-service about their perceptions of engineering, and used these perceptions as a means to guide conversation aimed at busting persistent myths in engineering (e.g. women need more math and science skills to succeed, all engineering requires a physical build, and there are groups of individuals that will not be successful in engineering). This same model will be followed for this workshop during the initial introductory period. The conversations will pull in the results of research from this team as well as the established body of literature related to diverse groups pursuit of engineering degrees.

The water wheel project also fosters diversity through the inclusion of educational groups who often feel excluded from due to perceptions of high cost. This project was intentionally designed to rely on a limited number of resources that are all lost cost. The materials used in this project require no special classroom setups or infrastructure improvements. The use of low cost materials opens up low socioeconomic status schools and provides and avenue for students of limited means to explore engineering and engineering concepts. During the completion of the water wheel project the presentation team will take time to address issues in teaming related to gender and minority status of students and provide instructors with tools that can be used to combat students taking or being forced into stereotypical roles.

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:

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:

20

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

All Seating is Classroom (tables and chairs).

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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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