Teaching Sound in Elementary, Middle and High School Physical Science Using Engineering Design

Dr. Laura Bottomley, North Carolina State University

Dr. Laura Bottomley, Teaching Associate Professor of Electrical Engineering and Elementary Education, is also the Director of Women in Engineering and The Engineering Place at NC State University. She has been working in the field of engineering education for over 20 years. She is dedicated to conveying the joint messages that engineering is a set of fields that can use all types of minds and every person needs to be literate in engineering and technology. She is an ASEE Fellow.

Ms. Elizabeth A Parry, North Carolina State University

Elizabeth (Liz) Parry

Elizabeth Parry is an engineer and consultant in K-12 Integrated STEM through Engineering Curriculum, Coaching and Professional Development and a Coordinator and Instructor of Introduction to Engineering at the College of Engineering at North Carolina State University. For the past sixteen years, she has worked extensively with students from kindergarten to graduate school, parents, preservice and in- service teachers to both educate and excite them about engineering. As the Co-PI and project director of a National Science Foundation GK-12 grant, Parry developed a highly effective tiered mentoring model for graduate and undergraduate engineering and education teams as well as a popular Family STEM event offering for both elementary and middle school communities.

Parry is currently a co-Pi on two NSF DR-K12 Projects: the Exploring the Efficacy of Elementary Engineering Project led by the Museum of Science Boston studying the efficacy of two elementary curricular programs and Engineering For All, a middle school project led by Hofstra University. Other current projects include providing comprehensive professional development, coaching, culture change and program consulting for multiple K-8 integrated STEM schools across the country, serving as a regional Professional Development for the Museum of Science, Boston's Engineering is Elementary curriculum program; and participating in the Family Engineering project.

In June, 2014, Liz was appointed by the Board of Directors of the American Society for Engineering Education (ASEE) to chair a new committee on K-12 Engineering. She is the Immediate Past Chair of the ASEE K-12 and Precollege Division; serves as the Vice President of the executive board of the Triangle Coalition for STEM Education, is a board member of the STEM Consortium and is a member of the K-12 Advisory Committee for the American Society of Mechanical Engineering. The past three years, Liz has been named a member of the USA Science and Engineering Festival's "Nifty Fifty" program, a select group of notable scientists and engineers invited to give keynote presentations in advance of the festival. She has authored or co-authored over 35 papers on issues relating to K-20 integrated STEM, including "Perspectives on Failure in the Classroom by Elementary Teachers New to Teaching Engineering," (co-author with Dr. Pamela Lottero-Perdue of Towson University) which was awarded best Division (K-12 and Precollege), Best PIC (IV) and Best Overall Conference paper for ASEE in 2014. Liz is a frequent invited keynote speaker both nationally and internationally. Prior to joining NCSU, Liz worked in engineering and management positions at IBM Corporation for ten years and co-owned an informal science education business.

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) Bottomley Laura Affiliation NC State University

2) Parry Elizabeth Affiliation NC State University

Contact Person's Name: Laura Bottomley

Contact Person's Email: laurab@ncsu.edu

Contact Person's Phone: 919-515-3263

Contact Person's Alternate Phone: 919-349-8510

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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) Dr. Laura Bottomley, Teaching Associate Professor of Electrical Engineering and Elementary Education, is also the Director of Women in Engineering and The Engineering Place at NC State University. She has been working in the field of engineering education for over 20 years. She is dedicated to conveying the joint messages that engineering is a set of fields that can use all types of minds and every person needs to be literate in engineering and technology. She is an ASEE Fellow.

2) Elizabeth Parry is an expert in engineering education, especially elementary, having transitioned from an industry job at IBM over 20 years ago. She is a partner for the Engineering is Elementary Curriculum from the Museum of Science, Boston. She is well known for coaching schools as they transform themselves to engineering magnets or as they use engineering as a vehicle for teaching the curriculum. Liz is the chairperson of an ASEE Board Committee looking at making strategic plans for ASEE's involvement in K-12 Engineering.

WORKSHOP INFORMATION

Proposed Title:

Teaching Sound in Elementary, Middle and High School Physical Science

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.

This workshop uses an engineering design challenge to teach about the aspects of sound, including its wave nature, how it transfers energy, how it has frequency and intensity and how humans make use of the nature of sound for our own interests. Participants are challenged to build a device that will reduce the volume of a Bluetooth speaker without distorting its sound. The workshop makes use of IPad apps and a decibel meter to measure sound intensity and frequency spread.

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

The workshop learning objectives include teaching participants how to use a deeply integrated STEM activity to teach the learning standards outlined below. Participants

will also learn classroom management techniques for use in an open-ended design challenge with students from grades K-12. The workshop will be differentiated appropriately and customized to those in attendance. Participants will also learn how to use the activity with both hearing and hearing impaired students to teach the same standards.

b. Hands-on activities and interactive exercises:
The workshop will include multiple hands-on activities. Participants will construct a resonance chamber and use it to learn about the wave nature of sound and how sound waves change frequency and intensity. The main design challenge will ask participants to use the engineering design process to solve the problem of reducing the sound coming out of a Bluetooth speaker playing music for a classroom activity. They will be challenged to use what they have already learned about sound in the resonance chamber activity to reduce the sound volume without distorting the music.

c. Materials that participants can take with them:
Participants will receive the activity write-up (attached to this proposal), materials list and suggestions and several writings about classroom management and pedagogy for encouraging deep learning in STEM activities implemented as engineering design challenges.

d. Practical application for teachers and outreach staff
The activity fits equally well inside and outside of the classroom. The activity itself has practical applicability, as the scenario is very engaging to students of all ages. Careful choice of the music played can make it quite fun!

Related standards:

NGSS:
Grade K-2 Physical Science: Sound can make matter vibrate, and vibrating matter can make sound.
Grade 6-8 Physical Science: A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena including sound and light. Waves can transmit energy.
Grade 9-12 Physical Science: The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. Waves can be used to transmit information and energy.

Grade K-2 Engineering:
K-2- Ask questions, make observations, and gather information about a situation people

ETS1-1. want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Grade 3-5 Engineering:

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.

Grade 6-8 Engineering:

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.

Grade 9-12 Engineering:

HS-ETS1A. Defining and delimiting engineering problems

HS-ETS1B. Developing possible solutions

HS-ETS1C. Optimizing the design solution

CCSS Mathematics

Grades K-5: Represent and interpret data.

Grades 6-12 Mathematical Practices:

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- Model with mathematics.
- Use appropriate tools strategically.

- Attend to precision.

Standards for Technological Literacy
Grades K-12 Design:

- Students will develop an understanding of the attributes of design.
- Students will develop an understanding of engineering design.
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

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 workshop requires the use of the EDP to solve the problem given. The participants define the problem, brainstorm solutions, build models to solve those solutions, test the models, take data, analyze the data and iterate until they have a solution that they bring to the final test and analysis stage. Each of the habits of mind (as defined by the NAE) is discussed in the course of the workshop as the facilitators highlight as the participants apply them: optimism in persisting, systems thinking in combining many materials that each have different effects on the sound, ethics as they share materials, communication as they pitch their solutions, collaboration as they work on a team to develop a solution to the problem, and creativity as they use materials that they have likely never used for the purpose at hand before. The engineering practices are all used, as outlined in the links to standards above. Finally, the facilitators will outline the connections to electrical engineering, materials engineering and mechanical engineering.

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):

The activity has been specifically designed to appeal to students of any gender equally, due to the topic of the problem. During the workshop, the facilitators will outline teaching methods to ensure that both boys and girls participate equally.

One unique aspect of this workshop on sound is the way in which it has been designed to appeal to both hearing and hearing impaired students. At each stage of the workshop, the sound is made visible. For younger (and even older) students, the resonance chambers illustrate the way that sound vibrations change with pitch and intensity. The use of the IPad Visible Sound App shows how energy is distributed among different frequencies and literally makes the sound visible to each student.

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):
The activity has been done with students in each of the grade bands.
☒ 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.

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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."*

N/A

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.

ASEE USE ONLY

Date Received:

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