Engineering Solutions to Storm Water Problems Through Community Participation

Dr. Mohamad Musavi, University of Maine

Mohamad Musavi is the Associate Dean of the College of Engineering at the University of Maine. Previously, he was the Chair and a Professor of the Electrical and Computer Engineering Department. He is the Principal Investigator of a NSF-EPSCoR award to engage secondary school students and teachers, especially female and minority students, in innovative engineering solutions to storm water. He has been working with Maine high schools in the developing and establishing STEM academies.

Mr. Cary Edward James, Bangor High School

Mr. Cary James has a BS in chemistry and an MS in Plant Pathology. He has received numerous teaching awards including the Siemens Award for Advanced Placement Teacher of the Year for Maine 2009, Pulp and Paper Foundation Maine Teacher Award 2009, New England Institute of Chemistry Maine State Teacher Award 2011, New England Water Environmental Association Public Educator Award 2013, and has received the Francis Crowe Society Honorary Engineering Degree from the University of Maine 2010. Recently he presented a lecture on High School Students as Water Researchers at the Climate Change and the Future of Water Conference in Abu Dhabi. His students have excelled in many national and international level science competitions including the 2010 National Stockholm Junior Water Prize (SJWP) winner and the 2011 Bjorn von Euler Innovation in Water Scholarship winner. Both students represented the United States at the International SJWP in Stockholm Sweden. Mr. James has a passion for improving the quality of water for people in developing countries and has focused student research on water sanitation and conservation. In the classroom he works to differentiate instruction for students using an evidenced based inquiry approach.

Prof. Ali Abedi, University of Maine

Ali Abedi is Associate Professor of Electrical and Computer Engineering at UMaine. His research includes performance evaluation of channel codes and wireless sensing for aerospace and biomedical applications. Dr. Abedi has several years of industry experience before entering Academia, working as telecom consultant and project manager at TEC and ISC Corporations. He is Co-founder of two startup companies, and author/Co-author of over 80 publications including 4 books and 2 patents.

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: 3

Presenter Name(s):

1) Last Musavi First Mohamad Affiliation University of Maine, Associate Dean, College of Engineering

2) Last Abedi First Ali Affiliation University of Maine, Associate Professor of Electrical and Computer Engineering

3) Last James First Cary Affiliation Bangor High School, Director of Science Department

Contact Person's Name: Mohamad Musavi

Contact Person's Email: musavi@maine.edu

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

Contact Person's Phone: 207-581-2218

Contact Person's Alternate Phone: 207-659-4470

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) Mohamad Musavi is the Associate Dean of the College of Engineering at the University of Maine. Previously, he was the Chair and a Professor of Electrical and Computer Engineering Department. He is the Principal Investigator of a NSF-EPSCoR award to engage secondary school students and teachers, especially female and minority students, in innovative engineering solutions to storm water. He is working with Maine high schools in the implementation of STEM academies.
2) Cary James is the STEM Director at Bangor High School in Bangor, Maine. He is interested in improving the quality of water for people in developing countries and has focused student research on water sanitation and conservation. His students have excelled in many national and international level competitions including the 2010 National Stockholm Junior Water Prize (SJWP) winner and the 2011 Bjorn von Euler Innovation in Water Scholarship winner
3) Ali Abedi is Associate Professor of Electrical and Computer Engineering at UMaine. His research includes performance evaluation of channel codes and wireless sensing for aerospace and biomedical applications. Dr. Abedi has several years of industry experience before entering Academia, working as telecom consultant and project manager at TEC and ISC Corporations. He is Co-founder of two startup companies, and author/Co-author of over 80 publications including 4 books and 2 patents.

WORKSHOP INFORMATION

Proposed Title:

Engineering Solutions to Storm Water Problems Through Community Participation

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.

The objective of this workshop is to introduce teachers and engineers to a learning model that empowers high school students, especially female and minorities, to create innovative solutions to a pervasive environmental problem: storm water. This model is based on the implementation of a NSF-EPSCoR funded project by the University of Maine faculty and teachers and students in several Maine high schools. The learning model actively engages students with STEM professionals in an inquiry and project based instructional environment. Using the latest sensor technology for data collection and computer

modeling for data analysis, students will address the widespread problem of storm water management. Students will monitor and map water quality around their communities and investigate innovative solutions to local storm water issues. Storm water runoff is a pressing and expensive problem, and the model presented in this workshop will have nation-wide applicability and appeal.

The workshop presents the participants with the instructions and activities for engaging students in science and engineering of storm water and integration on these activities in high school curriculum based on the recommendation of the *Framework* and *Next Generation Science Standards* (NGSS). These include: (1) Stationary water quality wireless sensor network units with microprocessor boards, (2) Students acting as *Live Sensors* in their communities, collecting real-time data via probes and sampling, (3) Learn to manage and use storm water data through lab analysis, dynamic online mapping and modeling tools, and direct involvement with staff at their respective water districts, (4) Investigating solutions to storm water problems, and (5) Participating in public outreach activities.

This highly hands-on learning model involves numerous STEM areas, including: engineering design, science, computer modeling, and information technology; therefore, satisfying many NGSS requirements, especially those related to the "science and engineering practices" core value. With its focus on investigating and improving water quality, this model will attract a diversity of individuals and community entities, including females, Native Americans, African Americans and rural high school students and teachers. In addition to attracting female and minorities to STEM education, the significant role of storm water in health of our environment and economy is a strong motivation for government, non-profit and for-profit organizations to support this learning model in their communities and assist in the sustainability of the project.

Important learning outcomes of this learning model would include: (1) advancing the knowledge of a diversity of students and teachers in STEM through a novel educational and technological strategy; (2) new watershed maps and management plans for numerous impaired streams leading to improved water quality; and (3) transfer of new student and teacher knowledge to middle schools and the public via student-created outreach programs.

Intellectual Merit: By offering a highly active and transformational educational experience to both teachers and students, this learning model will expand understanding of our environment and how to most effectively address critical problems using engineering and science solutions. Engaging a highly diverse group of participants will increase our understanding of effective community inclusive learning methods.

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

I. Learning Objectives

The overall goal of this workshop is to share the successful implementation of a project based educational model for engaging female and minority students, and diverse community groups in engineering and sciences and enable them to implement the model in their schools and communities. The educational objectives of this learning model are to enable high school teacher to:

1. Provide project based educational opportunities using emerging engineering technologies for students in high schools.
2. Promote interest in STEM education and careers for females and minorities.
3. Increase awareness and knowledge of the problem of storm water, and find solutions by connecting and empowering diverse community entities.
4. Improve enrollment and retention, especially female and minority, in post-secondary education in STEM fields.

II. Hands-on activities and interactive exercises

A. Overview of Storm Water Project Based Educational Model

This workshop presents the teachers and engineers with a STEM (Science, Technology, Engineering, Mathematics) experience for implementation in high schools. This experience involves creating a project based model to engage high school students, especially underrepresented and underserved students in science and engineering with a diverse and dynamic set of community entities that include higher education, secondary education, parents and caregivers, government, non-profits, and companies in an area of national importance.

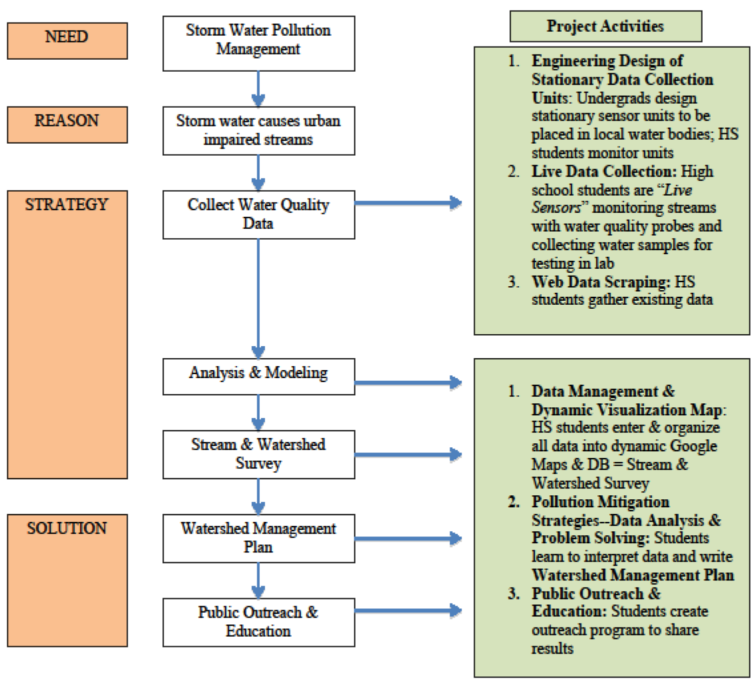

Figure1. Program Strategy

Figure 1 is an outline of the strategy for the implementation of this model. The middle column blocks show some of the components for addressing the storm water problem including deployment of sensors for water quality data collection, data analysis and modeling, developing dynamic watershed visualization map, the design of pollution mitigation strategies and a public outreach program. The right-hand column blocks provide the activities that the teachers and engineers can create for students to participate in engineering and science practices.

The following sections provide a brief description of these activities. For each section, appropriate materials, and where appropriate demonstration tools and equipment, will be provided. Teachers and engineers who are interested in implementing this learning model in their high school have the opportunity to collaborate and further learn from the presenting team and in follow up communications and meetings.

B. Sensor Network for Data collection (Module 1)

1. Engineering Design of Stationary Data Collection Units

With the guidance of the University of Maine faculty from the Laboratory for Surface Science and Technology (LASST) and the Senator George J. Mitchell Center for Environmental and Watershed Research, graduate and undergraduate students have designed, built, and tested stationary sensor units (Figure 2) to be placed in local community waterways based on the recommendation of local water districts. After data processing using on board micro controllers, the data will wirelessly be transmitted to a base node that is connected to the internet. For added reliability in case of wireless link failure, on board storage using SD (secure digital) is available on the units. The power for these units will be provided through Lithium-Polymer high capacity rechargeable batteries with solar chargers to assure long term data collection capability. Battery life time of these units varies depending on how often the data is sampled and transmitted. Low cost Arduino boards have been used for building these units. The wireless network topology is mesh or tandem, depending on the sampling locations and their relative distances. IEEE 802.15.4 low rate wireless PAN (personal area network) with ZigBee protocol stack has been used for the networking of these units. The closest node to a WiFi access point will serve as a gateway to transfer network data to a data base using ZigBee to WiFi Bridge. With training, teachers/students can program the units for various sampling rates and transmission strategies. Figure 3 shows a section of the Penjajawoc

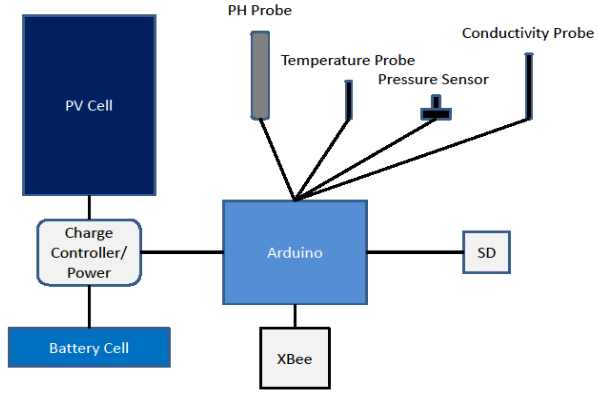

Figure 2. Stationary Sensor Unit

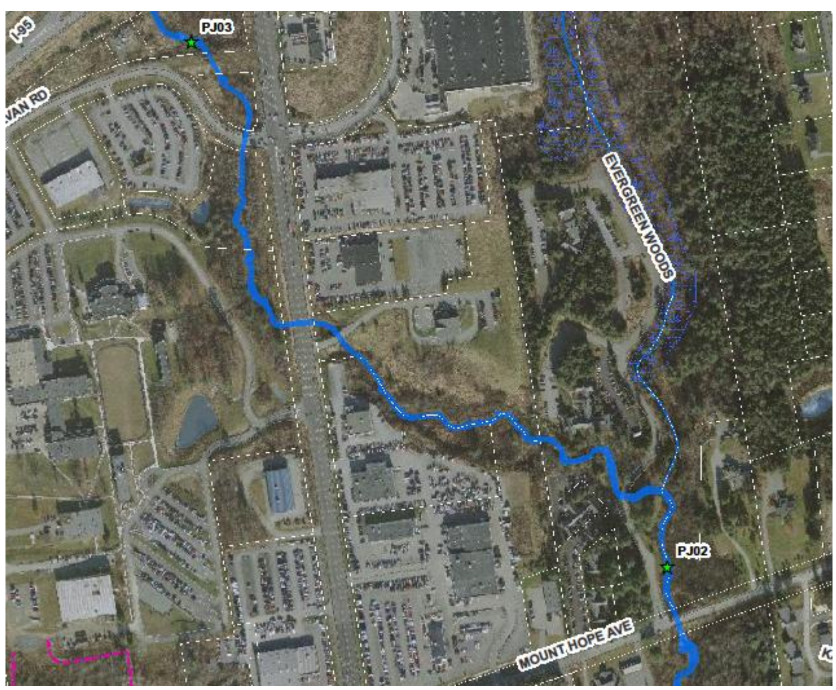

Figure 3. A section of a watershed in City of Bangor, Maine.

stream that goes through forested, residential, and industrial area in the City of Bangor, Maine. The locations for data collection (PJ02 and PJ03) have been recommended by the community water district.

In the ASEE workshop, the participating teachers and engineers will be trained on how to work with the wireless units and how to engage their students in collecting watershed data from watershed. Several data collecting units will be brought to the workshop for participants' inspection and learning materials will be distributed. Through a collaborative agreement, teachers and engineers can acquire these units from the University of Maine.

2. Live Data Collection

Other important watershed data that are not measurable through the stationary wireless units will be collected by students who participate as "Live Sensors," as part of their STEM education. The data includes, but not limited to: turbidity, nitrate, chloride, ortho and total phosphorous, total organic carbon, dissolved oxygen (DO), oxygen reduction potential (ORP), biological oxygen demand (BOD), total suspended solids (TSS), Nitrate and ammonium, and Colilert. Most of the variables listed can be measured by commercially available water quality sensors purchased for schools and used by students. However, phosphorous, arguably the most important variable, Carbon, TSS, and Colilert will be measured in the school laboratories. Water sample will be collected from the locations where the stationary sensors are located and brought to the schools for measurement by students. For these task, laboratory equipments and test kits, such as spectrophotometers and colilert tests, should be acquired by the participating schools.

In the ASEE workshop, the participating teachers and engineers will be introduced to equipment, materials, and processes for collecting some of the aforementioned data.

C. Data Analysis and Modeling (module 2)

The purpose of the data analysis and modeling is to build on rudiments of quality assurance, assessment of method accuracy, statistical characterization of data, and use of data in hypothesis testing. The fundamental concepts of measurement trueness and repeatability are needed to establish the reliability and utility of field and laboratory observations. Watershed data produced by students for utilization in hydrology and water quality analysis will not be trusted if not produced within a rigorous quality-control framework [1,2]. Students will learn to correlate, interpolate, and predict time series from incomplete and spotty data [3,4,5], develop watershed management plans and present their findings.

Important outcomes of students and teachers efforts will be to map out changes in hydrological conditions and water quality as they vary by location and over time. The master variable is hydrology and how it is altered by storm flow. Participants will use classical hydrology methods to construct storm hydrographs and derive time of concentration. These will be correlated with water chemistry to produce a time series record of concentration that can be translated to flux and mass transport. At the spatial scale of a sub-watershed in an urbanized area, the methodological framework will seek to understand how environmental flows contribute to degraded water quality [6,7,8]. Hydrologic variability and interactions within the natural and engineered components alter biogeochemical fluxes [9] and ecological integrity [10, 11] all of which are affected by storm water conveyances. Advanced students will expand the analysis of hydrologic connectivity by using: 1) landscape analysis; 2) historical water quality data; 3) observational data (precipitation, stage, freshwater discharge); 4) lumped parameter hydrologic modeling; 5) water resource indexing; and 6) statistical models of associations (e.g. nonparametric functional estimation, multiple-regression modeling, and covariance structure analysis). In terms of utility for management of storm water, hydrologic connectivity is important on different hierarchical levels using existing spatial and new field data to relate sources and discharges within drainage networks of study watersheds [12,13]. It would be worthwhile to use the data to model the flux of storm water into receiving waters using lumped-parameter simulations that allow examination and comparison of watershed outflow signatures. Model selection will be based on available data and watershed conditions [14,15,16] to achieve statistically representative flow time-series that account for the cumulative effects of precipitation, interception, evaporation, near-surface groundwater interactions, and routing. A potential output would be water resource indices linked to water pollution events in the receiving waters [17,18].

Each step of the process from establishing measurement points, to data collection, hydrologic analysis, and modeling allow students to conduct hypothesis-testing experiments. Students will be encourage to delve deeply into the components of the process and to work as a team to integrate their knowledge into solving the broad storm water management problems.

D. Data Management and Dynamic Visualization Map (module 3)

Participating students enter and organize data into dynamic Google Maps & Database to create a visualization map for stream and watershed management. The process includes adding sensor data from various sources into Spreadsheet Mapper from GoogleEarth Outreach program, followed by uploading and publishing data on Google Map. High School students will follow tutorials on http://www.google.com/earth/outreach/tutorials/spreadsheet.html. The data will be from wireless stationary units, results of chemical analysis of water samples, and outcomes of analysis and modeling.

E. Pollution Mitigation Strategies (module 4)

The watershed management plan lays out the findings and concerns; the areas in the watershed to prioritize; the best management practices (BMPs) and structural best management practices, such as installing green infrastructure or diverting swales or catch basin inserts, which then assist in mitigating pollution. Higher education faculty and water district engineers will offer presentations detailing the trade-offs between infrastructure/design options, and engineering decisions based on a systematic consideration of multiple, often competing, criteria. Through guidance from faculty and water professionals, high school students will become aware of hazard mitigation strategies and will develop and present their ideas and designs to their classmates, middle school students, and at science fairs.

III. Materials that participants can take with them

The workshop participants will be provided with handouts for:

1) Design of wireless water sensors,
2) Operation of wireless sensors,
3) Laboratory experiments for measuring water quality data, and
4) Entering data into Google Map and visualization.

IV. Practical application for teachers and students

This project includes activities during the summer months and academic months. During the summer, teachers will:

1) Identify and collaborate with engineers and scientists from local water district and other related industry and organizations to develop a plan for involving their expertise in students activities,
2) Identify watershed and location of data collection for stationary sensors and manual water sampling with the recommendation of water district engineers,
3) Acquire wireless sensors and install them at the identified locations,
4) Acquire laboratory equipment and prepare setups for the measurement of storm water components by students, and
5) Integrate storm water activities in the educational learning of students through existing courses, such as engineering and technology, science, and mathematics, or a dedicated new course.

During the school year, students will be involved with their teachers in:

1) Collecting and managing data from stationary sensors,
2) Collecting live data samples and taking them to their schools for testing,
3) Performing data analysis and modeling,
4) Entering data into Google Earth for developing a dynamic visual map of their community watershed area,
5) Working with local water districts to prepare watershed management plans, and
6) Participate in public outreach activities.

For outreach activities, students will work with peers as well as younger children (K-12) by stressing the importance of being cognizant of storm water and how to use engineering solutions to gather information and provide mitigation strategies. Everything that is on the ground surface, whether it be oils and greases or pet waste or metals or fertilizers and pesticides, eventually makes its way to our waterways by way of our storm sewers/catch basins.

In developing their outreach activities, as part of their school educational activities, students will work with their local city water districts and local organizations. For example, the students in Maine high schools are working with organizations such as the Bangor Area Storm Water Group (BASWG) [19], the Lake Auburn Watershed Protection Commission (LAWPC), Maine Learning Technology Initiative (MLTI), and the University of Maine College of Engineering. BASWG is a local organization with members from the City of Bangor and surrounding cities, the University of Maine, University of Maine at Augusta (Bangor Campus), Maine Air National Guard, Dorothea Dix Psychiatric Center, and Eastern Maine Community College, working in conjunction with the Penobscot County Soil and Water Conservation District to manage storm water protecting the Penobscot River, the largest river in Maine. LAWPC is Maine's primary host institution for project WET, an award-winning international water science and education program for formal and non-formal educators of K-12 students. MLTI seeks to provide professional development and 21st Century tools to middle and high schools to support the attainment of the Maine state standards.

The public outreach component activities will include:

1) Developing outreach materials such as design of Water Quality "Mascot," cartoon character and possibly animated video,
2) Mentoring and instructing K-12 students in water quality concepts and technology through in-school demonstrations and field trips to local schools; Teams of students (2 students/team) will visit their local K-12 schools twice/year, once in the fall and once in the winter,
3) Participating and competing in state and national conferences, and
4) Participating in state Engineering Week Expo and other related outreach activities.

V. BROADER IMPACTS

Benefits to society: This project based learning model will benefit society in that it aims to offer a viable and cost-effective solution to the problem of storm water. This model is designed to be easily replicable and scalable nation-wide and in other issues such as renewable energy, global warming, nano-technology, and health care. The techniques, tools and materials, e.g. the stationary sensor units and data collection and management systems—using students as "Live Sensors," can be expanded into routine methods and used in other schools.

Broadening participation of underrepresented groups: Each year, this model will offer education and mentoring opportunities to students and teachers in in secondary and post-secondary educational systems. Due to its environmental and practical approach, this model will appeal to female and minority students and would promote STEM for higher education and as a career path.

Advancing discovery and understanding while promoting teaching, training, and learning: This educational model will train high school teachers and engage students in the area of storm water, sensor technology, wireless communications, environmental science and data management. Outreach to middle school teachers and students will also be a part of the program. The data collected and awareness created from this project can lead to projects directly impacting our environment.

VI. Educational OUTCOME AND RELATION TO NGSS

The outcomes of this educational model and their contributions to the implementation of the Next Generation Science Standards (NGSS) in high schools are given below. :

1) Use technology tools and engineering practices for:
   - **(a)** Collecting data from real world events (Module 1)
   - **(b)** Understanding limitation of real data collection and its accuracy (Module 1-4)
   - **(c)** Data analysis and modeling (Module 2)
   - **(d)** Understanding and explaining scientific ideas (Module 4)
2) Understand and practice integrated science and engineering concepts and be able to provide solutions. The following outcomes have been linked to 9 out of 41 K-12 NGSS Disciplinary Core Ideas (CDI), as defined in [20]:
   - (a) Physical Sciences (PS)
     - PS4A – Wave Propagation (Module 1)
     - PS4B – Electromagnetic Radiation (Module 1)
     - PS4C – Information Technology and Instrumentation (Module 1)
   - (b) Earth and Space Science (ESS)
     - ESS2C – The role of water in earth surface processes (Module 2 & 3)

ESS3A – Natural Resources (Module 2)
ESS3C – Human impacts on earth systems (Module 2)
(c) Engineering, Technology, and Application of Science (ETS)
ETS1A – Defining and delimiting and engineering problem (Module 3)
ETS1B – Developing possible solutions (Module 4)
ETS1C – Optimizing the design solution (Module 4)

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:

X☐Use of an engineering design process that has at least one iteration/improvement
☐ Attention to specific engineering habits of mind
X☐ Attention to engineering practices (as described in the NGSS/Framework and as practiced by engineers)
X☐ 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 National Research Council's *Framework* [21] and the 2012 Next Generation Science Standards (NGSS) report [22] emphasize the critical role of engineering in enhancing K-12 students learning. The focus of the learning model presented here is to respond to this need and provide training for high school teacher to integrate engineering practices into their curricula. The proposed workshop addresses the specific engineering fields selected above. For example, the design and application of wireless sensors under uncertain and harsh storm water environment will give the opportunity to teachers and students to encounter the limitation of engineering systems and think of solutions to improve the design and application of these units. For the wireless sensors, the limitations can include lack of battery power for the operation of onboard electronics components if there are several days with the powering sun, strength of wireless signal for transfer of information due to dense forest, hilly landscape and other obstacles, and changing water level during high storms. In addition to the electrical and computer engineering, teachers and students will also become familiar with civil and environmental engineering practices and careers for designing appropriate mitigation solutions to deal with storm water issues. Finally, as explained in Section V – Educational Outcomes and Relation to NGSS – above, the learning outcome of the learning model addresses several NGSS Cross Disciplinary Ideas.

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):

I. Under-represented and Under-served Students and STEM

In the STEM fields—science, technology, engineering and math—women have been historically underrepresented in engineering more than any other STEM field. Over the last twenty years, the number of B.S. degrees conferred to women in engineering has been about 18% of all B.S. engineering degrees, and less than 1/3 and 1/2 of their respective ratios in biological sciences and mathematics [23]; see Figure 1. The fact that the percentage of female degrees in mathematics is more than twice that of engineering suggests that females' ability in mastering mathematics is not a factor. A recent study [24], tracking about 1,500 college-bound students over a decade, has found that more women had the highest scores on both the math and the verbal portion of the SAT test than their male counterparts. Apparently, only a small fraction of these high-achieving female students choose to enter engineering. Faculty in the University of Maine (UMaine) College of Engineering come in contact with many intellectually gifted female students; however, we struggle with attracting many of these students to our programs. With high salaries, a 2% unemployment rate, and the critical role that engineering plays in our society, why aren't there more female engineers?

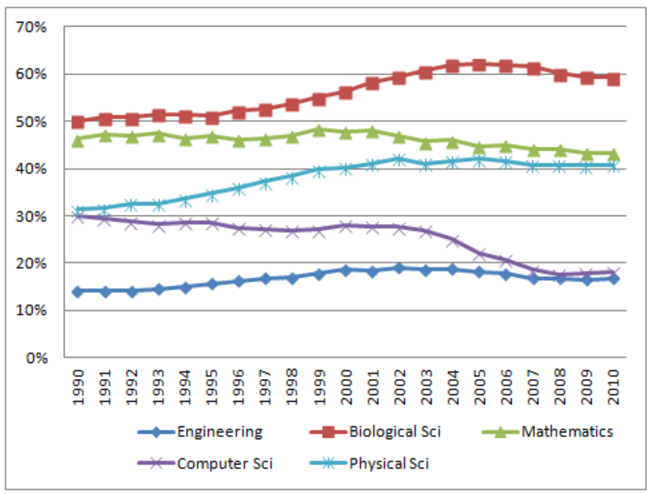

Figure 1. Percent Female B.S. Degrees.

There are likely many explanations why there is poor recruitment and retention of women in most engineering disciplines. One study suggests that stereotyping of the computer science workplace as masculine has contributed to a stagnant state of females in that field [25]. The reasons certainly have multiple origins and take numerous shapes—many are likely unique to each woman's circumstance; however, there are some commonalities which exist in the literature: (1) *the maleness of engineering* [26,27,28,29]; (2*) educational pipeline issues* [30,31]; and (3) *the absence of female scientists/engineers as role models* [32,33,34,35,36].

Our own experience supports the literature that females are drawn to the more environmentally focused disciplines, even the small percentage of females within engineering. The percentage of female engineering majors at UMaine follows the national average at post-secondary institutions, approximately 18%. However, UMaine's newly developed Bioengineering and Renewable Engineering programs have a high female enrollment at more than 35%. We also surveyed first-year female students regarding their choice of major. When asked what type of jobs they see themselves in, our female students who were accepted into engineering but decided to go to a non-engineering field, often responded that they wanted to be in people-engaged and environmentally responsible careers. They felt engineering would confine them in solitary cubicles working alone with machines—a common stereotype of engineering. While the stereotyping factor can only be resolved when there are more female engineers in the workforce, the environmental- and people-related factors should be used to close the gender gap in engineering. *Based on this rationale, we propose an innovative participatory educational model that uses storm water management and mitigation as a vehicle to attract more female and minority students to STEM, specifically engineering disciplines.*

Among minorities, Native American representation in engineering professions is astoundingly low. While 70% of 25-year-olds with a B.S. engineering degree are White, only 0.19% are Native American (African Americans make up 4%, and Hispanics, 7%) [23]. Research studies on lack of participation of Native Americans in STEM is sparse; however, two recent studies [37,38] suggest that linking STEM education to traditional values and tribal elders will improve perceptions of STEM as culturally relevant and supportive of the Native American community, consequently igniting students' interest in STEM. Streams, brooks, rivers, and water resources have always been of great traditional and cultural value to Native Americans not only as a means of subsistence but also for recreation. Therefore, the objective of this project—to develop storm water management and mitigation plans—will serve to attract students in Native American communities into STEM education.

II. Storm Water Issue Connects Minorities and Women to STEM

Storm water is runoff water from rain or melting snow that drains across the landscape. Runoff flows off rooftops, pavement, bare soil, and lawns, picking up pollutants along the way. It gathers in increasingly large amounts (from puddles, to ditches, to streams, to lakes and rivers) until it eventually flows into the ocean. By carrying numerous kinds of pollution into our waterways, storm water itself becomes a pollutant. Even in very small amounts, many of these pollutants can cause problems, such as heavy metals and chloride. Polluted storm water runoff is varied and ubiquitous and it is very difficult to address its sources.

Storm water management and mitigation is a pressing and expensive environmental and economical problem. Maine ranked 27th on the list of 30 coastal states rated for the water quality of their beaches by a national nonprofit environmental group. The 23rd annual "Testing the Waters" report revealed that 11 percent of water samples from 71 Maine beaches last summer failed to meet health standards by exceeding the state's maximum bacteria standard of 104 colonies per 100 milliliters of water sample: "The lower quality in 2012 was attributable in part to heavy rainfall last year, including the early-summer deluge that caused millions of dollars of damage in central Maine. Beach water quality generally declines following rain storms, which cause excessive runoff of sewage, pesticides, fertilizers, oil from streets and other pollutants from land into coastal waters" [39]. In addition, storm water pollution has a great impact on the health of fisheries, which is a significant economic factor in coastal states.

Treating storm water is both expensive financially and in terms of environmental and ecological costs. Polluted waterways cause species loss and deformity, and degradation of water quality decreases human enjoyment of waterways and ecosystem health. Municipalities do not have the resources to monitor and map the flow of their storm water with the level of detail necessary; the amount of water is too great and the sources of pollution too diverse in area and type. Due to increasing pollution levels, federal regulations on allowable storm water flows are becoming stricter.

This prevalent environmental issue has significant potential to attract minority and female students, and their communities: students and citizens can be directly involved in improving their local water bodies. There are several programs nation-wide that have used storm water to create excellent educational opportunities for middle and high school students and their communities. Some of these programs are: the Portland, Oregon Public School [40], the Farmington, Michigan Public School [41], City of Dallas, Texas [42], and the Environmental Protection Agency [43]. While these programs have proven the benefit of using environmental based projects in building community efforts, none have used their projects to bring emerging engineering technologies to an educational setting, with specific emphasis on recruiting female and minority students.

Previous studies have shown that environmental and societal based projects have great potential to engage the interests of female and minority students [44]. This program will demonstrate how students can use engineering and science to address important environmental issues in their communities [45] and improve the economic well-being of their communities. The model of this program, STEM solution-focused with diverse citizen involvement, will have nation-wide applicability and will encourage females and minorities.

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.)

X☐ No
☐ Yes

Please describe:
The only time that the presenter may need to have access to the web is to connect to the University of Maine server is show the data already connected by the Maine high school students.

Grade Level Target Audience (check all that apply):
☐ Primary (EC–2)
☐ Elementary (3–5)
X☐ Middle School (6-8)
X☐ High School (9-12)

Maximum Number of Participants:
50; or more as space allows

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

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

This workshop is a presentation of the successful implementation of the University of Maine NSF-EPSCoR storm water award. Within the 75 minute allocated time for this workshop, we can only familiarize the participants with three main components of the project: 1) wireless data acquisition system, 2) laboratory testing of water quality components, and 3) integration of the model in high school curricula. The participating teachers and engineers who are interested in implementing this educational model in their schools, can then follow up with the presenters for further training through future NSF awards or other collaborative agreements. These further trainings, which may take from 3-5 days, can be arranged in follow up workshops at the University of Maine or the interested school with smaller group of teachers and engineers.

In the ASEE Workshop, the wireless data acquisition system will be presented by Dr. Ali Abedi who will demonstrate the wireless sensors and familiarize the audience with the design and functionality of the system. The hard copy operational manual for working with the system, data collection, and data entry into Google Map will be distributed.

Mr. Cary James will present the laboratory procedures for testing storm water and integration of the learning model in high school curriculum. He will also explain the relevance of the educational model in satisfying the requirements of the Next Generation Science Standards (NGSS). He will also provide hard copy materials for the topics covered.

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."*

Internet Access

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:

Received By:

Proposal ID Number:

VII. REFERENCES

[1] Peckenham, J., T. Thornton, and P. Peckenham (2012) Validation of Student Generated Data for Assessment of Groundwater Quality, Jour. Sci. Educ. and Tech., 21:287-294.

[2] Thornton, T. and J. Leahy. 2012. Changes in social capital and networks: A study of community-based environmental management through a school-centered research program. Jour. Sci. Educ. and Tech., 21:167-182.

[3] Musavi, M.T., Ressom, H., Serirangam, S., Natarajan, P., Virnstein, R.W., Morris, L.J., and Tweedale, W., "Neural Network-Based Light Attenuation Model for Monitoring Seagrass Population in the Indian River Lagoon," *Journal of Intelligent Information Systems*, 29:63-77, 2007.

[4] Rambani, A., M. Musavi, Y. Wu,, Paul Lerley, and L. Fish. "Impact of Weather Conditions and Dynamic Load Models on Steady State and Dynamic Response of Power System," accepted for publication in Journal of Energy and Power Engineering, 2013.

[5] Ressom, H., S.K. Fyfe, S. Srirangam, P. Natarajan, and **M.T. Musavi** , "Neural network-based estimation of photosynthetic efficiency ," *International Journal of Ocean and Oceanography, Vol. 1, No. 3, September 2006.*

[6] Mallin, M., S. Ensign, M. McIver, G. Shank, and P. Fowler (2001). Demographic, landscape, and meteorological factors controlling the microbial pollution of coastal waters. Hydrobiologia, 460(1-3), 185.

[7] Brezonik, P. L., & Stadelmann, T. H. (2002). Analysis and predictive models of stormwater runoff volumes, loads, and pollutant concentrations from watersheds in the twin cities metropolitan area, Minnesota, USA. Water Research, 36(7), 1743.

[8] Lipscomb, S.W. 1998. Hydrologic classification and estimation of basin and hydrologic characteristics of subbasins in Idaho. USGS Professional Paper 1604.

[9] Carey, S. K., Tetzlaff, D., Seibert, J., Soulsby, C., Buttle, J., Laudon, H., and Pomeroy, J. W. (2010). Inter-comparison of hydro-climatic regimes across northern catchments: Synchronicity, resistance and resilience. Hydrological Processes, 24(24), 3591-3602. doi: 10.1002/hyp.7880

[10] Serrano, I., I. Buffam, D. Palm, E. Brännäs, and H. Laudon, H. (2008). Thresholds for survival of brown trout during the spring flood acid pulse in streams high in dissolved organic carbon. Transactions of the American Fisheries Society, 137(5), 1363-1377. doi: 10.1577/T07-069.1Sidhu, J., L. Hodgers, W. Ahmed, M. Chong, and S.Toze (2012). Prevalence of human pathogens and indicators in stormwater runoff in brisbane, australia. Water Research, 46(20), 6652-6660. doi: 10.1016/j.watres.2012.03.012

[11] Lookingbill, T., S. Kaushal, A. Elmore, R. Gardner, K. Eshleman, R. Hilderbrand, and W. Dennison (2009). Altered ecological flows blur boundaries in urbanizing watersheds. Ecology & Society, 14(2), 1-19.

[12] Jencso, K. and B. McGlynn (2011). Hierarchical controls on runoff generation: Topographically driven hydrologic connectivity, geology, and vegetation. Water Resources Research, 47(11), W11527-W11527. doi: 10.1029/2011WR010666

[13] McGuire, K.J. and J.J. McDonnell. 2010. Hydrological connectivity of hillslopes and streams: characteristic time scales and nonlinearities. Water Resources Research, Vol. 46, doi: 10.1029/2010WR009341.

[14] Yagow, G., T. Dillaha, S. Mostaghimi, K. Brannan, C. Heatwole, M.L. Wolfe. 2010. TMDL modeling of fecal coliform bacteria with HSPF. Paper No. 01-2066, Annual Meeting, American Soc. of Agricultural Engineers.

[15] Perrin, C., C. Michel, and V. Andreassian. 2003. Improvement of a parsimonious model for streamflow simulation. Journal of Hydrology, Vol. 279, pp. 275-289.

---

[16] USACOE, 2010. Hydrologic modeling system – User's manual, Version 3.5. Institute for Water Resources, U.S. Army Corps of Engineers. Davis, California.

[17] Vogel, R.M. and N.M. Fennessey. 1995. Flow duration curves II: a review of applications in water resources planning. Water Resources Bulletin, Vol. 31, No. 6, pp. 1029-1039.

[18] Vogel, R.M. 1994. Flow duration curves I. New interpretation and confidence intervals. Journal of Water Resources Planning and Management, Vol. 120, No. 4, pp. 485-503.

[19] http://www.baswg.org/

[20] http://www.nextgenscience.org/search-standards-dci

[21] "A Framework for K-12 Science Education" National Research Council of The National Academies, National Academies Press 2011

[22] "Standards for Engineering, Technology, and the Applications of Science," Next Generation Science Standards, 2012, http://www.nextgenscience.org/next-generation-science-standards.

[23] National Center for Education Statistics. 1990–2009. *Digest of Education Statistics.* US Department of Education. nces.ed.gov/programs/digest/

[24] Wang, M.T., Eccles, J.S., &, S. (2013). Not Lack of Ability but More Choice:Individual and Gender Differences in Choice of Careers in Science, Technology, Engineering, and Mathematics*Psychological Science* May 2013 24: 770-775, first published on March 18, 2013

[25] Cheryan, S., Plaut, V. C., Davies, P., & Steele, C. M. (2009). Ambient belonging: How stereotypical environments impact gender participation in computer science. *Journal of Personality and Social Psychology, 97,* 1045-1060.

[26] Bix, A. S. (2004). From "engineeresses" to "girl engineers" to "good engineers": A history of women's U.S. engineering education. *NWSA Journal, 16*(1), 27-49.

[27] Bystydzienski, J. M. (2004). (Re)gendering science fields: Transforming academic science and engineering. *NWSA Journal, 16*(1), viii-xii.

[28] Evetts, J. (1993). Women in engineering: Educational concomitants of a non-traditional career choice. *Gender and Education, 5*(2), 167.

[29] Sullivan, B. (2007). Closing the engineering gender gap: Viewers like you. *New England Board* of Higher Education, 22(1), 26-28.

[30] Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education, 17*(4), 369-386.

[31] Kohlstedt, S. G. (2004). Sustaining gains: Reflections on women in science and technology in 20th-century United States. *NWSA Journal, 16*(1), 1-26.

[32] Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education, 17*(4), 369-386.

[33] Kohlstedt, S. G. (2004). Sustaining gains: Reflections on women in science and technology in 20th-century United States. *NWSA Journal, 16*(1), 1-26.

[34] Morgan, K. P. (1996). Describing the emperor's new clothes: three myths of educational (in) equity. In A. Diller, B. Houston, K. P. Morgan, & M. Ayim (Eds.), The gender question in education: Theory, pedagogy, & politics. (pp. 105-123).

[35] Neithardt, L. A. (2007). Boulder, CO: Westview Press; Women hindered in science and engineering. Academe, 93(1), 15.

[36] Neimeier, D. A., & González, C. (2004). Breaking into the guildmasters' club: What we know about women science and engineering department chairs at AAU universities. NWSA, 16(1), 157-171.

---

[37] Ferreira, M.P. & Gendron, F. (2011). Community-based participatory research with traditional and indigenous communities of the Americas: Historical context and future directions. http://libjournal.uncg.edu/ojs/index.php/ijcp/article/viewFile/254/119

[38] Babco, Eleanor. 2005. "The Status of Native Americans in Science and Engineering," Eleanor Babco, Executive Director, Commission on Professionals in Science and Technology. American Association for the Advancement of Science, http://ehrweb.aaas.org/mge/Reports/Report1/Babco-StatusOfNativeAmericansInSandE.pdf

[39] June 27, 2013: http://www.onlinesentinel.com/news/maine-Beaches-water-quality-pollution.htmlReport: "Maine's beach water quality ranked among worst"

[40] http://www.pps.k12.or.us/departments/facilities/3233.htm

[41] http://www.farmington.k12.mi.us/community/stormwater/

[42] http://www.wheredoesitgo.com/students-middle-high-students.html

[43] http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=

[44] Kanter, David E. (2010). Science Education. "The impact of a project-based science curriculum on minority student achievement, attitudes, and careers: The effects of teacher content and pedagogical content knowledge and inquiry-based practices." Vol. 94 Issue 5, p855-887. 33p. 13 Charts.

[45] Kolok, Alan. S. (2011). BioScience. Aug2011, Vol. 61 Issue 8, p626-630. 5p. "Empowering Citizen Scientists: The Strength of Many in Monitoring Biologically Active Environmental Contaminants."