Water Sustainability: Science and Engineering Activities for the High School Classroom (Resource Exchange)

Ms. Christina Anlynette Crawford, Rice University

As Associate Director for Science & Engineering of the Rice Office of STEM Engagement, Christina leads the Rice Excellence in Secondary Science Teaching (RESST) biology program. In this capacity, she guides Houston area high school Life Science teachers in weekly meetings on Rice's campus to explore both biology concepts and the ways in which they can be taught using inquiry methods.

Carolyn Nichol, Rice University

Dr. Carolyn Nichol is a Faculty Fellow in Chemistry and the Director of the Rice Office of STEM Engagement (R-STEM). R-STEM provides teacher professional development to elementary and secondary teachers in science and math content and pedagogy, while also providing STEM outreach to the Houston Community. Dr. Nichol's research interests are in science education and science policy. She received her B.S. in chemical engineering from the University of Massachusetts at Amherst, her doctorate in chemical engineering from the University of Texas (UT) at Austin, and served as a postdoctoral fellow in the College of Pharmacy at UT Austin. Prior to joining Rice University, she worked at Boehringer Ingelheim on innovative drug delivery systems and she was an Assistant Professor in Diagnostic Radiology at UT MD Anderson Cancer Center, where she conducted research on nonviral gene therapy systems. At Rice University she has developed and taught courses in The Department of Bioengineering including Numerical Methods, Pharmaceutical Engineering, Systems Physiology, Biomaterials and Advances in BioNanotechnology.

Water Sustainability: Science & Engineering Activities for the High School Classroom (Resource Exchange)

The goal of this resource exchange is to disseminate over 27 lesson plans, research posters, and educational videos created by K-12 teachers conducting summer internships in the field of nanotechnology with a focused on water treatment broadly via an online database.

The Nanosystems Engineering Research Center (ERC) for Nano-Enabled Water Treatment (NEWT) is an NSF-funded interdisciplinary national center including Arizona State University (ASU), Rice University, University of Texas – El Paso (UTEP) and Yale University aimed to facilitate access to clean water almost anywhere in the world by developing efficient modular water treatment systems that are easy to deploy and can tap unconventional sources to provide humanitarian water or emergency response. The NEWT center was established in 2016 and has supported nine secondary science teachers in the Research Experience for Teachers (RET) internship program each year.

The NEWT RET program provides research opportunities to K-12 STEM teachers who serve economically disadvantaged students. The teachers who work with these populations are often the most unprepared for teaching engineering and thus can most benefit from the experience and impact their students. The program objectives consist of the following: 1) Use nanotechnology research experiences focused on water sustainability to enhance teacher content knowledge; 2) Improve the quality of secondary Science, Technology, Engineering and Mathematics (STEM) education through the development of student-centered lessons and activities; 3) Create a cadre of teacher leaders; and 4) Disseminate NEWT RET outcomes broadly by creating a network of teachers that are actively learning about nanotechnology research. This year-long, annual RET program is implemented at ASU, Rice, and UTEP.

NEWT RET full internships contain the following elements:

- Six-week summer internship in a NEWT lab;
- Scientific verbal and written communications training including poster development and engineering research symposium presentations;
- Three Fall semester curriculum development workshops; and
- Lesson plan dissemination in the classroom and at Spring Nano-Academies (free half-day workshops for K-12 students in the Houston, TX, El Paso, TX and Tempe, AZ areas.)

The NEWT Center has created an online space for all the curricula that teachers developed from their NEWT RET internships which may be found at http://www.newtcenter.org/#!ret-curriculum-2018/g2zjr. The educational material on the website is available to the public and is free to use. As cohorts of RETs complete their internships each year, their curriculum material will be added to the online website.

How to Browse Through the Website

Each RET is identified on the website with the following information:

- **Name, K-12 Subject Area, and Preferred Contact Email –** This information is provided for educators with specific questions regarding the implementation of lesson material.
- **School District and Lab Location** – The school district reveals the lesson's targeted student demographic population. The RET intern's university (Rice, ASU or UTEP) is listed as well as their faculty host and post-doctoral or graduate student mentor.
- **Research Topic** – This information provides the focus of the intern's project conducted during the six-week experience.

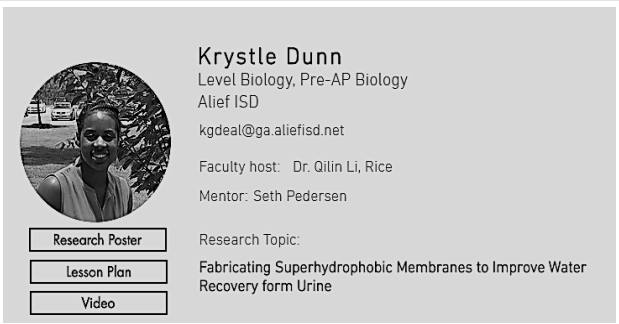

Figure 1. View of organization of curriculum material links found on NEWT website

K-12 educators visiting the website will have access to the following types of curricula material:

- **RET Research Posters** – This provides educators with background information on the RET summer internships and a more detailed overview of the research at the various NEWT institutions.
- **Videos** – Starting in 2018, RET interns created educational videos specifically targeted to middle and high school student audiences. These videos help students understand the significance and relevance of the research presented in the posters and lesson plans.
- **Lesson Plans** – NEWT-related STEM curricula are presented in the form of Maker Challenges, Science Labs, or Project-Based Learning experiences. Lesson plans range from one-class period activities to one-week units. All lesson plans are aligned to State science process standards. PowerPoint slides in PDF form are also included. Lessons created are submitted for publication on TeachEngineering.org, a free online depository of standards-based engineering curricula.

The following page provides a portion of RET- Krystal Dunn's lesson which, along with other NEWT RET created lessons, Research Posters, and Educational Videos can be found on the NEWT Curriculum website.

Excerpt of one lesson found on the NEWT website http://www.newtcenter.org/#!ret-curriculum-2018/g2zjr

Engineering Self Cleaning Hydrophobic Surfaces

Grade level: 9th **Subject area(s)** Biology, Life Sciences, Physical Science **Estimated Time Required:** 50 minutes

Maker Challenge Overview: The biomimetic engineering challenge introduces students to the field of nanotechnology and the topic of biomimicry which refers to human-made devices or systems that imitate nature. Participants will explore how materials can be modified at the nanoscale to provide features such as waterproofing and stain resistance. Working in teams, students will identify an intended use and application for self-cleaning nanomaterials and will be given the opportunity to test the material under specific constraints to determine hydrophobicity of each design. In essence, teams will design, create, test, and then think of ways to improve their self-cleaning superhydrophobic modification technique for a chosen material. (Further instructions are provided in the PowerPoint file).

Maker Materials & Supplies:

- Waterproofing materials for smoothing onto surface: wax, crayons, flax seed, lanolin, clay, glue, spoons or sticks
- Tools to modify surface roughness: sandpaper, wax paper, hydrophobic sand, and instant snow
- Depending on their target user, an appropriate material to modify: 4x4 Piece of flat wood and 4"x4" cotton fabric
- Materials to simulate dirt: glitter, salt, or pepper
- Materials to test roll-off angle: clipboard, protractor, masking tape or duct tape, small container of water, pipette or eyedroppers, and paper towels
- Materials to observe drop profile/contact angle: hand lens

Kickoff:

Have you ever noticed how water rolls off a leaf? Like the Lotus Leaf or how a Lily Pad floats on water? These plant parts are Superhydrophobic and their leaves never get dirty. Why is this? First, let's define hydrophobic. Hydro means water and phobic means fear. Think about oil and water. These plants have a waxy coating or tiny projections on their surface which results in a layer of air between the hairs and keeps the water away. Hydrophobic surfaces are in high demand because of the many useful applications such as in sweat and dirt proof clothing, rust prevention, anti-icing, and even sanitation uses. The number of applications are great!

Your challenge is to create two products that can make any surface dirt and stain resistant using your knowledge of hydrophobicity. Working with your team, you will decide who needs your product: construction industries, car companies, city planners, clothing companies, or homeowners, for example. Your team will then choose methods for modifying your surface which will then be tested to determine hydrophobicity and its ability to keep dirt and water off.

To begin you need to do some research and gain some background knowledge. Observe the materials that have been provided. You may use up to three different waterproofing materials to determine what combination works best. You may test the waterproofing materials to determine hydrophobicity and decide how you will use them to modify your surface. After testing, your team will evaluate your design and propose improvements for a next time around. Let's get started!

Engineering Time

1. Review the concepts behind hydrophobicity, the available materials, testing constraints, procedure, and steps of the engineering design process.
2. Divide the students into groups of 3-4, give students 5 minutes to brainstorm what target audience, potential surfaces needed, and potential waterproofing materials.
    a. During the brainstorming session, allow students to test waterproofing materials on their hydrophobic testing sheet.
3. Students will devise two ways to waterproof their chosen material. Students must develop a written plan for both methods. Students must modify and label at least two approaches Material A and Material B.
4. Students will engineer and modify their 2 surfaces.
5. Teams will then observe and diagram the drop profile/contact angle of a drop of water on their modified surface.
    a. Place a drop of water on the surface.
    b. Look at the drop from the side and sketch the drop profile or your worksheet. **Additional steps on full online version*

Wrap Up

Students will reflect upon their designs and test results. They will choose a spokesperson to communicate their results and future improvements to the class. 1) How would you describe your modified surface? Rough or Smooth * *Additional reflection questions on full online version*

Individuals with questions regarding the curriculum presented on the website may contact Christina Crawford by email at cc45@rice.edu or via phone at 713-348-4761.