How STEM Teachers Can Immerse Themselves in the Three Rs Over the Summer

Rejuvenate, Replenish, and Reenergize

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As each school year comes to an end, teachers often feel utterly exhausted and have an urgent need to rejuvenate, replenish, and reenergize before a new school year begins. The general public often believes that teachers take summers off to relax or supplement their income by taking an unrelated summer job, but a significant number of STEM (science, technology, engineering, and mathematics) teachers spend their summers working in laboratories and/or conducting field research as RETs (Research Experiences for Teachers). According to the National Science Foundation's website (NSF 2018), the purpose of its RET program is to promote active collaborative partnerships between K–12 STEM teachers and full-time college and university faculty to enhance the scientific disciplinary knowledge and capacity of the STEM teachers through participation in authentic summer research experiences. These teacher experiences are designed to filter down to K–12 students through engaging classroom inquiries based on the teacher's research experience.

There are many different types of RETs available for teachers across the country. These research experiences for teachers, or externships, often include stipends and can vary in time span from a couple of weeks to entire summers. Individual states and/or progressive STEM companies can sponsor these research opportunities for teachers; the Department of Energy (DOE) and the National Science Foundation (NSF) often sponsor externships.

Paid teacher professional development opportunities like NSF's RET programs are excellent ways to rejuvenate, replenish, and reenergize STEM teachers. Participating in a RET can enhance the way STEM concepts are delivered to elementary and secondary students. According to Pegg and Gummer (2010), "Many teachers at the elementary and secondary level have never been directly engaged in scientific research. Their view of science has come primarily from K–12 and university level coursework that often focuses on the concepts and skills of science rather than the nature of scientific process" (p. 448). Research has suggested that years of experience and numbers of degrees teachers possess do not matter in the classroom nearly so much as mastery of science and math (Wingert 2012). Collaboration among scientists and engineers with K–12 educators, such as that provided by a RET experience, supplies authentic opportunities to develop mastery in science and technological knowledge (Wingert 2012), while also providing teachers with the opportunity to engage in genuine science and engineering practices, one of the three guiding dimensions of the *Next Generation of Science Standards* (NGSS Lead States 2013).

Participation in RET programs can provide a rich experience by teaching key principles and ideas concerning the nature of science while also bolstering knowledge content by providing teachers with a deeper understanding and appreciation of commonly taught concepts (Buck 2003; Dresner and Worley 2006; Raphael, Tobias, and Greenberg 1999). K–12 students can also benefit from the experience by teachers helping them build a better understand-

ing of science and the nature of science within a contemporary context (Brookshire 2016; Pegg and Gummer 2010). Research experiences have also been found to increase teachers' confidence in teaching STEM principles through inquiry (Westerlund et al. 2002). A RET opportunity allows teachers explicit experience with another *NGSS* pillar, crosscutting concepts. These concepts, such as patterns; cause and effect; and the interdependence of science, engineering, and technology are firmly entrenched in research (see Figure 1).

Teaching through scientific inquiry is important in that it allows students to become engaged in science and engineering practices. If science is taught without inquiry, you cannot reasonably expect students to ask profound and thoughtful questions, form inspiring and deliberate hypotheses, conduct methodical experiments, decide which measurements to collect, and make connections and construct meaning in the world. A research experience can provide teachers with the necessary background that better supports inquiry-oriented science instruction in their classrooms.

The first author (Vassiliev) has had the opportunity to be associated with two very different NSF-funded University of Maine RET programs. The first RET program was during the summer of 2004, during which she worked in the field collecting lobsters (*Homarus americanus*) along the coast of Maine and in the laboratory testing heavy metal concentrations within lobster tissue. The opportunity provided intense bench chemistry experience, which yielded significant benefits to the author and her students.

The other RET program with which the author has been affiliated (for 12 summers) is the University of Maine's Forest Bioproduct Research Institute (FBRI; see Acknowledgment section for both RET programs). FBRI is a large, multi-disciplinary, collaborative effort that spans almost all of the different colleges at the University of Maine. The FBRI RET paradigm is unique in that it pairs the teacher with Research Experiences for Undergraduate

FIGURE 1: Outline of possible benefits that could transpire from participating in RET programs

Who benefits?	What is the benefit?
Students	• Receive more inquiry-oriented science instruction • Learn science content in a real-world or applicable context. • Develop a deeper understanding of the nature of science through being asked more critical-thinking questions. • Develop a better understanding of scientist and engineering career and necessary traits. • Encourage perseverance and fruitfully impact long-term research projects [science fair]
K–12 Teachers	• Enhance the scientific disciplinary knowledge • Summer pay • Engage in authentic scientific or engineering practices • Engage in the key principles and ideas concerning the nature of science within a contemporary context • Hone technical and/or laboratory skills • Provide leadership opportunities [presentations or lead professional development] • Cerebral challenge [stretch and grow academically] • Foster community relationships
Scientists/Principal Investigators	• Share research [more exposure] • Understanding K–12 education • Present and promote science and engineering as a possible career choice

(REU) students who are performing experiential research projects. The RET teacher learns about each of the REU student research projects and distills them down to *NGSS* disciplinary core ideas. The teacher then creates and beta tests (aided by the students) middle school inquiry activities employing the research in sustainable forest bioproducts as a vehicle that can be easily implemented in the classroom. Some summers the author has been the only RET working with the program; in other years, several RETs have participated. During the summer of 2017, the author worked with a high school biology teacher; a major and unanticipated outcome was a much greater understanding of how to better prepare middle school students through science and engineering practices for taking high school science and AP courses. For example, dimensional analysis and data collection were areas of observed weakness at the high school level, so now when students are conducting an inquiry activity, the author spends more time with the middle school students, ensuring that they not only can do dimensional analysis, but also are collecting and organizing data within spreadsheets and/or tables.

When teachers spend time diving into their own authentic scientific study, they can develop a much more sophisticated understanding of the nature of science and better appreciate that science is really a way of thinking, not just a body of knowledge that needs to be disseminated to students (Lederman 1992). Being able to draw from research experiences and hold them up as a model when discussing the nature of science helps to encourage perseverance and fruitfully impacts students' prevailing attitudes toward tackling large, long-term endeavors such as science and engineering fair projects and/or innovation projects like Invention Convention.

Uncovering research experiences for K–12 teachers may take some time, but exploring the NSTA, NSF, or DOE websites is a good start. Applications are usually available starting in February through April, but every RET is different so make sure to read the application process and requirements carefully. Reaching out to local universities, colleges, engineering firms, or laboratories to see if they might offer such teacher experiences is also recommended.

If the idea of conducting research at a university level scares you, then paradoxically, you should apply for a summer RET. The degree of confidence and accomplishment that such an experience provides STEM teachers greatly surpasses any initial misgivings. As educators we want our students to take risks. We know "you can't learn if you can't take risks" (Tough 2016). A research experience can be difficult and overwhelming at times, but your faculty mentor is there to support you throughout your project and wants you to be successful in conveying their research to your students. Teachers will find that research experiences will fuel their passion for teaching and will leave them rejuvenated, replenished, and reenergized. ●

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REFERENCES

Brookshire, B. 2016. Teachers get to do cool science in the Arctic. *Science News for Students* 1.

Buck, P.E. 2003. Authentic research experiences for Nevada high school teachers and students. *Journal of Geoscience Education* 51 (1): 48–53.

Dresner, M., and E. Worley. 2006. Teacher research experiences, partnerships with scientists, and teacher networks sustaining factors from professional development. *Journal of Science Teacher Education* 17 (1): 1–14.

Lederman, N.G. 1992. Students' and teachers' conception of the nature of science: A review of the research. *Journal of Research in Science*

Teaching 22 (4): 331–359.
National Science Foundation (NSF). 2018. *Research experience for teachers (RET) in engineering and computer science* (17-575). *www.nsf.gov*.
NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states.* Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards.*
Pegg, J., and E. Gummer. 2010. The influence of a multidisciplinary scientific research experience on teachers views of nature of science. *Montana Mathematics Enthusiast* 7 (2/3): 447–460.
Raphael, J., S. Tobias, and R. Greenberg. 1999. Research experience as a component of science and mathematics teacher preparation. *Journal of Science Teacher Education* 10 (2): 147–158.
Tough, P. 2016. How kids really succeed. *Atlantic* 317 (5): 56–66.
Westerlund, J.F., D.M. García, J.R. Koke, T.A. Taylor, and D.S. Mason. 2002. Summer scientific research for teachers: The experience and its effect. *Journal of Science Teacher Education* 13 (1): 63–83.
Wingert, P. 2012. Building a better science teacher. *Scientific American* 307 (2): 60–67.

RESOURCES

FBRI Teachers blog—*http://fbri.edublogs.org*
Vassiliev, T., P. Bernhardt, and D. Neivandt. 2013. Innovation Composite Research Modeled in the Middle School Classroom. *Science Scope* 37 (1): 42–53.
Vassiliev, T., and D. Neivandt. 2015. Let them eat cake . . . OE-Cake! *Science Scope* 38 (1): 60–68.

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