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The Research Experience for Teachers Program in Polymers at the University of Akron: Activities, Assessment, and Best Practices

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Introduction

The College of Polymer Science and Polymer Engineering at the University of Akron (UA) ran a National Science Foundation funded Research Experience for Teachers (RET) site from 2012-2016 and started a new cycle in 2016-2019. This paper is a summary of the 2012 – 2016 site. The main objective of this RET site was to bring ten high school science teachers to The University of Akron (UA) campus for eight weeks each summer to increase their knowledge of engineering research and enable them to effectively disseminate this knowledge in their high school classrooms. This was accomplished through a combination of (1) an independent research project for each teacher in the laboratory of a UA faculty member and (2) hands-on professional development activities to reinforce the fundamentals of engineering research, relate this knowledge to each teacher's independent project, and translate this knowledge and experience into a new lesson plan for their high school classroom. These lesson plans were disseminated broadly through the web (http://agpa.uakron.edu/p16/ret.php), workshops to local K-12 educators, and national conference symposia.

The targeted participants were high school science teachers (e.g. chemistry, physics, biology) in the Akron hub of the Ohio STEM Learning Network within a one hour drive of the University of Akron.[1] This encompasses Summit county and four surrounding counties (Portage, Stark, Wayne, and Medina counties).

The intellectual focus of this site was polymeric films and interfaces, but branched out after its inception to encompass polymer engineering. This field is described by the academic mission of the Department of Polymer Engineering at UAkron as "the practical application of scientific and engineering principles to generate new material and processing concepts and enhance technical problem solving capabilities related to the production and use of polymers."[2] Polymer materials are vital to advances in many of the grand engineering challenges of the 21st century (e.g. affordable solar energy, carbon sequestration, access to clean water, engineering better medicine)[3] and burgeoning fields, such as flexible electronics.[4] Overall polymer engineering is ideal for the intellectual focus of an RET site as this mission and the real-world application of polymers are directly in-line with the Ohio Science Standards, which list designing technological/engineering solutions using science concepts as one of four cognitive demands and emphasizes real-world applications in demonstrating content mastery.[5] The focus is also consistent with National Science Standards that emphasize both that "science and engineering are integrated in K–12 science education and K–12 science education should reflect real-world interconnections in science."[6]

Activities

The RET site ran as an eight week program each summer. The program met for five days the first week and four day each subsequent week. This is a similar number of days to a five day per week/six week program, but the extended total time of the program allows the teachers the time

to adjust to the program and achieve results, while the four day per week requirement is an attractive compromise for many teachers who need to balance other commitments during the summer. The teachers invested a majority of their time pursuing their independent research projects in the laboratories of UA faculty members. A main goal of this research experience was for the teachers to develop a new lesson-plan for their high school classrooms. To facilitate these efforts the teachers participated in a number of different lectures and hands-on activities.

Lectures during the first week were meant to orient the teachers and covered the basics of laboratory research including laboratory safety, data management, notebook keeping, and library resources. A second set of lectures with hands-on activities introduced the fundamentals of polymers including polymer properties, polymer processing, and polymer testing and characterization. In subsequent weeks the teachers met during lunch three days a week to first, present to other their research progress and lesson plan ideas, second, listen to faculty members present their own research, and third, an informal networking lunch with the faculty members and graduate students involved in the RET site.

One way day a week was devoted to lesson plan development. A common lesson plan template was used based on the 5E learning cycle developed by the Biological Sciences Curriculum Study.[7] It is a constructivist, hands-on instructional method, where the 5E's are Engagement, Exploration, Explanation, Extension, and Evaluation.[8] A number of studies have shown this is an effective teaching method across numerous topics and age levels and useful to develop 21st century skills (i.e. problem solving, critical thinking, collaboration and self-management) stressed in current Ohio and National science standards.[5,6,9-16] During the first two weeks of the program the teachers ran existing lesson plans and discussed their experience with the lesson. The following six weeks was devoted to developing their own new lessons.

In the school year following the completion of the summer program the teachers were expected to deliver their lesson plan in their classroom. Based on this initial delivery and comments from the faculty mentors the lesson plans were revised and uploaded to the Akron Global Polymer Academy website for broad dissemination to the education community. In addition to these activities, three workshops were held to disseminate the results of the site to local teachers and included demonstrations of lessons and classroom materials.

Outcomes

22 teachers participated in this site, a number of which participated for two summers. A wide range of polymer engineering topics were investigated in the independent research projects including adhesion, batteries, biomaterials, biomimicry, coatings, hydrogels, nano-manufacturing, responsive polymers, and tissue engineering. From these research experiences 31 lesson plans were produced, 19 of which were posted on the Akron Global Polymer website.[17] One publication with an RET as a co-author has resulted from this work.[18] Three workshops were held to disseminate the results to local middle and high school teachers to broaden the impact of the work. The PI co-organized a symposium focused on chemistry and polymer outreach activities in K-12 education for the spring 2013 and spring 2015 National American Chemical Society meetings. Five RETs participated in these two symposiums giving oral presentations.[19-22]

The RET site was evaluated by an independent evaluator on the topics of teacher content knowledge, professional development and instructional practice, the professional learning community, and student learning. Data was collected through content assessments, observation, focus group interviews and surveys. A primary objective of the site was to increase RETs knowledge of engineering research and enable them to effectively disseminate this knowledge in their high school classrooms. As shown from the selection of survey results in Figure 1 (answers range from 1-4, 1 = no impact and 4 = great impact), this RET site has been highly effective in accomplishing this objective. One comment noted by the evaluator summarizing an RETs experience with the site was "*The RET experience reinvigorated me. This got me back in touch with why I love science and got me excited to go teach again. Thank you."* Student learning was assessed through the focus groups with the teachers. Most RETs felt that the program has a positive benefit on student learning through increased inquiry-based instruction. Also the increased knowledge in content and practices through the lab experience could be passed onto their students.

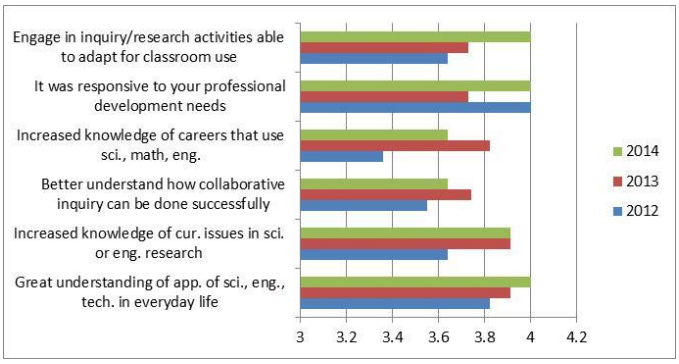

Figure 1. Selected survey results.[23]

Overall, the impact on the teachers by participation in the RET site was the advancement in their knowledge of engineering content, which enhances their ability to positively impact the education of their students. The partnerships built between the K-12 STEM community and UA through this site has enabled broader impact by providing avenues to expose students and the general public to science and engineering beyond standard classroom activities. For example, participation in the RET site and workshops directly resulted in the establishment of one high school science club and involvement by UA in a number of high school and middle science nights open to the general public. Therefore, the research experiences offered by the RET site provided a method to positively impact both individuals and larger communities to benefit society.

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