Extended Abstract with Poster

STEM High School Teaching Enhancement Through Collaborative Engineering Research on Extreme Winds

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Abstract

The Research Experience for Teachers (RET) project on Hazard Mitigation at UT Arlington was funded by the National Science Foundation (NSF). The project had the important intellectual focus of educating high school STEM teachers in inquiry-based research learning, research design, execution and implementation, and in solving real-world hazard-related engineering problems with open-ended solutions. The RET program brought together 27 high school STEM teachers from 10 high schools in the Arlington, Texas, and five other school districts from surrounding areas. A total of seven summer research projects with the common theme of hazard mitigation were identified and conducted. In the six week summer extreme wind RET project, the STEM teachers were provided with hands on research experience with the International Building Code (IBC) wind load provisions, analysis of existing structures for wind loads, determining shortcomings (if any) of the analyzed structures, and designing upgrades and retrofits for the structures for complying with the building code provisions. Potential ethical issues arising out of deliberately or negligently using faulty design, inferior material selection and/or sub-standard construction practice, and the effect of such practice on wind integrity of structures were also covered.

A total of 12 comprehensive classroom lectures were given to the participating teachers on the RET project on Extreme Winds. A description of the various types of extreme winds and their effects on structures were shown through the use of mathematics and statistics. They could then relate the wind loads to the appropriate mathematical and physical formulations. Lectures on basic mechanics of structures were also provided. Knowledge on the analysis of structures for wind load was very helpful to the teachers for designing small classroom projects in their classes. The teachers were provided with the knowledge of calculating forces in simple structural members like roof trusses, as they are one of the most important parts of residential homes and are very common. The teachers were given the opportunity to explore

structural analysis and the design software RISA 3D. The structures were then analyzed and responses were evaluated in terms of stress and deflection. The analyses were done by the teachers under the supervision of the faculty mentor and the graduate research assistant. A field trip was undertaken to a local truss production facility in Ft. Worth, Texas. The field trip provided a clear concept to the teachers about the fabrication process of different parts of a truss and how these parts are assembled. The field trips helped the teachers in building their prototype class projects with balsa wood pieces which were connected to each other resembling actual connections.

At the initiation of the summer RET program, each teacher was asked to produce the current lesson plan that they were using in their classrooms. At the end of the summer program, each teacher produced a modified and enhanced lesson plan, based on their acquired knowledge from the RET project. At one High School, a modified post-RET lesson plan was developed as a project for the Honors or Pre-Advanced Placement (pre-AP) Physics students. Using the concept of forces, students develop roof trusses that withstand the greatest amount of force with a limited amount of materials. Once the maximum load is determined, the students evaluate the truss members in solving two dimensional components of the forces that satisfy the condition for static equilibrium. After the RET project experience, one Teacher modified her teaching approach for the AP Physics class as follows. Students were asked to research and report on recent failures in engineering infrastructure and how ethics may have played a role. The AP students also complete the roof truss exercise, similar to the pre-AP Physics students, extending the application into the building walls. Students are given a construction budget, simulating real life projects. In the first two years of the RET project, students were able to take various field trips to UT Arlington. Students took the first trip to understand how various materials are tested in the laboratory. During the second visit, students were able to explore the same areas plus the manufacturing and robotics laboratory, 3D engineering design lab in aerospace engineering, and the projects in computer engineering and smart robotics. Student groups also were able to make modifications to their projects to determine what could be added or removed from their designs to improve the performance of their structure in the wind loads provided in the simulation. Building a structure that is strong enough and balances cost, strength, and time required to build, as learned by the students through the RET project, is sound engineering practice. Overall, the students had generally positive comments about the RET lesson experience. Of the 20 junior and senior students surveyed after the field trips in 2008 and 2009, six are currently studying engineering.

From the teacher's perspective, it is important to help students see real life applications to the lessons that are taught in the classroom. It is apparent that the exposure to real life examples helped students understand why they needed to learn the material; it also helped motivate their interest in career fields (such as engineering, sciences, mathematics and technology). The teacher benefits in other ways, such as the ability to gain knowledge outside their area of expertise, create new educational and professional relationships between the high schools and the university, better understand career fields in relation to material in the classroom, acquire professional development hours and the financial assistance in terms of a summer stipend. Through the RET project, teachers began to view themselves as researchers, not in the traditional way of performing experiments in a laboratory and gathering data, but in gathering new engineering and educational information. They were able to develop real life scenarios for lesson plans that students could find relevant and experience a small part of engineering. Fifteen teachers were able to present their RET experiences at various conferences.

Additionally, three teachers were awarded a scholarship for graduate school, earning a Master of Education degree in Curriculum and Instruction. Teachers felt that the RET experience was one of the most rewarding teacher development programs for them.

DANIELLE REYNOLDS
Danielle Reynolds has 15 years of teaching experience, currently teaching high school Physics at John A. Dubiski Career High School in Grand Prairie, Texas. She earned her Master of Education in Curriculum and Instruction in 2011, and her Bachelor of Science in Physics in 1993, both from the University of Texas at Arlington. She was elected by her peers as Campus Teacher of the Year in 2011-2012 school year.

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Dr. Tanvir Manzur earned his Ph.D. in Civil Engineering from the University of Texas at Arlington in 2011. He earned his M.Sc. and B.Sc. from Bangladesh University of Engineering and Technology (BUET) in 2003 and 2006, respectively. He has almost 10 years of teaching experience at university level. Dr. Manzur is working as an assistant professor in the Department of Civil Engineering, BUET.