Using Problem-based Learning to Introduce Middle School Students to Engineering and the Engineering Design Process

Linda S. Hirsch, Ed.D.
Center for Pre-College Programs, New Jersey Institute of Technology

Introduction of the Next Generation Science Standards (NGSS) increased efforts to integrate engineering concepts and principles of engineering design into K-12 science curriculum, but progress has been slow. Many current teachers are not knowledgeable about engineering and/or schools have not given them adequate support. Summer enrichment programs designed to increase students' interest in the STEM fields can be instrumental in providing young students with essential engineering skills and informing them about careers in engineering so they realize the value of pursuing a career in engineering and the importance of obtaining the proper academic background to study engineering in college. The Center for Pre-College Programs at New Jersey Institute of Technology provides a variety of such summer programs. One of the programs, sponsored by ExxonMobil and the Harris Foundation, the ExxonMobil Bernard Harris Summer Science Camp (EMBHSSC), recruits 5th, 6th and 7th grade students from traditionally underserved and typically underrepresented populations who in addition to not being introduced to engineering in school are less likely to be exposed to engineering outside the classroom.

The academic curriculum for EMBHSSC, aligned with the NGSS focuses on 21st century skills and self-efficacy by providing an interdisciplinary, project-based learning environment that draws mostly on math, science, and technology and fosters essential 21st century skills such as problem-solving, communication, collaborative teamwork, imagination and creativity. At the start of the program students are presented with a real-life scenario that contains a core problem to be solved and are assigned to work in teams of four. Students receive an introduction to the Engineering Design Process (EDP), are taught how to apply the EDP in developing and testing a prototype, receive instruction in how to keep an engineering logbook and are required to make a presentation about their solution to the core problem. Presentations include an outline of how the EDP was applied and a demonstration of the prototype. In addition to classroom lessons, students participate in hands-on activities, laboratory experiments, team-building exercises, and go on field trips. Incorporating engineering principles, including the Engineering Design Process, into science and mathematics instruction through a problem-solving, inquiry pedagogy of this type stimulates students and helps them discover links between their lessons and engineering in the real world. Students need to recognize that scientific inquiry answers questions about the world as it exists while engineering develops solutions to problems people encounter in everyday life.

Results of pre-post evaluations conducted during the two most recent summers indicate that, in addition to significant increases in STEM content knowledge and their attitudes toward science, mathematics and engineering, most students demonstrated increased knowledge about careers in engineering and an understanding of the engineering design process at the conclusion of the program. In addition, a rubric has been developed to evaluate students' understanding and application of the EDP from their presentations. Evaluation of students' presentations using the rubric also indicated understanding and application of the engineering design process. Correlations among students' responses to the questions of the post-test related to the EDP and scores from the rubric have been found.