Inspiring and Building Tomorrow's Workforce: A K-12 Engineering Continuum

by Janet Yowell, University of Colorado at Boulder

When not skateboarding competitively, Carleigh Samson teaches middle school students in Longmont, CO, that engineering is about creating things for health, happiness and safety. Samson, a National Science Foundation-funded K-12 graduate engineering fellow and civil engineering graduate student at the University of Colorado at Boulder (CU-Boulder), engages students in hands-on engineering design projects so they can learn that engineering is about contributing to society in fun, creative ways. Samson is also part of CU-Boulder's **T**omorrow's **E**ngineers … cre**A**te. i**M**agine. **S**ucceed. (TEAMS) program.

After teaching math for several years at a public school in Baltimore, Samson moved to Boulder to pursue a master's degree in environmental engineering with a concentration on engineering for developing communities (EDC). Students enjoy hearing how engineering is a natural fit for her own passion to help third-world countries provide basic services for its rural communities.

"They are amazed how much engineering plays in bringing services to underdeveloped countries," Samson said. "This really gets them thinking about how important engineering is in their everyday lives, and the lives of those not as fortunate as most Americans." She hopes to spend time in Nepal or Peru next summer working on an EDC project.

Why teach engineering early and often?

Despite soaring U.S. college enrollments, the number of U.S. undergraduates completing engineering degrees peaked in 1988, with fewer graduates today than 20 years ago. And, the limited and decreasing participation of women and minorities in the engineering and technology fields is distressing. Clearly, the United States' intention to improve K-12 math and science education has proved disappointing, as compared to the international math and science performance of K-12 students.

Specifically, the persistently low student achievement among Colorado's high-poverty students is shocking. To help close achievement gaps, engineering offers a real-world application of the fundamental science and math principles that students learn early in their education. Schoolroom experiences in an engineering context provide a gateway to creative, real-life problem solving and exploration in all areas of science and math. By experiencing the engineering design process first hand, students begin to see how engineering ingenuity and inventions touch and shape their everyday lives, and they begin to develop a self-identity that encompasses a technological future.

An engineering education creates access to the American dream and should provide people from all backgrounds the opportunity to share in that dream. Although society is becoming more technology-driven, the number of women and underrepresented students who are prepared to contribute to this technological revolution is shrinking at an alarming rate.

Sadly, the U.S. education system is not equipped to adequately arm K-12 students with the tools to succeed and compete in science, technology, engineering and math (STEM) fields. Our oftentimes poor performance in teaching math and science discourages youth from joining

the ranks of tomorrow's scientists and engineers; thus, today's students show decreased inclination to choose STEM futures. Research tells us that K-12 students do not consider math and science as professionally relevant, which tragically closes off future career pathways as early as the sixth grade. This is a crisis for the United States' productivity and future, and continuing down this path will greatly diminish our nation's capacity to perform.

A key objective of CU-Boulder's Integrated Teaching and Learning (ITL) Program's mission (http://itll.colorado.edu) is to influence disadvantaged—but academically-capable—K-12 students to consider engineering as a potential career. The multi-faceted K-12 engineering program targets Colorado students who are traditionally underrepresented in the engineering profession: low-income youth, first-generation college-bound youngsters, children of color and girls. The program seeks to develop innovative programs based on the research concerning achievement gap barriers to afford K-12 students the technological literacy necessary to succeed in an increasingly competitive society.

Samson is not alone in her passion for teaching engineering. This year, through the TEAMS Program, five graduate engineering fellows use engineering as the vehicle to integrate hands-on science and math to impact more than 1,600 students weekly via in-class engineering instruction and after-school engineering clubs in about 50 classrooms in nine high-needs schools in Longmont and Boulder.

The use of age-appropriate engineering curricula that integrates science and math, builds on the wonder of hands-on, scientific inquiry and couples it with logical thinking and reasoning skills is a proven, effective approach.

Through the TEAMS Program, engineering fellows exchange content and pedagogy with the K-12 community, and develop and deliver hands-on, standards-based STEM curricula, which is published in the TeachEngineering (www.teachengineering.org) digital library, also funded by the National Science Foundation.

The TEAMS vision is to provide students, regardless of circumstance, with the opportunity and preparation to pursue an engineering education. Engineering is known as a compelling framework for other STEM educational endeavors, such as pursuit of medical school. Engineering—the creative and inventive use of science, math and technology to serve human and environmental needs—is a way to engage young girls and boys that transcends and builds on science and math study.

Why learn engineering?

In the TEAMS approach, fundamental and often theoretical K-12 science and math concepts become more relevant and accessible to young students when presented within the context of the applied world of engineering. Program results show STEM content learning is dramatically enhanced through inquiry-based curricula and creative designing, building, testing and evaluating experiences. By gaining an understanding of the pervasiveness of engineering in their world, students become aware and appreciate how engineering is fundamentally about creating things for the benefit of humanity and the planet. With this approach, the TEAMS Program expects to grow the pipeline of disadvantaged Colorado students to STEM studies.

Engineering complements the science and math concepts taught in K-12 classrooms,

anchoring the concepts from an applied perspective that makes engineering relevant to the lives of youth. These real-world applications address the question of "why are we learning this?" and help students become more intrigued in learning. Through early engineering experiences, students also understand the societal relevance of the science and math they study.

Furthermore, early engineering experiences and education promote technological literacy and prepare tomorrow's adults to make well-informed choices in their healthcare and other facets of their lives. Creating a citizenry, as well as a workforce, prepared to understand and engage in complex subjects and apply its knowledge and skills to create new processes and products will help ensure our presence at the global economic table. True, it's about technological literacy, but it's also about the continued innovative strength of the nation.

The ITL TEAMS Program at CU-Boulder is committed to fostering academic excellence to prepare Colorado K-12 students to become tomorrow's engineering leaders and provide affordable higher education opportunities to strengthen the nation's economy and future.

Janet Yowell is the K-12 engineering education coordinator for the University of Colorado at Boulder's College of Engineering and Applied Science's Integrated Teaching and Learning Program. She oversees the program's ambitious K-12 engineering initiative, including its capacity-building and school partnership programs, as well as recruiting, access and retention efforts. She is a contributing curriculum writer and editor for the TeachEngineering digital library. Yowell earned a bachelor's degree in communications from CU-Boulder. For more information on the TEAMS program or CU-Boulder's ambitious engineering education efforts, contact Yowell at janet.yowell@colorado.edu.

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Carleigh Samson (left), middle-school teacher and current graduate engineering student and K-12 Fellow at CU-Boulder.

Fourth-grade students (below) in Lafayette, CO, learn about solar energy and how it relates to engineering through designing and building a working solar oven.