Innovation in Everyday Life:
Making Engineering Come Alive for the K-12 Community

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Abstract — This paper describes the challenges inherent in developing an extensive outreach program, explores strategies for gaining internal and external commitment to the program, and recommends an approach to initiating a program at other institutions.

In-te-grate (In’ ti-grat’) v. 1. To make into a whole by bringing all parts together; to unify.

Imagine a Learning Environment Where…

• The science of sound and music are explored as children design and build musical instruments
• Elementary children explore via pendulums, energy, momentum and more, the world of kinetics
• Middle school teams take apart and reassemble motors and explore sensor use in everyday life
• Middle school children and teachers delve into the role of fluid mechanics in their daily lives
• Teenage “engineers” design to minimize harmful impacts of human activities on the environment
• First-year engineering students create a “tornado in a box” for a middle school meteorology class
• Engineering students invent a prosthetic device to improve an injured classmate’s gripping strength
• Arbitrary barriers of age and grade disappear as K-16 students navigate the world of technology, and
• Students understand, through experience, that engineering is about building things to help people.

All of this — and more — is happening today at the University of Colorado at Boulder in the College of Engineering and Applied Science’s Integrated Teaching and Learning (ITL) Program. The college-wide ITL program models the real world of engineering where skills in communication, teamwork, and leadership, as well as the ability and self-confidence to define and solve open-ended problems, are demanded. To better meet tomorrow’s challenges, our educational methods have expanded to exploit teaming, active and group learning, and project-based design and problem-solving experiences. Concepts of innovation, entrepreneurship and invention are explored first-hand in interdisciplinary, product-oriented design/build classes. As engineering educators, we have come to understand that creating a seamless K-16 partnership is vital to our engineering mission and to society.

To create a K-16 learning community in which students, K-12 teachers and the College of Engineering explore, through hands-on doing, the role of innovation and engineering in everyday life. And, to appreciate and apply the art of engineering and invention through designing and building solutions to meet the needs of society.

—K-16 Integrated Engineering Outreach Vision Statement
The ITL program reaches beyond the campus walls and deep into the K-12 community; we intend to become a national leader in the integration of engineering principles and practices into the K-12 community. Our K-16 Integrated Outreach program engages undergraduate engineering students and faculty with the broad K-16 community of learners. Arbitrary barriers of age and grade level fall away as students acquire and integrate first-hand knowledge in science, mathematics, engineering and technology. Engineering students are enriched as they:

- Design and build devices to serve the broader K-12 community
- Help develop and teach summer K-12 engineering classes
- Participate in invention and design initiatives throughout their undergraduate experience
- Create a comprehensive on-line science education and technology resource
- Mentor K-12 students, especially those from traditionally under-served populations

CU engineering students learn by doing, teaching, and engaging in relevant, real-world problem solving. Pre-college students and K-12 teachers come to better understand the rewards and challenges offered by a career in engineering. The three inter-related ITL K-16 integrated outreach program components are: Design for the Community, Innovation and Engineering in Everyday Life, and Advancing Under-served Audiences.

**Design for the Community** — Building upon highly successful pilot projects, engineering students design and build sophisticated client-based projects that anchor their learning experience while creating useful engineering products for the community. We’ve learned that students work harder and learn more when their products meet the needs of real-world clients. Students design and build products in the areas of:

- **Assistive Technology**—custom products designed and built by students to aid people with disabilities
- **Museum Exhibits**—prototyped and finished for science and youth museums in Colorado
- **Interactive Learning Exhibits**—designed and fabricated for elementary and middle school classrooms

Products from recent semesters include a specialized bed for a child with Down Syndrome, a portable desktop tornado, an interactive bubble exhibit that illustrates the effects of varying gas densities, and a demonstration of the ability of various soils to buffer acid rain. These client-based projects model the possibilities for new university/community collaborations while benefiting individuals and institutions.

**Innovation and Engineering in Everyday Life** — This initiative promotes standards-based science, mathematics, and technological literacy by developing interactive, hands-on pre-college mathematics and science-based engineering activities and curriculum. Many states have established K-12 educational standards; however, many of the changes taking place in K-12 education are unrecognized, or poorly understood, by most university engineering faculty and students. Our Innovation and Engineering in Everyday Life program is targeted to change this, by developing exciting new standards-based workshops for K-12 students and
teachers. By establishing formative feedback between K-12 and higher education, CU engineering faculty become more aware of pre-college, standards-based preparation. An advisory board involving engineering faculty and K-12 mathematics and science teachers created standards-based workshop design criterion. With the help of the advisory board, CU K-12 engineering workshops incorporate many of the recent insights gleaned from the National Council of Teachers of Mathematics and the National Research Council on effective professional development activities for K-12 students and teachers. By building on the successes and partnerships established by the NSF-funded State-wide Systemic Initiative (CONNECT Colorado), two parallel elements of the Innovation and Engineering in Everyday Life program were developed:

Engineering Workshops for K-12 Students and Teachers — Engineering faculty and students develop hands-on activities, curriculum modules, and resource guides that form the basis for upper elementary, middle, and high school student and teacher training workshops. The program has two components: weeklong “Innovation and Engineering in Everyday Life” workshops for K-12 children, accompanied by week-long design and build workshops for teachers. “Go With the Flow,” “Too Hot to Handle” and “Kinetics for Kids” are middle school-level fluid mechanics, thermodynamics and kinetics workshops. “Green by Design,” “The Sounds of Music,” and “How Do Things Work?” are hands-on, ears-on and minds-on workshops for elementary and middle school children, to be further developed by summer 2000 as K-12 teacher workshops. As we learn more about what students are capable of, the integration of more design and build, invention-based workshops will be added, tested and evaluated.

Creation of Dynamic ITLL K-12 Web Site and Networking Opportunities — The excitement and learning experienced by teachers attending workshops during the summer programs reaches others through a designated web server housed in the ITL Laboratory. All learning materials are posted on a web site during teacher workshops to encourage networking among workshop participants and dialogue with others interested in the subject matter, as well as to ensure that teachers are comfortable with use of the World Wide Web. When teachers return to their classrooms they are encouraged (and coached) to stay connected to each other via a private web site to share successes, trouble-shoot problems, and maintain contact with CU content specialists. Workshop participant learning is assessed during the workshops and throughout the following school year to track their progress in using these new resources.

Advancing Under-Served Audiences — The goal of equity in education is to ensure that all students have access, opportunity, participation and success in mathematics and science. Our College currently has successful Women in Engineering and Minority Engineering Programs. The successes of these two programs is enhanced by providing hands-on learning experiences that expose students to the challenging and fun world of engineering at critical points in their K-12 careers when they can still make pivotal academic and life
choices. Innovation and Engineering in Everyday Life outreach initiatives targeted at under-served audiences include:

- Pre-college experiences for children of color to expose them and their families to the exciting world of engineering and invention
- A summer design/build engineering course for high school students before their senior year
- Pre-college workshops for rural students that motivate technology-based careers
- Development, piloting, and refinement of a concentrated summer Engineering Projects course designed to “jump-start” first-year engineering students considered “at-risk”

**Conclusion** — The ITL program strives to model engagement of engineering colleges with the K-12 community in order to attract more and more diverse students to the challenging and rewarding profession of engineering. CU engineering students and faculty demonstrate that *engineering is about building things to help people* while K-12 students and teachers explore the joys and frustrations of engineering. The ITL Laboratory is becoming a regional center for exploration of science, technology and invention by Colorado teachers and children. Preparing K-12 students with the skills necessary to flourish in an increasingly technological world becomes more challenging every day. Beyond the pipeline issue—nurturing enough motivated students to study engineering and technology—lingers a growing concern for general technological literacy. The more members of society who understand the nature of technology, how it transforms social systems, and the ramifications of technology on culture, the greater likelihood we as a nation will continue to innovate, invent and prosper.

*Proceedings, 1999 National Collegiate Inventors and Innovators Alliance*

Annual National Conference, Washington, DC, March 1999