

Inspiring and Engaging the Next Generation in STEM Through PLTW and REAL

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ABSTRACT

Our nation's shortage of engineering graduates is an issue in which higher education institutions have placed ongoing efforts. Recently, a greater emphasis has been designated to increasing the number of underrepresented groups that would account for a diverse pool of well qualified engineers (Genalo et al., 2000). The College of Engineering (CoE) at California State Polytechnic University, Pomona (Cal Poly Pomona), a Hispanic Serving Institution, is committed to increasing the number of individuals within engineering, including women and underrepresented students, through the implementation of various programs that promote early engagement in K-12 schools. The CoE at Cal Poly Pomona has taken an approach that engages and inspires the next generation of engineering students through comprehensive outreach that incorporates middle and high school engineering curriculum through Project Lead The Way (PLTW), elementary school exposure through the Robotics Education through Active Learning (REAL) Program, and the fostering of student implemented K-12 outreach that serves the dual purpose of retention for our current students and outreach.

Keywords: STEM, Conference Proceedings, K-12 Outreach, Engineering

INTRODUCTION

Globally, the United States is trailing behind other countries in the number of science and engineering bachelor degrees being awarded, accounting for only 11% (NSF, 2011). With recent U.S. Census Bureau demographic trends indicating that by 2050 ethnic and racial minorities will account for approximately half of the population, it is imperative for our STEM (Science, Technology, Engineering, and Mathematics) higher education system to be aligned with these changes and to create a pool of diverse well-qualified engineers (NSF, 2011). The College of Engineering (CoE) at California State Polytechnic University, Pomona (Cal Poly Pomona), a Hispanic Serving Institution, implements several components that are meant to inspire and engage K-12 students in engineering with a specific focus on underrepresented groups, including women, through hands-on activities and curriculum that sparks interest from an early age. Through PLTW, Cal Poly Pomona exposes and engages middle and high school students to engineering by means of training their teachers with a "project-based" curriculum and the implementation of said curriculum within their classrooms. Elementary school students are exposed to engineering through the REAL Program and student-organization run outreach that include hands-on activities that both engage and inspire students.

LITERATURE REVIEW

Exposing K-12 students to engineering at an early age is key to creating a successful educational pipeline that will eventually lead to a higher education institution (Kimmel et al., 2007). Research shows that, "interest in science and math is fading in American children, resulting in fewer students seeking education and professions in engineering" (Crawford et al., 1994; Jeffers et al., 2004). An additional factor playing a role in a lack of student interest in engineering, "is

the limited understanding of the engineering profession...[and]...that many K-12 teachers have no idea what engineers actually do” (Fadali et al., 2000; Jeffers et al., 2004). Outreach should engage K-12 students in engineering hands-on activities that develop their skills and interest in this field and allows them to understand the impact of engineers on society, in addition to effectively training K-12 teachers in engineering curriculum.

K-12 OUTREACH COMPONENTS

Project Lead The Way (PLTW)

Cal Poly Pomona is committed to increasing the number of underrepresented groups within engineering through the implementation of various programs that promote early engagement in K-12 schools. CoE is a regional training center for the national non-profit organization PLTW that provides project-based, engineering and engineering technology curriculum to middle and high schools in order to “inspire” and “engage” students in engineering fields. Through the success of PLTW at Cal Poly Pomona we have been able to establish partnerships with 154 schools in our service area and engage students of participating schools in engineering. The percent of Cal Poly Pomona Engineering First Time Freshmen from PLTW schools has increased from 9% in fall 2009 to 19% in fall 2011. At the national level, PLTW reports that PLTW alumni are, “5 to 10 times more likely to pursue engineering and technology classes than other first-year college students,...[in addition to having] on average a GPA 0.21 points higher” (PLTW, 2011). Approximately, “97% of PLTW alumni said they planned to pursue a four-year degree as opposed to 67% of non-PLTW students” (PLTW, 2011). This program not only assists in exposing students to the engineering field, but also offers professional development to their teachers in an effort to effectively prepare them to implement innovative problem-based learning curricula in their classrooms. PLTW creates a sustainable form of engagement and outreach in engineering since teachers are trained to offer the engineering curricula starting at the middle school level and continuing into participating high schools. In addition, we work closely with PLTW schools to provide their students with experiences that allow them to visit our college laboratories and interact with current engineering students through various hands on activities as a means of enriching their engineering higher education knowledge. Through PLTW Cal Poly Pomona is able to confront problems that hinder student engineering interest, such as a lack of knowledge about the field and the development of essential skills, by means of training teachers and the implementation of engineering curriculum within their classrooms.

Robotics Education through Active Learning (REAL) Program

Engagement of elementary students is implemented through our REAL Program, which is an innovative approach to training elementary level teachers and providing them with age appropriate curriculum for their students to learn and apply robotics. After 20 weeks of learning, the participating schools partake in the culminating annual Robot Rally that allows students to show off their creations in four events that are fun, engaging, and demanding. It has been found that, “young children are inherently active with strong impulses to investigate...construct things, and to create, in other words a child is a natural engineer” (Genalo et al., 2000). A cultivation of hands-on activities, such as those employed by the REAL program, assist students with the development of the skills necessary to, “develop their engineering intuition” (NRC, 1996; Erwin, 1998; Jeffers et al., 2004). The robotics curriculum allows students to engage in a multidisciplinary field that develops critical thinking skills, problem solving strategies, team skills, and provides hands-on experience that builds confidence by allowing students to realize

that they can attain goals, such as building their own robot. The REAL program has served over 1,000 students of which 85% are underrepresented minorities and 50% are girls. The REAL Program allows for the development and hands-on experience of essential skills necessary to creating interest and success in engineering by building and testing their robot designs.

Outreach Led by Student Organizations

Although REAL and PLTW provide outreach and curriculum to K-12 students, CoE also fosters K-12 outreach activities organized by student club organizations that serve a dual purpose, including retention through the increase of student involvement on campus (Astin, 1999). The University student chapter of the Society of Women Engineers is a great example of the nationally recognized outreach that is being conducted with their Youth Engineering Success (YES!) day, which exposes middle and high school girls to engineering disciplines, generating a pipeline of women who may one day choose engineering as a career. With the support of CoE, student organizations are able to develop outreach activities that expose K-12 students to engineering through hands-on activities.

CONCLUSION

Overall, a great effort is being placed on bringing exposure of engineering to K-12 students and creating awareness for all groups, including underrepresented students. In an effort to produce quality programs, we survey event attendees and/or program participants along with implementing debriefing sessions for faculty and staff involved in order to provide recommendations and improvements for the programs. Survey instruments and debriefing sessions allow us to continuously improve our programs and events in a manner that allows us to have the most impact. An in depth analysis through quantitative and qualitative data of the impact that these components are having is our next step in developing a best practices plan.

REFERENCES

- Astin, A.W. 1999. Student involvement: A developmental theory for higher education. *Journal of College Student Development*, 40(5), 518-529.
- Crawford, R. H., Wood, K. L., Fowler, M. L., & Norrell, J. L. 1994. An engineering design curriculum for the elementary grades. *Journal of Engineering Education*, 83(2), 172–181.
- Erwin, B.1998. K–12 education and systems engineering: A new perspective. *Proceedings, 1998 ASEE Annual Conference, American Society for Engineering Education*. Washington, D.C.
- Fadali, M. S., Robinson, M., & McNichols, K. 2000. Teaching engineering to K–12 students using role playing games. *Proceedings, 2000 ASEE Annual Conference, American Society for Engineering Education*. Washington, D.C.
- Genalo, L. J., Bruning, M., & Adams, B. 2000. Creating a K–12 engineering educational outreach center. *Proceedings, 2000 ASEE Annual Conference, American Society for Engineering Education*. Washington, D.C.
- Jeffers, A. T., Safferman, A. G., & Safferman, S. I. 2004. Understanding K-12 Engineering Outreach Programs. . *Journal of Professional Issues in Engineering Education and Practice*, 130(2), 95-108.
- Kimmel, H., Carpinelli, J., & Rockland, R. 2007. Bringing engineering into K-12 schools: A problem looking for solutions?. *International Conference on Engineering Education*.

Coimbra, Portugal.

National Research Council (NRC). 1996. National science education standards. *National Academy Press*. Washington, D.C.

National Science Foundation (NSF), Division of Science Resources Statistics. 2011. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2011*. Special Report NSF11-309. Arlington, VA. Retrieved from <http://www.nsf.gov/statistics/wmpd/>.

Project Lead the Way (PLTW). 2011. *Outcomes*. Retrieved from <http://www.pltw.org/educators-administrators/outcomes>.

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