AC 2008-1876: OPPORTUNITIES FOR ENGINEERING EDUCATORS THROUGH PARTICIPATION OUTREACH ACTIVITIES

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Opportunities for Engineering Educators through Participation

Outreach Activities

Abstract
While community outreach programs and recruiting campaigns are common to all engineering programs, engineering educators often overlook opportunities for professional development found through participating in these activities. For example, an engineering educator might volunteer as a judge for a local science fair competition, serve as a mentor for a community improvement project, and maintain the more traditional activities of teaching and research in engineering classroom, yet participate in each activity as a separate event instead of incorporating these programs and activities to other areas of application. Our paper examines the opportunities to forge connections between college outreach programs and the processes of "continuous improvement" as professional engineering educators through the example of one such program in our own institution.

Our experiences with the 2007 Canstruction® competition are included as a model applicable to multiple concepts of civil engineering courses. We begin by discussing the "live" characteristics of value found in the Canstruction® project including the preparatory requirements, participants involved, and the competition's overall contribution to engineering education. We then discuss the "dormant" opportunities for civil engineering students and educators to use links between programs such as the Canstruction® project and existing curricular content such as promoting multi-level mentorship and "real-time" problem solving activities.

Additional advantages of such links include opportunities for expanding instructional methods and addressing critical crossover areas of the revised *Criteria for Accrediting Engineering Programs* (ABET)[1]. Throughout our discussion, we also share our experiences with related pedagogical theories and instructional strategies for customizing similar programs in existing undergraduate engineering courses. More specifically, we explore areas for engineering students and educators to engage in life-long learning experiences through participation in such programs.

Introduction

Despite the increasing number of community outreach and recruiting programs in most engineering programs, engineering educators often overlook multiple opportunities to emphasize curricular areas of alignment with existing undergraduate engineering courses. The purpose of this paper is to examine methods of forging more explicitly defined connections between course-level engineering content and learning opportunities and these community outreach and K-12 programs. More specifically, we explore areas for engineering students and educators to engage in life-long learning experiences through participation in such programs.

We begin with our interpretations and definitions of life-long learning in relation to the field of professional engineering. Next, we identify "dormant" stakeholders as engineering students and faculty while emphasizing both educational and professional benefits of participation in community outreach and K-12 experiences in engineering education. Our examples are drawn from our own experiences as organizers and participants of such programs at our university and the lessons-learned from other engineering educators. We conclude by highlighting potential areas of alignment between the engineering content contained in such programs and our own course-level pedagogical theories and instructional strategies in hopes of urging other engineering educators to explore and expand such ideas at their own institutions.

Background

We have limited our discussion in this paper to highlight the benefits of participation in outreach activities primarily to engineering educators as program participants. Essentially, our question is quite simple:

> *Why is it important for engineering educators to support community outreach and K-12 programs in engineering education?*

Our answers to this question are presented in three sections:

- Section 1 examines the perception of value of outreach activities from the perspective of engineering educators. Essentially, most of us allocate the most of our time and resources in the areas we perceive as important. This section explores links between perceptions, participation, and perspectives of ordinary engineering educators.
- Section 2 presents our own experiences as participants in the 2007 Canstruction® competition;
- Section 3 addresses the potential crossover areas between educational value, professional value, and life-long learning skills for engineering educators.

Section 1: Perceptions of Value between Engineering Educators and Outreach Activities

The purpose of this paper is to address the multi-level, multi-dimensional learning opportunities for engineering educators through participation in outreach activities, and the first step in doing so is by establishing credibility through previous research findings in this area. We have addressed our questions from three perspectives that appear consistently throughout previous research studies: (1) Applicational values, (2) Professional values, and (3) Situational values. These terms have been applied to previous instructional methodology, and we believe that they appeal to an engineering educator's inquisitive nature by asking questions and generating answers. Each perspective is summarized briefly as follows:

> (1) Applicational values describe theoretical concepts of learning and cognition by presenting educational research supporting higher levels of learning for students who are able to apply content knowledge to procedural knowledge. In other words, applicational

values examine the importance of participation in outreach activities by addressing this question:

> *How do we know that knowledge from outreach activities is relevant to the engineering students we teach?*

(2) Professional values examine how engineering educators can use outreach activities as opportunities for professional growth. Essentially, this perspective asks the question:

> *How is participation in outreach activities relevant to my role as an engineering educator?*

(3) Situational values extend the scope of outreach activities to include potential long-term implications and benefits for ALL outreach activity participants. Analysis of situational values addresses this question:

> *What long-term implications have been reported by different types of outreach participants as a result of participation in outreach activities?*

Each of the three perspectives is presented in greater detail in the following sections, and while each section presents different information, please note one consistency throughout this discussion. This consistency is the value of each perspective, and value is the thread that connects the perspectives to each other, then extends the explanation to the larger issues of how/if these values are important to engineering educators. When combined, we believe these values respresent characteristics of lifelong learning through voluntary, active participation as engineers and engineering educators.

Background Information of Applicational values:

Applicational values represent "real-time" opportunities for increased levels of cognition, comprehension, and evaluation of knowledge when there is a clear path between "learning" and "doing". Essentially, application opportunities occur when students are able to link theoretical concepts of engineering (learning) to "real-time" examples and activities (doing). Participation in outreach and recruiting programs provides opportunities and experiences for students of all levels to create these neural links, and research studies have suggested higher levels of long-term learning. For example, recently published research findings by Mahalik, Doppelt, and Schunn suggest that middle school and high school students achieve higher degrees of content retention when conceptual information is linked to examples[2].

These findings support Bloom's Taxonomy of Learning (1956, 2001) both the original and revised versions. According to Bloom's Taxonomy, there are lower-order levels of learning such as remembering and understanding, and there are progressively complex higher-order levels such as synthesis and evaluation. Higher-order levels of learning cannot be achieved before lower-order levels of are mastered[3,4]. For engineering educators, these ideas suggest that if content information is presented in a manner that allows the student to access and match previous

knowledge to new concepts through use of an example, the new information is more likely to be retained[5].

In addition, results of Mahalik, et. al's 5-year longitudinal study also found links between students' problem solving strategies and the concept of relevance. In the same way that use of examples promotes higher degrees of higher-order levels of learning and comprehension, Mahalik et.al suggested a method of teaching to design instruction around those principles. Their findings suggested that instructional methods that followed a consistent trend of introducing new content within the context of how, when, and where the knowledge can/will be used resulted in higher levels of learning and comprehension[5].

Relevance to Engineering Educators:

Longitudinal studies performed by Kilgore, et al. extends these findings to undergraduate student learning patterns as well[3]. Following a study of 160 undergraduate engineering students at 4 separate U.S. universities, the researchers concluded that effective problem solving skills and learning strategies are strongly related to students' ability to recall conceptual information through understanding the contextual background of a problem.

Such knowledge is relevant to outreach activities in several ways. Participating in outreach activities demands conceptual understanding, and programs that encourage undergraduate students to function as mentors for other students provide a means of reinforcing both conceptual and procedure learning through basic processes of *seeing* and/or *doing*.
Knowledge of these processes of cognition and learning combined with observation of such skills in action allows engineering educators to more accurately assess a student's real understanding of a concept.

Background Information: Professional values

While the applicational value of outreach activities describes engineering educators in a primarily academic environment, the professional value perspective includes a wider view of engineering educators as practicing members of a professional community.
Consider the common issue of stereotypes associated with engineering professionals: Researchers in engineering education have long been concerned about the public's misperceptions of engineering as a professional field. Henry Petroski makes this point succinctly by summarizing an excerpt of an e-mail distributed to professional engineers in Texas from the Executive Director of the Texas Board of Professional Engineers[4]. In the excerpt, the Director described the field of engineering as "the most unrecognized occupation in the world". Ironically, his e-mail coincided with National Engineers' Week, 2007.

Active participation in outreach activities offers opportunities for engineering educators to challenge such stereotypes. In addition, some people maintain illusions regarding a university professor's familiarity with the realities of "real-life". Participation in community forums and outreach activities often include opportunities for informal types of interaction—in other words, engineering professors have a chance to dispel dated ideas by participating in such activities to model the engineer of the 21st century. These types of activities also encourage engineering

educators to assume active roles within the community. Examples include attending professional meetings such as the American Society of Civil Engineers (ASCE), speaking at local school recruiting functions, and interacting with alumni[5]. In essence, these activities are a valuable means of presenting "real-time-realism" with multiple community constituents.

Background Information: Situational value

While the primary focus of this paper relates to engineering educators as a target audience for joining college and university-level outreach programs, other audience members play significant roles in such activities. In general, outreach activities involve interaction between a broad range of people who share some common identity, and situation value refers to potential benefits for *all* participants in outreach programs. ABET critieria defines all target audiences of engineering outreach programs as "program constituents," meaning that each member represents a valuable point of contact for the sponsoring engineering college. Examples of constituents include the program participants (usually students), their parents, K-12 teachers, guidance counselors, and administrators, and all members of the local community, including local professional representatives from industry and employers.

Research studies have indicated that outreach programs often have potential benefits for *all* participants. Consider the issues of recruiting and retention, for instance. Recruiting engineering students is difficult enough—retaining them has become somewhat of a dire predicament for many engineering recruiters. Research findings conducted at the Colorado School of Mines documented examples of these positive benefits. Their findings from four separate, NSF-funded community outreach programs involving middle and high-school science and math teachers, their students, and undergraduate engineering students described benefits for all participants.[6] Specifically, the middle-school and high school teachers reported increased mastery of subject content in their classrooms following the outreach activities. In addition, the teachers reported a social benefit too: final survey data indicated that the teachers enjoyed the informal means of interaction with program faculty from the sponsoring university and their undergraduate and graduate engineering students.

The targeted audience of learners in these programs were middle-school and high-school students enrolled in physics courses, and their responses following the outreach activity involved multiple categories of benefits. In addition to increased scores on the national Colorado Student Assessment Program tests, the students reported increases in social areas as well. Students reported increased interest in science and mathematics along with increased interests in pursuing college-level study.

The Memphis City Schools District reports graduation rates of approximately 69.5%, and while this rate has increased in the past five years, it still translates into roughly seven recruitable candidates for every ten students in our local city school system[7]. Research findings such as those described at Colorado School of Mines Preparation emphasizes the critical point is that establishing relationships with university professors is important. Outreach activities promote interest—for everyone.

Section 2: Program Example: 2007-2008 Canstruction®

Program Overview:

The outreach activity used as the primary example in this paper is an annual competition that takes place at The University of Memphis, a large urban university comprised primarily of commuter students. An international competition was selected, and our University serves as a "host site". Trademarked by the Society for Design Administration, and working in tandem with the American Institute of Architects and other members of the design and construction industry, Canstruction® is making a significant contribution to the fight against HUNGER. Canstruction® combines the competitive spirit of a design/build competition with a unique way to help feed hungry people. Competing teams, lead by architects and engineers, showcase their talents by designing giant sculptures made entirely out of canned foods. At the close of the exhibitions all of the food used in the structures is donated to local food banks for distribution to pantries, shelters, soup kitchens, elderly and day care centers (www.canstruction.org).

The Herff College of Engineering hosts the Memphis Canstruction® competition, which is organized by the West Tennessee Branch American Society of Civil Engineers (ASCE) Younger Members group. The Memphis Canstruction® competition is a unique, non-profit, multi-disciplinary design competition where high-school students interested in Science, Technology, Engineering, and Mathematics (STEM) fields work in teams with science and math teachers, undergraduate civil engineering student mentors, and faculty members from local universities to build structures from unopened cans of food purchased through support of local consulting firms.

Section 3: Educational Values, Professional Values, and Life-long Learning Skills

In addition to ASCE student chapter mentors, each high school team is also provided a professional mentor from the Memphis civil engineering consulting community. The professional mentors meet with the high school groups and provide additional insight to the challenges students faced in designing their structures within the constraints imposed by competition rules, and explain the connections to engineering practice. A judging panel is assembled from local professionals, including civil engineers and civil engineering faculty. This results in an opportunity for interaction between faculty and consultants, and between these professionals and both the college and high school students. In addition, the competitions are held at The University of Memphis, and this offeres student participants, teachers, and parents the opportunity to interact informally with other faculty members and academic advisors, engineering students, and local ASCE members. Further details are available at our 2008 website: http://www.ce.memphis.edu/asce/canstruction.htm

Interestingly, these opportunities for learning are not limited to student participants—research studies suggest that similar opportunities for learning exist for other outreach activity participants. Studies have indicated that engineering educators are able to apply these theories to assessment and evaluation of students' overall comprehension of content knowledge through working "with" student participants in outreach activities. These types of shared outreach experiences offer educators unique opportunities for assessment that isn't possible in a traditional classroom or lab environment. Instead, participation in outreach activities often allows educators

are to assess students' levels of comprehension of conceptual knowledge by observing the range of interactions that take place between engineering students and other participants in the outreach activity.

Pedagogically, the Canstruction® competition offers an opportunity for engineering educators to link previous competition designs to principles of structural design. Instructors are able to use the physical designs to provide a shared context for comparative and contrasting analyses. Curricular content such as the elements of statics and principles of structural design were reinforced through the rules of the competition and supervised construction of the structures. Competition entries are required to be structurally self-supporting (items such as card board or foam core are permissible only as leveling material). Teams that successfully create their designs completely from cans (i.e. no use of tape, string, Velcro, or other allowable materials) receive higher scores in the Structural Ingenuity category. Engineering student volunteers experienced occasional frustration in re-phrasing these concepts to the high-school team members in terms that made sense to them. According to one of the student volunteers, "it was a constant balance in talking about what the student groups *wanted* to do, and what was actually *possible* to do"[9]. Comments such as these provide evidence of the students' abilities to apply theoretical and conceptual knowledge to "real-time" problem solving activities in a manner that conventional assessment methods do not.

Conclusions

The educational value associated with the Canstruction® competition has not been limited to the competition period alone; instead, the period of preparation and post-project reporting has expanded to include a standing committee of ASCE Younger Members in the West TN branch. In addition, both professional engineers and engineering faculty members meet throughout the academic year with the undergraduate student volunteers to plan and organize the upcoming competition. Changes for the 2008 Competition will include assessment measures to obtain feedback representative of the wide range of participants, and it is hoped that this feedback will yield valuable insights at this formative stage of program evaluation.

Finally, one of the more meaningful benefits of this competition includes the opportunity for engineering educators and engineering professionals to model community service, charitable contributions and outreach to the both the engineering and high school students. The 2007 competition raised 6,024 pounds of food for the Memphis Food Bank. We have attempted to share our interpretations of the benefits related to participation in outreach and recruiting programs such as the as 2007 Canstruction® competition.
Advantages include opportunities for increased levels of participation in local and regional professional engineering communities while also offering ideas for expanding instructional methods. We conclude by encouraging other engineering educators to explore and expand such ideas at their own institutions.

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