Developing Professional Skills through Student-Run STEM Outreach Activities

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Abstract

Successful engineers need sound technical skills coupled with a wide range of professional skills. Villanova University students have opportunities to develop these professional skills through a student-run, service-learning activity called NovaCANE (acronym for Villanova Community Action by New Engineers). NovaCANE was established in 2009 with the goal of inspiring middle school students' curiosity and creativity towards technical issues through hands-on lessons and activities. The organization was initially limited to graduate students in structural engineering and focused on the 6th grade at an inner city school. The organization has transitioned over the past 6 years into a largely undergraduate club with numerous urban and suburban schools participating. Student teams from all discipline areas (Civil and Environmental, Chemical, Mechanical, and Electrical and Computer) visit several schools and complete projects with 6th, 7th and 8th grade students with the themes of infrastructure, green engineering and chemistry, and mechanical/electrical engineering, respectively. The program culminates in a campus visit by the middle school students for more in-depth projects and laboratory demonstrations. Undergraduates coordinate schedules with the schoolteachers and develop and deliver the technical content and activities. These responsibilities require the engineering students to draw on critical skills such as organization, communication, leadership, teamwork, management and creativity. Undergraduates that participate have opportunities to continue in the program through their graduate studies. As with many service-learning activities, all participants become learners and are enriched by the shared experience.

Background

Villanova Community Action by New Engineers (NovaCANE) is a service-learning program established within Villanova University's College of Engineering in 2009. The group aims to develop excitement and interest towards engineering careers, especially among under-represented groups, by offering hands-on educational activities in engineering and science at host schools. The initial group membership was primarily focused on graduate students and upper-class undergraduates[1] but has transitioned to more significant undergraduate membership. This is consistent with a strong service-learning commitment among Villanova undergraduates and the faculty.

The founding group was comprised of primarily civil engineers who created activities associated with structural engineering for sixth grade students. Due to interest expressed by the host schools, the content has expanded to include a seventh grade group that focuses on green engineering and sustainability concepts (primarily presented by chemical engineering students) and is developing an eighth grade group that addresses themes in mechanical and electrical engineering.

Goals of NovaCANE

The objective of NovaCANE is to inspire the next generation of engineers by sharing the enthusiasm of current engineering students and demonstrating the basic concepts of engineering. NovaCANE has established host sites through requests of local school administrators or teachers and has developed unique relationships with each school to best serve their needs.

Although the original concept of NovaCANE was to giveback to the next generation of students, this service program provides ample opportunities for Villanova students to strengthen professional skills that will support their own careers. There are many leadership positions, such as club officers, site coordinators, supply managers and activity presenters that require students to organize and plan visits to the host schools. From arranging volunteers, to scheduling site visits, to ensuring the pick-up and drop-off of supplies, to preparing for and delivering the presentations, students commit their energies and talents to ensuring the host school students learn from and enjoy the visit.

Format and Content Delivery

The content presented by NovaCANE is divided into a sixth grade group which focuses on structural engineering and a seventh grade group which focuses on chemistry and sustainable engineering. The presentations are run as a club or after-school activity at the host school and student participation is voluntary, but historically is a high percentage of the students in the grade. Meetings at the host schools are held approximately monthly and consist of a short presentation, typically 15 minutes in length, accompanied by activities. The number of Villanova participants range from two to four, depending on the number of students at the host school. A teacher from the host school remains with the students during the meeting and the Villanova students present the lesson and provide all instruction and materials for the activities.

The sixth and seventh grade groups have developed presentations that are used at each host school. Table 1 lists the current activity themes, however students and host schoolteachers continue to suggest new topics that can be developed. The activities are intended to highlight

important concepts within engineering, such as material properties, structures and their stability, natural resources, energy, sustainability and chemical transformations. The presentations can be given by one NovaCANE student or shared among the volunteer group. The critical requirement for each activity is that it must be able to be performed safely within the host school environment with materials provided by NovaCANE. In addition to the activity itself, interactions between the NovaCANE students and the host school students during the activity build interest and enthusiasm for the program.

Table 1. Activity themes for the sixth and seventh grade groups.

Sixth Grade Structures Group Activities	Seventh Grade Green Engineering Activities
1. Paper Cross 2. Gum Drop Dome 3. Gingerbread House 4. Wood Truss Bridge 5. Egg Drop 6. Spaghetti Tower 7. Concrete Strength	1. Recycling 2. Water Treatment 3. Green Energy 4. Chemical Reactions 5. Acids and Bases 6. Battery Chemistry 7. Food Chemistry

Figures 1 and 2 show some activities performed at by sixth grade and seventh groups, respectively, at a school in Philadelphia. The student groups enjoy working together to accomplish the tasks.

As a culminating experience, all host schools are invited to a Villanova University campus visit at the end of the spring semester. The site visit offers opportunities for middle school students to visit the structures lab and test concrete samples, tour analytical labs, perform activities that are too difficult to transport to the host schools and interact with additional students and faculty. Activities related to structures, chromatography, solar cells and chemical reactions have been performed. Figure 3 shows middle school students participating in some of these experiences.

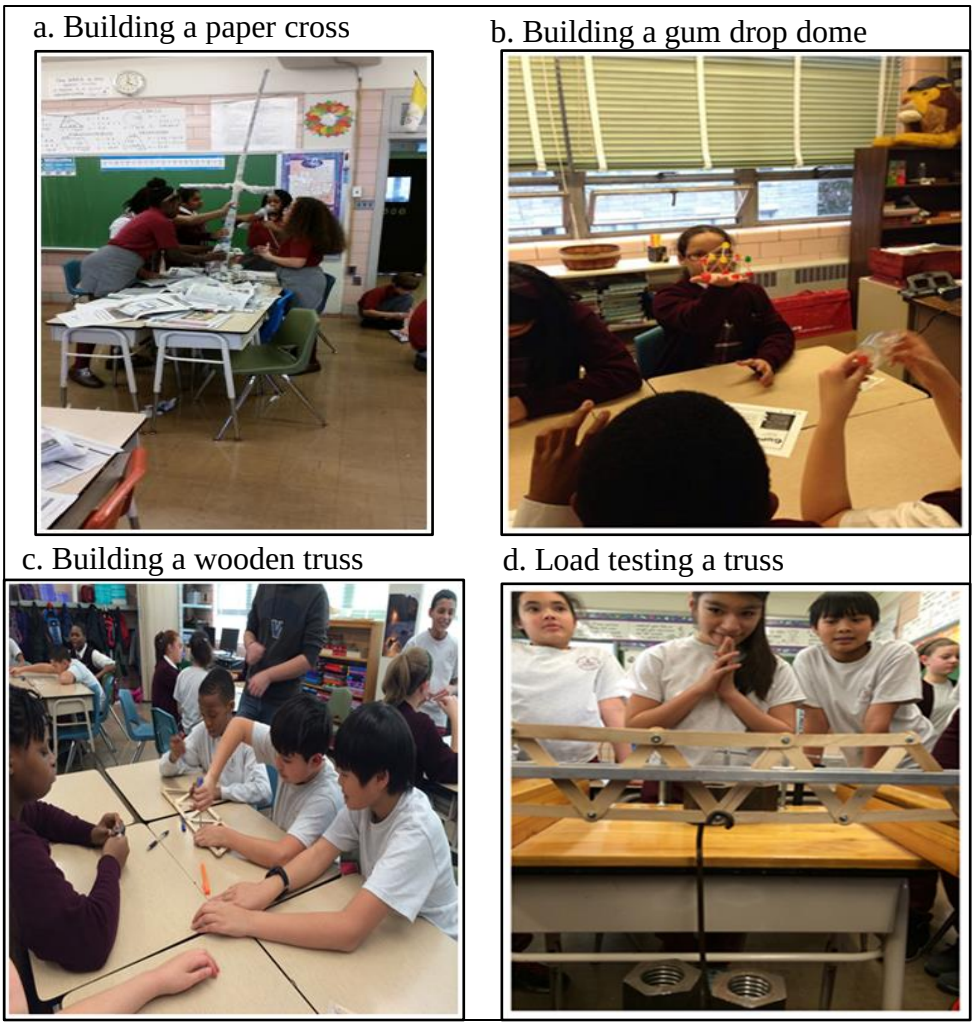
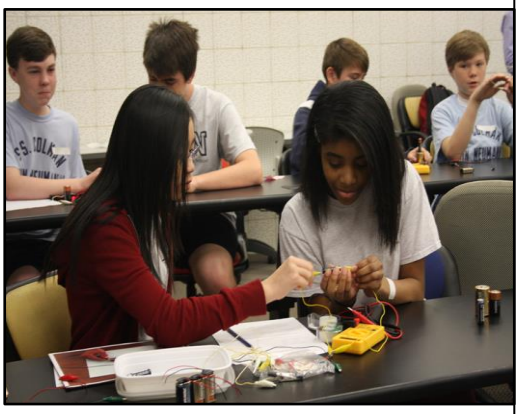


Figure 1. Sixth grade students engaged in building and testing structures.

Figure 2. Seventh grade students testing the pH of household items using red cabbage indicator solution.

a. Taking measurements

b. Comparing batteries and solar cells



c. Investigating surface tension

d. Testing a wooden I-joist

Figure 3. Examples of activities for the joint campus visit.

College Student Outcomes

Service learning in first-year engineering courses has been shown to positively impact several engineering leadership skills, including communication, problem solving, team skills, creativity and self-confidence[2]. For the NovaCANE students, the technical concepts involved in the presentation are fundamental and are not a major area of growth, however the students grow professionally by coordinating and delivering the learning activities at the host schools.

Informal assessment indicates that NovaCANE students feel their experiences have strengthened professional skills in the area of

- Communication
- Organization & Planning
- Leadership

- Teamwork
- Responsibility
- Initiative
- Adaptability
- Mentoring

One student commented that communications skills are very important for NovaCANE, and are considered at several points, ranging from determining the most important message, to deciding how to best share the ideas with young students, and most importantly, making sure that the activity is not boring. One graduate student commented that the skills built through participation in NovaCANE would be very useful in his intended academic career. The student team visiting a site often develops a strong bond and each team decides how to best present the activity at their school site. The teams must also learn to be responsive and flexible, as each site has different facilities, resources, student preparedness and group size.

The site coordinators gain considerable leadership and organizational experience by scheduling with the host schools, arranging for volunteers and transportation and managing supplies. The site coordinators are the main contact with the host schools and hold considerable responsibility.

Several Villanova students have commented that the satisfaction of sharing their interest and enthusiasm for engineering with young students was inspirational to them and they hope to continue this type of outreach effort as professional engineers. To help build group identity, NovaCANE also contributes to other Villanova University service activities and has supported projects such as Special Olympics, St. Thomas of Villanova Day of Service and Engineer's Week Activities.

Middle Student Outcomes

NovaCANE has maintained a long-term relationship with several host schools, enabling the schools to expose their students to technical concepts as they develop greater awareness of engineering careers. Some of the concepts are complementary to topics covered in science classes and some concepts are completely new to the middle school students. The interaction of engineering students in middle school science programs enhances the perception and understanding of engineering, based on an extended study of graduate engineering student involvement in middle schools[3].

Middle school students benefit from interacting with the NovaCANE students as role models and are encouraged to continue their interest in engineering and science. Some middle school students discuss their aspirations to study engineering and science with the NovaCANE volunteers. One student volunteer noted that the impact on the middle school students was evidenced by the students' greeting the returning volunteers and discussing the activities that were performed in the previous school year.

Considerations Before Implementing a STEM Outreach Program

STEM outreach through service-learning projects can be a rewarding endeavor for many programs. However it is critical to ensure that the students are committed to building a relationship with the host school and that the scheduling and resource hurdles can be successfully

navigated. The service-learning group must have student leaders with strong sense of responsibility: disappointing the host school will quickly degrade the relationship. Therefore, undergraduate students with previously demonstrated commitment or graduate students are strong candidates for site coordinators. Another difficulty can be continuity of the teacher or sponsor at the host school. Changes in staffing at the host school can make it difficult to maintain communication and student participation.

However, the most significant hurdle in establishing a STEM outreach program run by student volunteers is schedule limitations. All current host schools require an after-school program and some sites are limited to specific days of the week due to availability of the school sponsor or the school's extracurricular schedule. Changes in Villanova student schedules from Fall to Spring semesters can introduce new conflicts and require reassignment of responsibilities and volunteers. This is especially a consideration for the engineering courses with laboratory requirements that are often offered in the afternoons at Villanova. To accommodate this issue, advance planning and selection of site coordinators will ensure smooth transitions between semesters.

The availability of transportation can present another problem, since many Villanova freshman and sophomore students do not have vehicles on campus. However, Villanova University has generously provided vehicles for some site visits. And finally, since many activities involve reusable supplies, a convenient and accessible storage location is needed for these materials.

Each service-learning group must evaluate their level of commitment and only grow at a pace that enables it to maintain established relationships with schools. NovaCANE has had more requests for site schools than it can support and is currently considering other avenues for expanding the outreach through the use of instructional technology.

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