Work in Progress: Twenty Year Evolution of an Outreach Program

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Almost twenty years ago, in an undergraduate-level Introduction to Biomedical Engineering elective, a group project was created which allowed an opportunity for students to delve deeply into an area of interest that was not covered in the class material. A second objective was to provide a forum for the students to hone their presentation and group interaction skills. The project integrated a high school outreach presentation and required undergraduate students to participate in problem-based learning, demonstrations, and hands-on activities and challenged undergraduates to present highly technical material to an audience with little technical knowledge [1]. Within a year, this project expanded to be *included* in a required junior level chemical engineering course (and was no longer a part of the Introduction to Biomedical Engineering elective). Over the past twenty years, this project is a required project for a wider spectrum of required chemical engineering courses and has grown to include presentations to K-12 students – and has impacted almost one-thousand undergraduate chemical engineering students and over 10,000 K-12 students.

This is a work in progress, since the author would like to gather input as to what information would be helpful to provide to the community to enable this program to be transferable to other institutions.

Project Description

The outreach project is to perform a group presentation in a local K-12 class or program of the undergraduate's choice. The topic of the project is up to the undergrads, but it should pertain to fundamental principles of Chemical Engineering. Each project consists of a presentation, hands-on activities and evaluation of the presentation by the class and teacher, and it should take one school class period (~ 45 minutes). In addition, the group (~ four undergrads) must leave the classroom with some material for the students interested in learning more about the topic presented. Safety is of utmost concern for this project and as such, all of the activities and materials must be safe for both the presenters and the K-12 students.

This project is an opportunity for the undergrads to be creative and to share their experiences with K-12 students. All of our undergrads are great role models, and this is a chance to introduce K-12 students to technical areas and careers that they might have not considered. It is also an exercise in problem-based learning. Undergrads must decide what they need to learn, then figure out how to learn it and then how to teach the material. Our undergraduate students also have the opportunity to practice communication skills with people who possess little technical knowledge. In addition, they also have to work in a group setting, towards a common goal and they have to critically assess their own performance, as well as the performance of others.

The project has the following milestones which have to be met:

- The group must identify the school or program, course name and time, teacher name and

contact information, number of students enrolled, and level of students; to whom the presentation is given. (If undergrads are unable to find a school or program, the faculty member has a list of schools/teachers who have participated before and would like to host another outreach project in their classroom.)

- The group should have a preliminary meeting with the teacher, where each group member will have preliminary ideas for the project (what they will do in the classroom).
- Each group member should come to a secondary meeting with a full outline of the project presentation. The group should include details of what they will present and how it will be presented and be sure that the presentation will meet the needs of the teacher and class.
- The group should visit the school/program classroom to meet the teacher in person, verify the date and time for the project and to assess if the room is adequate for the presentation. If not, arrangements should be made at that time for another room. If possible, briefly (no more than 5 minutes) survey the students in the class to assess their level of technical knowledge related to the activities and presentation. The faculty member attends all of the group presentations, therefore each group will need to ensure the date/time of the presentation fits with the faculty member's schedule. (In the twenty years of this program transportation has not been an issue, as either at least one undergraduate in each group had access to a car, or the faculty member was able to provide rides from campus to the K-12 school, or the school was accessible via public transportation.)
- Each group must practice their outreach presentation in front of the faculty member. It should be ***exactly*** as the group plans to present it in the classroom. The presentation must be timed to ensure that it will fit in the allocated period. All of the materials needed for activities, must also be included. The group must bring the pre/post class surveys they plan to use. The practice presentation must take place a minimum of one week prior to the actual school presentation. If this practice presentation is not well prepared and complete, the group will receive a grade of zero for the project, and will not be allowed to perform the outreach project.
- Each student must present during his/her group presentation and attend one other presentation. Each student will complete an outreach project evaluation for the presentation that he/she observes. The project grade will be based on the efficacy and creativity of the presentation. (The faculty member has developed the peer evaluation rubric for the presentation and will be happy to share the rubric.)
- Each group must turn in a critical assessment of the efficacy of the outreach project (three typed pages maximum). The following questions should be addressed in the report: Was the presentation effective? As engineers, the group needs to critically assess the efficacy of the project and determine how this can be measured. What did the group do well? What could be done better? What would the group do differently if the project were repeated? How well did the group function together? How could the group improve the way they functioned? What overall grade would the group assign themselves? Points will be given for accuracy for the assessment and for writing ability.
- The group must turn in the original copies of any and all of the completed surveys that were collected for their project. (The undergraduate students create the surveys for the K-12 students to complete – and are in direct alignment to the material that they are teaching – this gives the undergraduate students the opportunity to communicate at an appropriate level and create a survey/test at the correct reading level of the K-12 students that they are teaching.)
- Each undergraduate student must coordinate with the presenters of the outreach project that they plan to attend – the number of observers will be limited so that the observers are equally

distributed between all of the presentations.

- If an undergraduate student arrives late to observe another presentation, they are not allowed to enter the classroom and will need to observe a different presentation.
- Each undergraduate student must be mindful of appropriate attire and language to be used during the presentation – they are reminded that they are fortunate to have this opportunity to visit the classroom and they must be respectful of this opportunity.
- Undergraduate students may not request or use any hazardous chemicals/materials, which require special handling (i.e. safety goggles, gloves, spill clean-up kit, hoods, etc.) to be used for the outreach project.

Practice Presentation

Each group is required to practice their presentation with the faculty member, and although the groups are allowed to select their own topics and activities, it is during this practice presentation that many misconceptions that the undergrads have, have been uncovered. These misconceptions are typically not revealed during a written exam or quiz – but rather through oral explanation. For example, during the demonstration shown below in Figure 1, where yellow colored hot water is allowed to mix due to a temperature gradient, with blue colored cold water – the undergraduates mistakenly referred to the color change as a chemical reaction [2]. This was also the case when discussing activities associated with a phase change [2, pp. 15-20, 3].

Figure 1. Allowing yellow colored hot water and blue colored cold water to mix.

Misconceptions regarding air pressure [4] were also uncovered during various activities (breaking a wooden ruler with a newspaper, imploding can, and an upside down glass of water) as shown in Figure 2.

Figure 2. Exploring Air Pressure Activities

Heat transfer misconceptions [5] were also discovered with temperature versus perception activities performed with a group of first graders, shown in Figure 3.

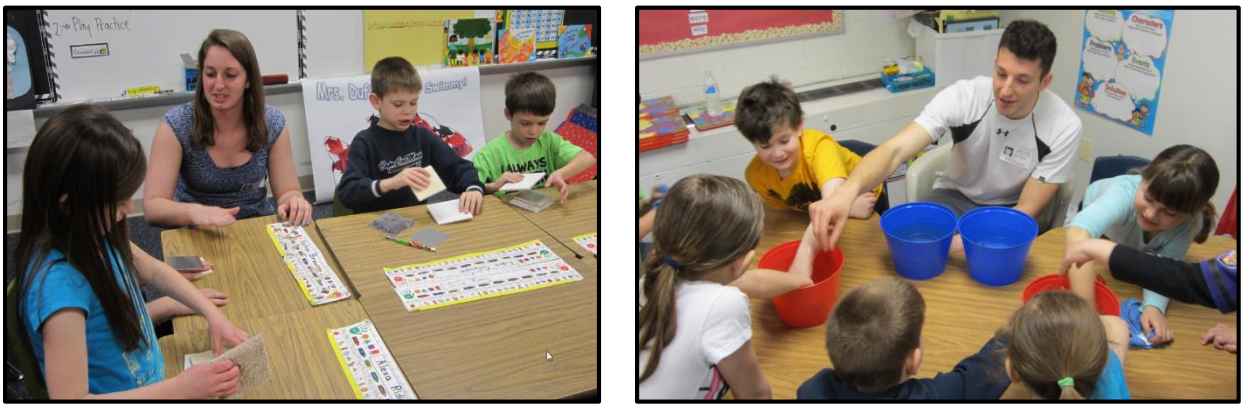

Figure 3. Temperature versus Perception Activities with First Graders
(Pictures are provided with students' permission).

These are just a few of the misconceptions that have been revealed during this outreach project – and as a result they are addressed (and assessed) when covering the course material by the faculty member. (Additional misconceptions will also be shared during the presentation/discussion.)

Additional Benefits

Over the last twenty years, most Chemical Engineering programs have included statistics in their curriculums, and as a result this project allows our undergrads an opportunity to apply these skills in another course project. Since the groups must determine the efficacy of their presentation, most groups develop pre- and post-surveys for the K-12 students to complete and then use a paired t-test to determine if statistically significant gains are achieved as a result of their presentation and activities. Preparing the surveys also help the undergrads understand the appropriate reading level statistics for their audience.

ABET has approved new student outcomes [6] criteria starting in the 2019-2020 review cycle which include: 'an ability to communicate effectively to a ***range*** of audiences'. During most of our students' courses, their presentations are limited to presenting to their instructors, peers and industrial guests; so this project allows them to communicate technical information to a non-technical audience – which not only supports the new ABET student outcomes criteria, but is also good practice for their future career.

As part of the end of the semester surveys undergraduate students report this project is very enjoyable – it allows them to contact their old teachers and visit their previous schools – and they appreciate the creativity of the project and the opportunity to be role models. In addition, after graduation many of our former undergrads are asked to lead Engineers Week K-12 activities for their employers, and they report back that this project provided them with many ideas for activities and the confidence to complete this assignment.

References

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[4] Russell, T., "Children's Conceptions of Air Pressure: Exploring the Nature of Conceptual Change", *International Journal of Science Education*, 20:8, pp. 929-958, 1998.

[5] Prince, M., M. Vigeant and K. Nottis, "Repairing Student Misconceptions in Heat Transfer using Inquiry-Based Activities, *Chemical Engineering Education*, pp. 52-61, 2016.

[6] ABET Accreditation Changes for the 2019 - 2020 Review Cycle, https://www.abet.org/accreditation/accreditation-criteria/accreditation-changes/, accessed February 2, 2019.