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Outreach Projects: Towards a Structured Curricular Activity for Chemical Engineering Students

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Abstract

Promotion of STEM careers in K-12 schools is essential for the sustainable progress of the world. College students from engineering careers can provide a unique contribution to this effort. Their experience is like the K-12 school environment. However, they have advanced knowledge and skills of their critical role in society. They can offer a realistic model for K-12 students to guide their career choice and to become motivated for STEM college education. In addition, college students benefit from these experiences by reinforcing their commitment to a successful career, and to service the communities that have supported their education. Moreover, the teamwork required for an efficient and engaging set of activities provides possibilities for the inclusion and diversity of different perspectives based on their personal experiences at school. In addition, this team effort provides for the development of multiple skills for their professional job. However, though the benefit of this strategy is well known, most colleges promote outreach as extra-curricular activities. This paper discusses a three-year experience in the Chemical Engineering Department, with the participation of 360 college students, in 70 projects, reaching over 2,000 school students, as a curricular requirement for capstone courses. Continuous improvements have been in progress to provide a systematic approach while remaining flexible for innovation. This has proved valuable in sustaining the continuity of the experience during the COVID-19 pandemic. Activities are organized each semester using project management techniques (plan, logbook, reports, and meetings). The instructor monitors and coaches these activities using a virtual platform MS TEAMS. Activities include an early presentation of the project proposal (week 2), a scheduled progress report presentation (week 4), a meeting with the instructor before delivering the activity to the selected community (weeks 4-8), a poster and a final presentation (weeks 12-14). Students also deliver a package with all the information, including in-person or virtual presentation or hands-on activity, pre- and post- surveys to the audience, interactions with K-12teachers, flyers and other materials (i.e., materials for demonstrations, activities). Schoolteachers frequently report on their impression or evaluation of the activities. Students gather and analyze surveys on the impact of their activities. All classmates review and peer grade deliverables from other teams. Students evaluate their teammates' performance in this project. Students provide a self-assessment of their individual experience. They earn up to 10% of the definitive grade of the course for this outreach project. This approach has proved to be fully sustainable, and with an overwhelming satisfaction of all the participants.

Introduction

The fourth of the sustainable development goals (UN SGD #4) established by the United Nations Assembly in September 2015 (A/RES/70/1) calls to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all", including equal and affordable access to university for all women and men, by 2030 [1]. Universities are called to align their educational strategies with the SDG objectives and provide for plans of action for their implementation and timely achievement [2].

The University of Pittsburgh is in Pittsburgh, PA. The city is home of 54 public K-12 schools (20,350 students) and 107 private schools (16,754). The county is home of 43 school districts with over 271 K-12 schools (146,700 students) and 185 private schools (26,167 students). This offers a tremendous potential of over 200,000 students [3], [4], [5] who can benefit from outreach projects where engineering college students introduce and inspire school students effectively and enthusiastically to pursue STEM careers.

By the end of the last century, it was recognized that engineering was mostly unknown among the public, and particularly among K-12 students. Combined with the perception that the related fields of mathematics and science were very difficult, discouraged the interest in college engineering, even more among women and minorities. This led to take initiatives on promoting the interest in engineering by college students and faculty by visiting elementary, middle, and high schools, with engaging and age-customized hands-on experiments and demonstrations for different engineering careers. This was largely the initiative of women and minority programs, serving as inspiring roles [6]. The underrepresentation of women in engineering was the motivation for this type of visits and summer camps in many parts of the world [7]. The dramatic increase in demand for engineering professionals and the lack of growth in undergraduate engineering enrolments by the mid-1990s in North America [8] provided a sustainable driven force for multiple initiatives of outreach programs.

The incorporation of outreach projects into ChE courses have been in practice for over 20 years [9]. The initiative was to provide college students with experience on problem-based learning, presentation, and teamwork, and reaching audiences with little technical knowledge as a critical skill for successful careers [10]. Basic elements of the projects were early established. They included a mix of lecture and demonstrations, hands-on activities, and games to keep the audience engaged. College students offered personal experiences to their career development, industrial and research experience, and provided their plans. Time for questions at the end of the presentation, surveys to assess the impact of the experience, and “leave behinds” materials for further learning or contact [10]. In addition, the basic structure of the project management was introduced. Students start identifying a high school classroom, size, teacher, and contact information (1-2 weeks). Students meet the schoolteacher and present their ideas for the session (1-2 weeks). A second meeting with the schoolteacher followed to outline details and final content, and a visit to the school to verify classroom conditions for the intended activities. A meeting with the college instructor (at least two weeks before the final presentation) mimicking all the intended activities in time and content, and examining materials to be left with the class, leading to extensive feedback from the instructor. The presentation was generally given towards the end of the semester. The CHE instructor and one other group attended each presentation and completed a rubric for the presentation. Finally, the schoolteacher and students completed pre- and post- surveys to determine the effectiveness of the presentation. The analysis of this data was used to determine the efficacy of the presentation. Three distinctive outcomes were noticed. College students’ improvement in presentation and teamwork skills, and personal satisfaction with the service of their communities. School students were presented with inspirational role models and challenged their stereotypes of the engineering profession [10].

This approach has been in place for over twenty years at various institutions. It is reported to have influenced around one thousand ChE students and over ten thousand K-12 students [9]. It has proved valuable in addressing ABET Criterion 3, Student Outcome 3, introduced in the 2019-2020 review cycle, to include "an ability to communicate effectively to a *range* of audiences", where the "range of audiences" was introduced [11].

Context

The Department of Chemical and Petroleum Engineering at the University of Pittsburgh is exploring the opportunity to develop a strategic outreach program to extend the work of faculty, staff and students beyond the teaching and research environment. The vision calls for a broader impact on the quality of life of the nearby communities with the ambition to reach beyond the nearby community. This effort looks for integrating well-established best practices and innovative approaches. Several initiatives are now in progress involving alumni and foreign partners. A critical element of this mission is to provide sustainability of this program, combined with compliance to ABET accreditation criteria. A further necessary demand is to provide for increasing diversity, equality, and inclusion. The program is based on the conviction that our academic institutions are uniquely responsible to train the future workforce, anticipating the rapid changes (i.e., demographics) taking place in our world. Appendix 1 provides some preliminary notes on this program, still at an early stage.

As described above, outreach projects have a well-established tradition of over 20 years [9]. Faculty and students reach out nearby elementary, middle, and high schools with presentation and activities to engage students with higher education objectives. Engineering departments took the initiative to promote an increasing enrollment, particularly of minority groups (i.e., women, minority). They offered the additional benefit of enriching the formation of the college students involved with these projects by improving communication and teamwork skills. However, they have relied on the initiative and passion of some faculty members. It is the intention of our program to provide a more systematic, sustainable, and institutionalized structure for these projects. The department proposed to provide this structure with substantial flexibility for faculty to incorporate it in their regular teaching assignments. The initiative seeks to provide students with multiple opportunities to develop these projects and improve their skills in their experiential learning. It is the goal for the proposal to make these projects an essential component of the culture of service of our department, and call for the integration of alumni, communities, and industry to join the effort.

The initiative has been in progress for three years (2019-21) as a proof-of concept stage. It has demonstrated its potential to reach the intended goals. It is now looking for developing into a school/college wide initiative.

Curricular structure

The backbone of the Chemical Engineering curriculum at the University of Pittsburgh is a sequence of six Pillar courses, from sophomore to senior years: Foundations of Chemical Engineering, Thermodynamics Transport Phenomena, Reactive Process Engineering, Process Control, and Process Design [12]. A co-requisite one-credit hands-on laboratory course integrates with each of the first five courses, while a Safety and Ethics course accompanies the Process

Design class. Approximately one third of the students alternate the last three class-semesters with co-op rotations. These last two years (which include summer terms) offer the best potential for students get involved in outreach. At this point, they have developed significant knowledge and valuable industry/research experience to document the narrative on the scope of the career and the college experience.

The Reactive Process Engineering (RPE) and Process Design (PD) courses are offered every spring and summer terms. The Process Control (PC) is offered only during the fall term. Spring and fall terms normally have two sections of each pillar/laboratory course with an enrollment cap of 50 students each. Summer courses are limited to one section (20-30 students) each of the Reactive Process Engineering and Process Design pillars. Graduation rate is currently around 100-120 students/class. Table 1 presents the number of students developing these outreach projects for the last three years.

Table 1. Students developing outreach projects (2019-21)

Year	2019		2020			2021			Total
Course	RPE	PC	RPE	RPE	PC	PD	RPE	PC	-
Term	Spring	Fall	Spring	Summer	Fall	Spring	Summer	Fall	-
Students	28	59	67	32	55	48	23	48	360
Teams	6	11	12	6	11	9	4	10	69

Some students had the opportunity of taking more than one course in this sequence offering these outreach projects, as presented in Table 2.

Table 2. Distribution of students that developed one, two or three outreach projects

Number of projects	Only one	Two	Three	Total
Students	263	76	21	360

In addition, a parallel section for the Process Design course was offering outreach projects following the method reported above [9]. Over 125 students took this option, with some of them completing two or three projects (from attending the other previous courses). The overall estimate is that for Classes 2019, 2020, 2021 around 90% of students worked out at least one outreach project, about 25% worked in two outreach projects, and at least 10% worked out three outreach projects. It is important to mention that this period covers the initial two years of the COVID19 pandemic. This curricular structure provides for students to develop up to three outreach projects before graduation.

Project description

The first key element of this program is to provide students with total freedom to select the audience, the topic, and the communication strategy. The instructor presents this initiative to students on the first day of class and encourages them to take responsibility giving back to their communities and other motivational criteria as presented in Table 3. Self-selection of members for the team (4-6 depending on the size of the course) is another key element to reinforce the freedom and responsibility of the work in the project.

Table 3. Starting motivational criteria for the outreach projects

Motivational arguments shared with students on outreach projects
It is a concrete way to give back to their communities
It is a problem-based learning experience enriching students' education
It develops important skills for teamwork performance
It helps learning to tackle open-ended projects
It satisfies ABET requirement on "ability to communicate effectively with a range of audiences"
It provides training for outreach assignments at jobs, as companies get increasingly involved with surrounding communities
It supports the development of the outreach strategic program for the Department
It earns 10% of the definitive grade of the course

Teams are instructed to develop best practices in team forming, storming, norming and performing. The project should be structured as an example of those practices. The sequence of major steps is presented in Table 4. Team activities are developed over a MS TEAM space where students interact with shared files, meetings, on-line collaborative writing, etc. Instructor plays the coaching role providing rubrics, reports on previous experiences, suggesting initiatives, taking questions, monitoring the progress of the project, encouraging and warning on progress or delays, etc. This happens on continuous basis through the semester.

Table 4. Outreach project structure, schedule, and grading

Step, activity, product	Week	Grade, %
Team forming, storming, norming	1	-
Team performance (plan, logbook)	1-14	20
Proposal presentation (3-min, pre-recorded)	2	10
Reaching out intended community (representative). Arrange for activity	2-4	-
Preparing activity (research, content, materials, practices)	3-8	-
Progress report (1-slide, 3-min presentation, pre-recorded)	4	10
Meeting with instructor before delivering to the community	6-8	-
Performing activity with selected audience	6-12	-
Poster	11	20
Final presentation (6-min, pre-recorded)	13	20
Package of material presented and collected (presentation, surveys, etc.)	13	-
Individual assessment (3 pp)	14	20

Students submit a pre-recorded 3-minute presentation with the proposal for the project containing the identification of team members and roles in the project, the selected audience (qualitatively and quantitatively), the motivation for the selection of that audience, the selected strategy for communication and the motivation for that choice, and the intended plan for the project during the entire semester. The deadline is the second week of the course, with peer or instructor grading by a specific rubric.

Results

The preferred choices for audiences are K-12 programs, but the flexibility on this selection has open the opportunity for some other audiences as presented in Table 4. Other communities included non-engineering college classes, religious student associations, SWE Engineering fair, college-tutoring groups, Beer's brewer fans, parents of chemical engineering students, minority students' programs, "Chemfest" at the Carnegie Museum, open public, social media (Instagram, TikTok), college sorority, and summer camps. Providing for these alternatives proved to be convenient to allow students to experiment with non-K-12 groups and widespread audiences via social media.

Table 4. Selected audiences

Year	2019		2020			2021			Total
Audience	Spring	Fall	Spring	Summer	Fall	Spring	Summer	Fall	19-21
Elementary	1	4	4	-	3	-	-	1	13
Middle	3	1	1	3	-	2	-	1	12
High	2	4	5	3	4	6	2	2	28
Other	-	2	2	-	4	2	2	3	13

High school students were the preferred target audience (Table 5). One reason could be the closer connection with AP Chemistry and Physics class teachers. Also, because the content of many projects refers to the structure and scope of the chemical engineering career. However, the initiative of reaching out students through social media (i.e., Instagram) proved to address larger audiences than school classes. Further research is needed in tracking analytics (followers, likes, accounts) for these initiatives.

Table 5. Size of selected audiences

Year	2019		2020			2021			Total
Audience	Spring	Fall	Spring	Summer	Fall	Spring	Summer	Fall	19-21
Elementary	100	171	75	-	45	-	-	12	403
Middle	123	51	-	80+	-	5	-	17	276
High	227	215	60	110+	102	208	32	143	1097
Other	-	36	54	-	86	300	92	515	1083
Total	450	473	189*	190+	233+	513	124	687+	2859
Teachers	14	12	8	3	14	8	1	7	67
Notes. (*) Spring 2020 was the breakout of the COVID19 pandemic, and many projects were cancelled for the targeted community presentation though the students elaborated all the materials. (+) Some of the products (videos, presentations, web pages) went open due to pandemic with insufficient record of students reaching the content.									

Approximately 3,000 people (primarily K-12 school students) were impacted by this sequence of outreach projects. This provides a tremendous potential for community service activity when incorporated in a curricular structure. In addition, 67 schoolteachers have collaborated with these projects, designing strategies with the college students, making their classes available for in-person or remote presentations. They are the anchoring component for the sustainability of this initiative. However, no attempt was made at this time to structure a stable relationship with teachers, to allow students with complete open choice for their initiatives; however, it is envisioned to provide for such structure and to be receptive to teacher requests for support with their classes. Some materials like videos and pre-recorded presentations can help them in subsequent years, and web sites can be timely curated to update and adapt to teachers' current needs.

Two main topics dominated the selection for content: description of the chemical engineering career and hands-on or videos on science experiments (Table 6). The description of the chemical engineering career encompassed the curricular structure, the main courses, applications for college, scope for jobs, opportunities in research, etc. Chemical engineering principles and chemical reactions, and the roles of chemical engineers in societies complemented this field. What could be considered a "similar" content was presented in many diverse ways and formats, as described below, proving that the creativity of students can suffice for the sustainability of the content. The other major area of content was a broad selection of experiments (Table 7).

Table 6. Topics

Term	19S	19F	20S	20Su	20F	21S	21Su	21F	Total
Chemical Engineering career	2	4	4	2	6	6	2	6	30
Experiments	2	2	8	4	5	1	1	4	27
Chemical engineering principles and reactions	1	1	1	-	-	1	-	-	4
Sustainability	1	1	-	-	-	1	-	-	3
Engineer's role in society	1	-	-	-	1	-	-	-	2
Chemical engineer roles	-	-	2	-	-	-	-	-	2
Basic thermodynamic	-	-	1	-	-	1	-	-	2
Air pollution and control	1	-	-	-	-	-	-	-	1
Drinking water treatment and distribution	-	1	-	-	-	-	-	-	1
Types of "forces"	-	1	-	-	-	-	-	-	1
The Haber-Bosch process	-	1	-	-	-	-	-	-	1
Microwave oven principles	-	1	-	-	-	-	-	-	1
Advanced lab experiences	-	-	1	-	-	-	-	-	1
Industrial plant tour (video)	-	-	-	1	-	-	-	-	1
Beer brewing process *	-	-	-	-	1	-	-	-	1
A parents' guide to chemical engineering	-	-	-	-	1	-	-	-	1
Chemistry and chemical engineering	-	-	-	-	-	-	-	1	1
Alcoholic beverages production *	-	-	-	-	-	-	1	-	1
Chemical bonds	-	-	-	-	-	1	-	-	1
COVID-19 vaccine technology	-	-	-	-	-	1	-	-	1

(*) These presentations were life and live streamed to adult audiences of over 21 years old members

The students performed most of the experiments for hands-on demonstrations or pre-recorded videos. A few students added some videos from available sources to their presentations. The "elephant toothpaste" experiment was the favorite, mainly to reach elementary school students. In many cases, narratives or dramatizations completed the videos, as an additional source for engagement.

Table 7. Popular reference for experiments used (hands-on, video) in the outreach projects

Lava lamp	Rotating bucket	Bernoulli's principle
Hot/cold colored water	Elephant toothpaste	Vitamin C clock
Luminol	Steam engine soda can	Electrolytic cell
Shear thinning and thickening	Balloon (acid/base reaction)	Milk, food dye and soap
Golden pennies	Ice cream in-a-bag	Rainbow in a jar
Bottle rockets	Polymer bouncing balls	Make your own playdough
Styrofoam dissolution	Coke and Mentos	Solids, liquids, and gases
Bouncing egg	Color moves	Peeper dance
Un-mixing	Exploding lunch bag	Home forging
Storm in a glass	Walking water	Lichtenberg figures
Vacuum chamber	Potato canon	Spidey silk
Reaction car	Rap battle	

Presentations were the preferred choice for communication (Table 8). It is worth noticing that in addition to the presentation students made for the audience, they prepare three presentations for the course (proposal progress, report, and final presentation). Presentations for the audience were in person until the breakout of the pandemic, switching to digital formats (life streaming, pre-recorded) after that. This was proof of the high adaptability of these projects as they could mimic the changes in teaching to remote environments due to the pandemic. Hands-on experiments started to dominate the communication strategies, but they were also moved to video versions with the pandemic. Web sites, take home or digital brochures, and panel discussions (on college experiences) became very successful during the pandemic. Projects based on the use of social media (i.e., Instagram) to deliver similar content than in presentations and experiments but in shorter and sequencing format were game changers in the size of the audience.

Table 8. Communication strategies

Term	19S	19F	20S	20Su	20F	21S	21Su	21F	Total
Hands-on experiments	2	2	6	-	-		1	1	12
Presentation	5	3	4	2	4	2	1	4	24
Interactive game	1	-	-	-	-		-	-	1
Web page	1	2	-	-	2	1	-	1	7
Video	-	4	1	4	5	4	1	2	21
Brochure	-	-	4	-	1		1	-	6
Panel discussion	-	-	-	-	2	1	1	2	6
Social media	-	-	-	-	-	1	-	1	2

Progress reports (one slide, less than 3-minute presentation) were introduced in the second year to let students share common problems and solutions. Previous experience was relying very much on instructor help for these problems. This provided for improvement in collaboration skills, underscoring the message that all teams unite in the common purpose of supporting nearby communities. Students presented in these reports the updates but also the changes in the project, difficulties in arranging for an audience to confirm availability, requests and suggestions from the teachers, concerns on how to keep the engagement of the audience (particularly with videos or remote presentations). After this step, students normally took 4-6 weeks to collect information and materials, and to prepare the content and activities.

Checkup meeting with instructor was requested to happen at least one week ahead of final delivery of the activities to the audience. It normally happened in weeks 6-9. This request was partially relaxed as circumstances imposed some rapid changes or actions (i.e., last minute completion). One or several members of the team met with the instructor and review the activities, strategies, and content to be delivered. It generally took about 30 minutes, with the dominant advice from the instructor being to emphasize safety, either as a priority for the activities or to include in the presentations as a major concern for chemical engineers.

Posters were designed for the choice of advertising (i.e., activity at school, website) or presenting the scope and results of the project (i.e., as intended for an outreach fair event). The creativity, colorful and richness of experiential learning is impressive. The digital archive of these designs (Figure 1) is a valuable resource to display in events for promoting outreach programs.

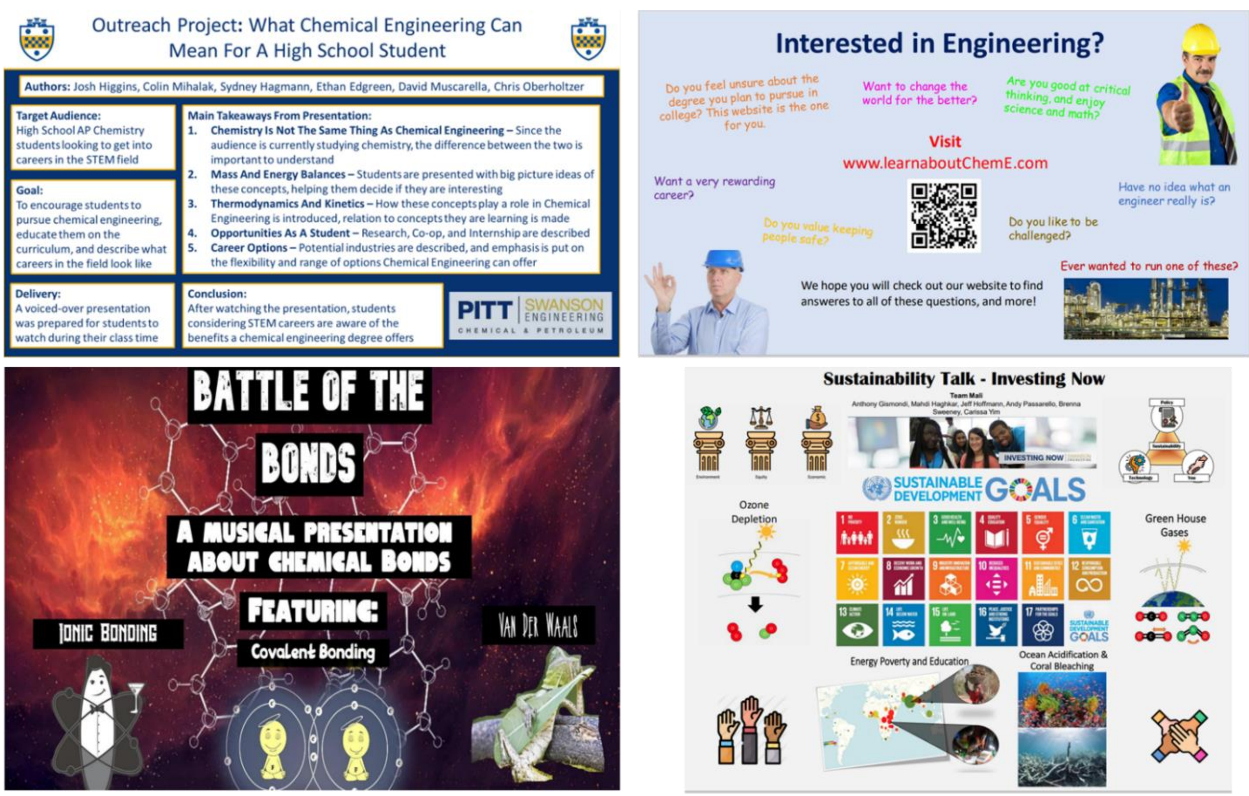

Figure 1. Examples of outreach posters

Two types of presentations are included in the project. One presentation integrates all the deliverables for the audience (from hands-on materials to handout brochures). The students arrange with the teacher or coordinator at the institution or group the format and date for the activities, and for the surveys. Students provide a package with all the pieces of information delivered to the audience. The other type of presentation is to address the class reporting on the complete project, including assessment. It is limited to 6 minutes each. Before the pandemic, the presentations were provided in person in the classroom, but we moved to pre-recorded versions with the pandemic, and currently use this format. Students review the presentations of the other teams. The archives of these presentations are a valuable repository of outreach experiences to share with schoolteachers and for the promotion of outreach programs. Most of the presentations are well arranged and narrated. A few present some technical mishandlings (low audio, slow track, etc.)

Two types of assessments are included in the project. One is provided by surveys with the audience. Generally, pre and post presentation surveys focus on the efficacy of the activity to promote the choice of engineering (preferably chemical engineering) majors, and the level of attraction for students. Surveys are generally completed via Google after the pandemic. Some teams have advanced statistical analysis of the data, though it has not been required, but it is considered an improvement for future assignments. In many instances, this assessment is reinforced from a separate survey or alternate report from teachers. The common factor of assessments is the appreciation for the initiative, with many schools reporting to be the only visit they got from college students. Teachers report on their interest for future college student visits to their classrooms and reuse of the materials and content. Some teachers email back the instructor to show their appreciation and willingness to keep collaborating with the project.

Project management and grading

A distinctive feature of this approach is the framing of the projects by project management strategies. Self-selected teams are provided with a specific MS TEAMS space, where the instructor acts as coach, posting templates, giving advice, warning on lack of progress, encouraging activities or contacts, backing up with previous examples, etc. There is much to improve here, depending mainly on instructor availability. Students are requested to develop an early plan and update it often. They are also requested to keep a logbook for main activities, both individually and as a team, with entries at least every week. It provides for a timely follow up of the plan, and for monitoring members' individual contributions. All the files related to the project are developed collaboratively, synchronously, and orderly arranged, from rubrics to final presentations. Meetings are also recorded in this platform. Consultations and replies are immediately notified by the system, as comments to documents and presentations, for a continuous flow of information. Assessments on team performance, based on CATME, are also posted at least three times during the term.

Grading is still an evolving issue (Table 9). Emphasis was on motivating students to do a great job and they did. The 8-12% weight on definitive grade for the course was presented more as a reward for their additional effort than for an evaluation of skills and performance. Initially the grade was equally determined by the grade from the audience, the peers, self-grade, and instructor. It was difficult to normalize grading by the audience, as some teachers were not systematically providing the grade, and some initiatives did not have a community representative (i.e., social media). Then grading evolved to provide more weight to the peers to stimulate the collaborative nature of this service that should run lifelong. Grading inconsistencies were observed when students provided high scores for deliverables that they had not observed. Some self-grading was very honest with some students claiming that they did less than the rest of the team, but most gave themselves full credit for their efforts. The instructor was also lenient, particularly during the pandemic, to offer more support than evaluation. Current grading emphasizes teamwork performance. This is reflected on the most recent evaluation. However, more consideration needs to be given to this issue.

Table 9. Grading evolution

Year	2019		2020			2021		
Grading	Spring	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Weight, %	10	8	10	12	10	10	10	10
Average	98.04	100.00	98.00	98.72	98.40	98.70	99.78	88.23
St. Dev.	4.69	0.00	1.75	0.51	1.72	2.93	0.42	6.25
Audience, %	25	25	25	0	0	0	0	0
Peer, %	25	25	25	83	80	80	60	60
Self, %	25	25	25	17	20	20	20	20
Instructor, %	25	25	25	0	0	0	20	20

Conclusions

The experience of this past three years at the Department has proved that an outreach program can be sustained to provide students with enriching experience in community service, additionally improving teamwork skills. The selection of three courses (second semester junior and senior years) opens the opportunity for three experiential learning opportunities, accounting for over 120 hours.

This experience has proved the tremendous potential to reach thousands of students in K-12 programs, and some other audiences, in nearby communities, fostering the promotion of STEM careers. The replication of this program in other departments and schools can provide for an extended coverage of the education system around the university.

Options are available to develop these projects with professional structures to enrich the career potential of students, equipping them with content and techniques to bring to their jobs in industry, business, and academia.

The program can be combined with NSF requirement to provide for broader impact of research proposals, adapting content and involving faculty and graduate students.

Further work

To provide an “Outreach Day” event every year to celebrate the achievements of students and the engagement with communities.

To develop a digital platform for easy accessibility of presentations, posters, and materials from past experiences to offer inspiration and content for further projects.

To structure a network with K-12 schools for a more systematic coverage and support of teachers and K-12 student with content and experience from engineering careers.

Bibliography

[1]https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf [Accessed Jan 22, 2022]

[2] R.A. Ramirez-Mendoza, R. Morales-Menendez, E.M. Melchor-Martinez, *et al.* "Incorporating the sustainable development goals in engineering education." *Int J Interact Des Manuf* **14,** 739–745 (2020). https://doi.org/10.1007/s12008-020-00661-0 [Accessed Jan 22, 2022]

[3]https://statisticalatlas.com/county/Pennsylvania/Allegheny-County/School-Enrollment [Accessed Jan 22, 2022]

[4]https://www.privateschoolreview.com/pennsylvania/allegheny-county/high [Accessed Jan 22, 2022]

[5]https://www.pghschools.org/domain/17 [Accessed Jan 22, 2022]

[6] L.J. Bottomley, S. Rajala and R. Porter. "Engineering outreach teams: K-12 outreach at North Carolina State University". *29th ASEE/IEE frontiers in education conference*, Session 13a7, pp. 14-17, Jan Juan, Puerto Rico, 1999

[7] K. A. Gilbride, D.C. Kennedy, J.K. Waalen and M. Zywno. "A proactive strategy for attracting women into engineering". *Canadian Journal of Counselling*. Vol. 33:1, pp. 55-65, 1999

[8] L.S. Anderson and K. A. Gilbride. "Pre-university outreach: encouraging students to consider engineering careers". *Global J. of Engng. Educ.*, Vol. 7, No. 1, 2003

[9] T.M. Bayles, "Work in Progress: Twenty-year evolution of an outreach program". *American Society for Engineering Education*, 2019, #27019

[10] J.M. Ross and T.M. Bayles, "Incorporating high school outreach into ChE courses." *Chemical Engineering Education*. Summer 2003. Vol. 37, Number 3, pp. 184-187, 2003

[11] ABET criteria for accrediting engineering programs, 2019-2020, https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/ [Accessed Jan 22, 2022]

[12] McCarthy, J. J., & Parker, R. S. (2011, June), "Evaluation and Results for an Integrated Curriculum in Chemical Engineering" Paper presented at 2011 ASEE Annual Conference & Exposition, Vancouver, BC. 10.18260/1-2--17931

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Appendix 1. A work-in-progress proposal for the strategic outreach program at the Department of Chemical and Petroleum Engineering at the University of Pittsburgh

Vision

To reach out nearby communities and further beyond with engineering solutions of sustainable impact to increase the life quality of people.

Mission

To develop a culture of providing experiences, proposals, and solutions derived from the teaching and research activities of the Department to enrich the welfare of people in nearby communities or in connection with the University.

Participants

Faculty, staff, students, and alumni.

Some current activities

Outreach projects. Faculty and students reach out K-12 programs in nearby schools (and some other organizations) promoting STEM careers and the appreciation of engineering roles in society. Every year about 200 students develop over 30 projects reaching out more than 1,000 public school students.

Global projects. Faculty and students approach problems in foreign countries to rise awareness on global partnership and addressing potential solutions. Every year about 50 students develop over 10 projects in collaboration with foreign partners around the world.

Legacy project. Students get connected with alumni on individual relationships to explore improvements in chemical engineering education, career development mentoring, and strengthening of the Alumni Association.

Pilot program of collaboration with Latin American Universities. A group of 12 universities with strong chemical engineering programs in Chile, Colombia, Uruguay, and Venezuela are connected in exploring opportunities for collaboration, including the selection of candidates for graduate programs at Pitt, opportunities for sharing teaching courses and for research exchange.

Entrepreneurship. Interested students are supported with training and advice to reach out entrepreneurial competition with innovative proposals and launching start-ups.

Sustainability project. Proposal to enrich the chemical engineering curriculum with sustainability content and experiences.

Teamwork project. Proposal to develop a structural approach for teamwork, leadership and project management training.