

## **Engineering Ambassadors: Bridging the Gap between Engineering and Education Undergraduates and Middle and High Schools Students (Evaluation)**

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Kathleen Mancuso is a Secondary Education Major with a concentration in Chemistry at Manhattan College located in Riverdale, NY. As a senior, Kathleen will be graduating in February 2017 with a teaching certification for grades 5-12 in New York State and a B.S. in Education and Chemistry. Her passion for teaching began in her high school chemistry class with Mrs. Merante, after seeing just how valuable a talented and determined teacher was to future STEM fields. Kathleen enjoys teaching tennis over the summer to students ages 8-16 and is looking forward to her graduation to begin her career.

# **Engineering Ambassadors: Bridging the Gap between Engineering and Education Undergraduates and Middle and High School Students**

## **Abstract**

Engineering Ambassadors program at Manhattan College includes engineering and education undergraduate students and faculty members who work together and aim to improve STEM education and encourage young generation of middle/high school students into STEM related occupations. Also, with the support of national science foundation we partnered with local schools who are mostly serving financially disadvantage and under-represented minorities to have regular visits from these schools. In this paper we will explain the goals, achievements and challenges of the program.

## **Introduction**

Reaching out to high school students to introduce engineering concepts and encouraging them to engineering disciplines has been a very important role of higher education institutes. Several different programs have been developed toward this goal such as Galileo Project at University of Connecticut [1], Engineering ambassadors program at Pennsylvania State University [2] and engineering ambassadors' network [3].

Engineering ambassadors program at Penn State was established in 2009 [4]. The program became a network when United Technologies Corporation (UTC), University of Connecticut, Rensselaer Polytechnic Institute, and Worcester Polytechnic Institute formed a partnership. The partnership has expanded to include over 20 universities and increased industries attention to include Chevrolet, Rockwell Automation, and other companies. UTC in addition to Chevrolet and Rockwell Automation were able to supply financial support and provide internship opportunities to selected ambassadors. All three of the institutions have the same message from National Academy of Engineering, "Changing *the Conversation*", provide outreach to middle and high school students, and provide professional development for the ambassadors.

The major difference of our engineering ambassadors program comparing to engineering ambassadors network is, instead of industry partner, we collaborate with the School of Education and health and local high schools to encourage the students both from college and high schools to consider STEM teaching jobs as well as engineering ones. We also work with future teachers to educate them about engineering and how they can incorporate engineering in their math and science courses.

## **Engineering Ambassadors at Manhattan College**

Engineering Ambassadors program at Manhattan College started in fall 2012 as a student club, following the model of engineering ambassadors' network. In 2014 with the support of National Science Foundation (NSF) and the collaboration with School of Education and Health, the program expanded and introduced several new aspects.

In this section we explain the goals and underlying needs as well as specific objectives of the program.

1. *Introducing engineering disciplines to middle/high school students and encouraging them to consider STEM related education.*

According to the National Academy of Engineering [5], two-thirds of the growth in our GDP has its roots in STEM. Therefore STEM jobs are projected to continue to grow by 17 percent (2008 to 2018), as compared to 10 percent in non-STEM fields. But report after report shows that the next generation of American employees will be unprepared for these jobs. This gap between demand and supply raised national concerns about producing STEM workforce and equally important STEM grades 6-12 education [6].

Although several states indicated a combination of STEM standards, evidence points to the emphasis on the science and math components, with limited technology and nearly non-existent engineering as part of the former standards in grades 6-12 education.

Exposing students from early ages to engineering majors has the potential to contribute to the vital need of engineering workforce [7].

Currently, projects and programs incorporated in some grades 6-12 settings to promote engineering education include: Engineer Your World [8], Project Lead the Way [9], Engineering Is Elementary [10], Engineering by Design [11], and Future City [12] play an important role to achieve this goal.

Through our engineering ambassador program, middle/high school students become acquainted with engineering and engineering profession and receive information regarding the paths to realizing an engineering related profession. We aim to broaden the pool of applicants for engineering programs by targeting next generation college students.

*2. Encouraging women and underrepresented minorities to engineering programs and providing mentoring opportunity to high school students.*

A portion of visit time is allocated to discussion between engineering ambassadors and high school students for conversation about engineering and what is the path to become an engineer. Since our engineering ambassadors' group is a very diverse group, it provides role models and mentors to middle and high school students from underrepresented minority groups. In addition, as explained in next section, we mainly visit schools serving under-privileged students primarily from under-represented minorities.

*3. Improving Engineering students' presentations skills*

According to ASME 2030 [13], one of the major skills that engineering students required accomplishing in order to become successful in engineering profession, is communication skills. Unfortunately there is no formal education on communication skills incorporated in engineering curriculum. This program provides such opportunity by including presentation skills, group work, public speaking and other related workshops for engineering students.

*4. Providing opportunities for engineering students to participate in hands-on experiment design*

Although engineering profession involves designing and building new products, engineering education, especially the first two years is heavily invested in math and science courses. For some students, since they have very little opportunity to do engineering related hands-on activities, this can be discouraging. This program provides a no-risk environment for engineering students to design and implement hands-on activities while having fun.

*5. Learning about all engineering majors and collaborating within interdisciplinary teams*

One intended ABET outcome for evaluating engineering programs is “An ability to function on multi-disciplinary teams” [14]. Traditionally engineering students participate in required and elective courses offered by the department of their major and have little to zero chance to learn about other engineering disciplines. This program sets the stage for engineering students from different engineering majors to work within multi-disciplinary groups and learn about the other disciplines in engineering.

*6. Facilitate engineering and education students collaboration*

This program brings together engineering and education students and faculty to collaborate and learn from each other. Engineering participants benefit from education participants' knowledge in developing lesson plans, teaching techniques and classroom management skills. Engineering and education faculty work together to advise the students from both schools. This collaborative environment creates a mutual learning atmosphere for both students and faculty.

*7. Provide opportunity to learn about engineering for education students*

The release of the *Next Generation Science Standards* in April 2013 has included engineering in K-12 curriculum in NYS [15]. However education majors have no education on engineering topics and are not

prepared to teach engineering courses. This program provides a unique opportunity for education students to learn about engineering and learn how to incorporate engineering into their math and science lessons.

8. *Encouraging engineering students to enroll in a newly developed minor in engineering education.*

Manhattan College has started a new minor in engineering education for engineering students and a certificate in engineering education for education majors. The engineering ambassador program has also served as a recruiting tool for the two new academic programs. Students from both schools have the opportunity to learn about engineering education and receive a first-hand experience. Interested students in engineering education then continue to the minor or certificate program.

**Program Participants**

Participants of this program include engineering students, education students, engineering and education faculty members and middle/high school students. The program started with 10 Mechanical Engineering students, one engineering faculty and only one visit per semester. However the program has been expanded to 19 students from all engineering disciplines and 4 education students from freshman to senior. Mentoring faculty also expanded to 5 engineering and 2 education faculty members. Also the number of visits has been increased to two to three per semester.

Graphs in Figures 1 to 3 show the diversity of engineering ambassadors.

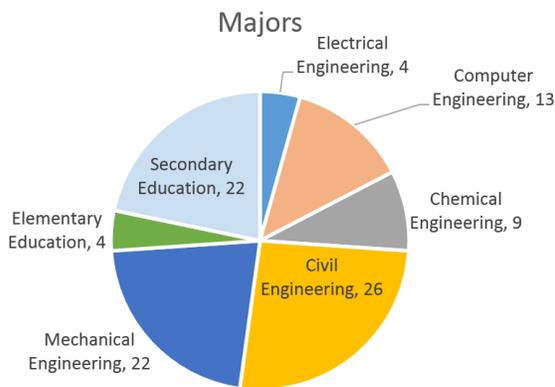


Figure 1. Majors of engineering ambassadors (%)

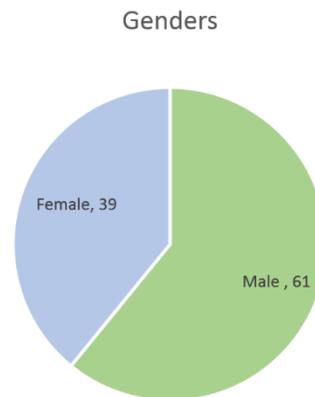


Figure 2. Gender of engineering ambassadors (%)

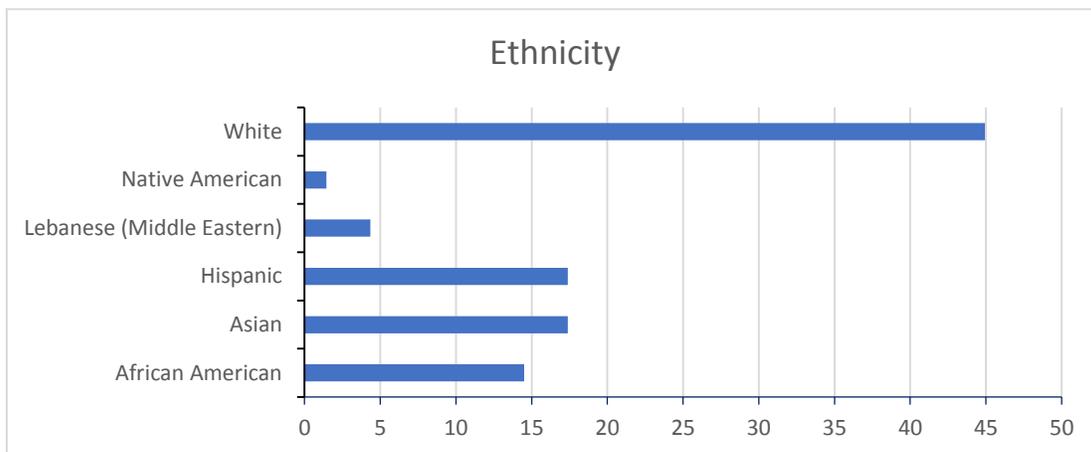


Figure 3. Ethnicity of engineering ambassadors (%)

As mentioned before one of the goals of the program is to target fanatically disadvantage and under-represented minorities to encourage them to consider engineering disciplines. The NYC Department of Education, specifically its Bronx schools (District 10) and the Yonkers Public School Districts are among the neediest (fanatically) in the nation [16]. Therefore, one public school from each district was selected for engineering ambassadors' visits. We partnered with two of these schools and have one visit per semester. The two partner schools are In-Tech Academy and Riverside High School.

In-Tech Academy, located in District 10 the most over-crowded district in the State, serves approximately 1,100 students in grades 6-12. Eighty-five percent of the students qualify for free or reduced lunch. The school population includes 82% Hispanic/Latino students, 12% Black/African American students, and 4% Asian/Pacific Islander students. Eighteen percent of students have disabilities. Thirty-eight percent of teachers hold advanced degrees [17].

Riverside High School for Engineering and Design is located in Yonkers, NY. The school serves approximately 1000 students in Grades 9-12. Eighty-seven percent of the students qualify for free or reduced lunch. The school population includes 57% Hispanic/Latino students, 32% Black/African American students, and 5% Asian/Pacific Islander students. Sixty-seven percent of the teachers have advanced degrees [18].

In addition to these two partner schools we visit other local schools to impact more students.

### **Activities**

Recruitment: Starting from the first or second week of the semester the engineering ambassadors have a general recruiting meeting where current members explain the program, the benefits of joining, and the commitments.

Preparing workshops: Following that meeting the members have weekly group meetings for the rest of the semester. The first half of the semester the engineering ambassadors split into groups of four students to design and test new presentations and hands-on activities. The presentations are geared to maximize visual aids and relate the new topics to concepts that students are familiar with either from everyday activities or class.

Professional Development workshops: Additionally throughout the semester two meetings addressed by guest speaker is for the ambassadors to improve their public speaking, teaching, or group work skills.

Visits: The second half of the semester is spent visiting middle and high schools, adjusting the presentations to be suitable for audience and practicing presenting. During the practice sessions the ambassadors and mentors give feedback on the content, visual aid, and individual presentation skills. Figure 4 shows the activities that ambassadors are involve through engineering ambassadors program.

### **A sample professional development**

One of the professional development workshops offered in Fall 2015 was "learning styles workshop". This workshop enabled the engineering ambassadors to explore their own preferred learning style so as to understand how others learn. Part of the workshop included an inventory for the participants. The inventory included about 20 questions which the EA's chose a preferred way to learn a task. Three preferences were noted: auditory, visual, or kinesthetic. For this particular group (mainly engineers) the group preferred to learn kinesthetically - hands on - although they noted that many of their professors do not teach that way. We examined some of the strategies used in teaching and considered how we could use these strategies in presenting the workshops at schools.

### **A sample visit**

In fall 2015 ambassadors visited Riverside high school at Yonkers NY. The workshop started with a short (10 minutes) presentation on different engineering disciplines. The purpose of this presentation was to engage the students in conversation about engineering. The ambassadors typically ask questions like if anyone knows an engineer, if anyone knows what an engineer does, or an example of something an

engineer would work with. Presentation includes four slides one for each of the traditional engineering disciplines (mechanical, civil, electrical and chemical).

Then the workshop was followed by a short demonstration of chemical and electrical engineering and how disciplines can cross and correlate. Next the science behind, “why a pickle would glow when 120V passes through it” was explained. Next, students were gathered around the front desk where the pickle was and one of the ambassadors connected it to an outlet for the students to see it glow. Due to the safety concern of high school students, they only observed this part.

Next students were given the opportunity to experience a hands-on engineering project. Ambassadors discussed how the brain controls muscle movements and how the bones act as the structure of the body and the bone makeup with denser bone on the outside and softer bone on the inside. Once students got a better understanding of bone structure, then they were instructed to build a prosthetic leg for one student in their four student group. While the students were designing, the engineering ambassadors were walking around from group to group giving them advice, asking if they have any questions, inquire about their thought process, and periodically give them time updates.

After their designs were complete, the legs were tested by putting as much pressure on the leg as it would hold. The groups were then brought back into the classroom to discuss what designs worked better and how they would go about their design if they were to do this project again.

Engineering ambassadors wrap up their visit by answering any further questions that students had about engineering, being an engineering student, or being a college student in general.

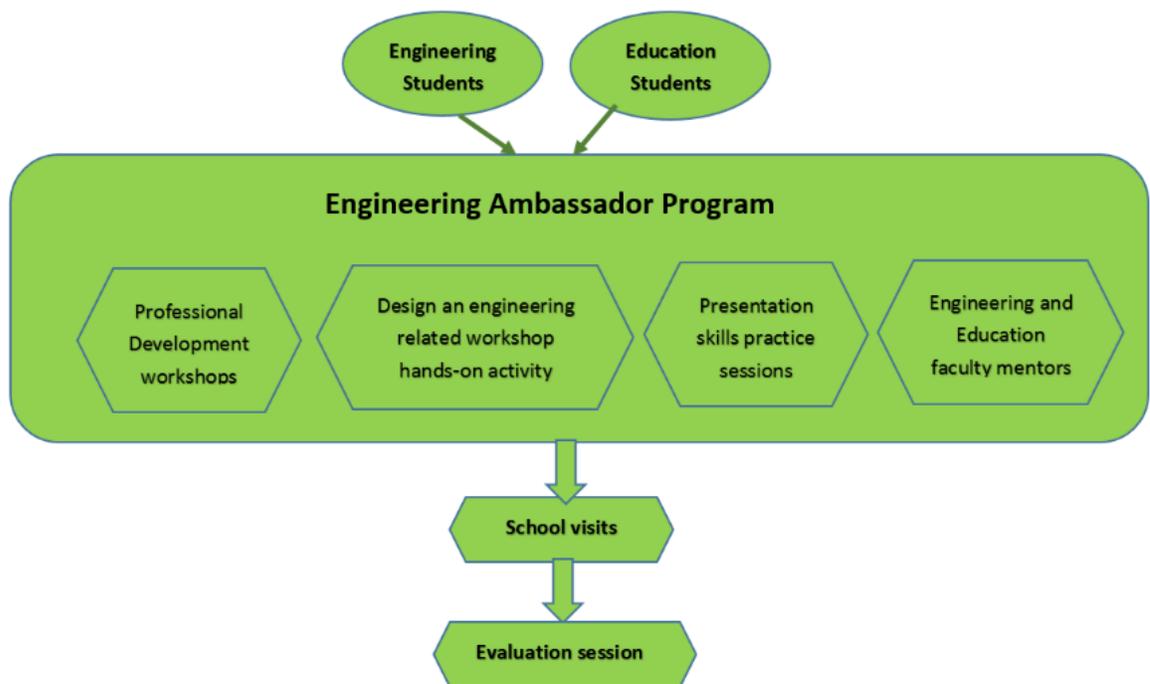


Figure 4. Engineering Ambassadors activities

### Program evaluation

To evaluate the success and effectiveness of the goals of the program a set of assessment statements were used. We categorized them to target two specific groups: College students (engineering ambassadors) and high/middle school students.

## Engineering Ambassadors Assessment:

For engineering ambassadors we had to evaluate the effectiveness of training workshops as well as their experience presenting workshops at middle/high schools. The following instruments were identified to use for this group:

### 1. Assessment of training workshops

Since each workshop was designed to educate students about a specific topic, specialized surveys were designed and asked students to fill out at the end of workshop. Table 1 shows a sample of this type of assessment tool for learning style workshop (explained previously).

Table 1: Evaluation form for learning style workshop

	SD	D	U	A	SA
I was introduced to the idea that learning styles can have an effect on work and communication styles	0%	8%	0%	23%	69%
I was encouraged to analyze my own personality type by: self -assessing and supporting with evidence (proof), working with my partner and sharing my experiences.	0%	0%	0%	54%	46%
I have a new or improved awareness of different learning styles and the effect they can have on work	0%	0%	0%	54%	46%
I have a new or improved awareness of different learning styles and the effect they can have on communication.	0%	0%	0%	62%	38%
I feel empowered by this new or improved awareness because it will enhance my ability to analyze, change and control my own objectives and outcomes in teaching and learning	0%	0%	8%	31%	62%

As shown in this assessment the workshop successfully introduced learning styles to engineering students and improved their readiness for effective presentations.

Each workshop was evaluated individually and required changes were applied. For example, after “learning style” workshop, we identified that these types of workshops can be more effective if offered as a two part training session and students work on a related assignment between two sessions and reflect on their learnings in group meetings.

### 2. Assess content validity of workshop plans

Once ambassadors select a topic and study the related background, they design a related hands-on activity. Then they meet with a faculty mentor to evaluate the designed activity. After first validation, students design a lesson plan including required worksheets for the activity. Once again faculty mentors evaluate the lesson plans and advise students accordingly.

3. *Self-reporting surveys from the Ambassadors who taught the lesson*

At the end of each visit, ambassadors fill out an assessment form to reflect on their experience. Then they meet in small groups and discuss their observations and make the necessary adjustments to their workshop for next time. Table 2 shows a sample assessment after one of the visits.

Table 2: Ambassador’s assessment form after a visit

Lesson topic	Lemon Battery/Egg Drop
Briefly describe your lesson	We related mechanical and electrical engineering sciences to simple experiments. Students used a lemon battery to power a LED light and paper, popsicle sticks, and tape to cushion an egg drop
What part of the lesson went really well?	the presentations
What part of your lesson will you do the same?	Lemon Battery
What part of your lesson will you change?	Have more time for egg drop
What will you do to make that change?	allow for more time before/after presentation
What knowledge and/or skill would help you in planning and presenting future lessons?	Effectively communicate a topic using a small amount of text on a slide. Use pictures to show a concept.

4. *Pre and post presentations skill critique session*

Before and after each visit each of ambassadors presents for a short time to the entire group and receives comments from fellow ambassadors. Table 3 shows the form used for this assessment.

Table3: Sample of ambassadors peer evaluations

Name:	Student A			
Skill	Excellent	Good	Average	Needs Improvement
Posture	6	5		
Filler Words	2	7	2	
Body Language	7	4		
Verbal tone and volume	4	5	2	
Eye contact	7	3	1	

5. *Videotape presentations at schools and engage in video analysis of real workshops with Ambassadors*

Videotaping presentations and participating in a critique session with peers and faculty members is the next step of this work which is planned for spring 2016. Arrangements have been made with partner schools and an education faculty member to supervise this activity.

Below are a few quotes from our engineering ambassadors about the program.

- “Participating in engineering ambassadors gave me the confidence to be a leader. Together as a team we worked on rethinking scientific concepts to make them more appealing to a younger audience.”
- “You often had to think outside the box which gave you the opportunity to be creative while thinking critically.”
- "Engineering ambassadors gave me the skills to communicate with coworkers effectively and clearly"
- "Engineering Ambassadors has showed me how important a great engineering education program is for young students."

**Middle/High school Assessment:**

6. Assessment of perception of community students who were served

Middle/high school students’ perception toward this program has been evaluated through an anonymous questioner. A five-point Likert scale with 5 representing “Strongly Agree” and 1 representing “Strongly Disagree” were employed.

Figure 5 shows the results from the visits in fall 2015 where we had 89 participants.

Below are some of the pie charts generated from the results of the surveys.

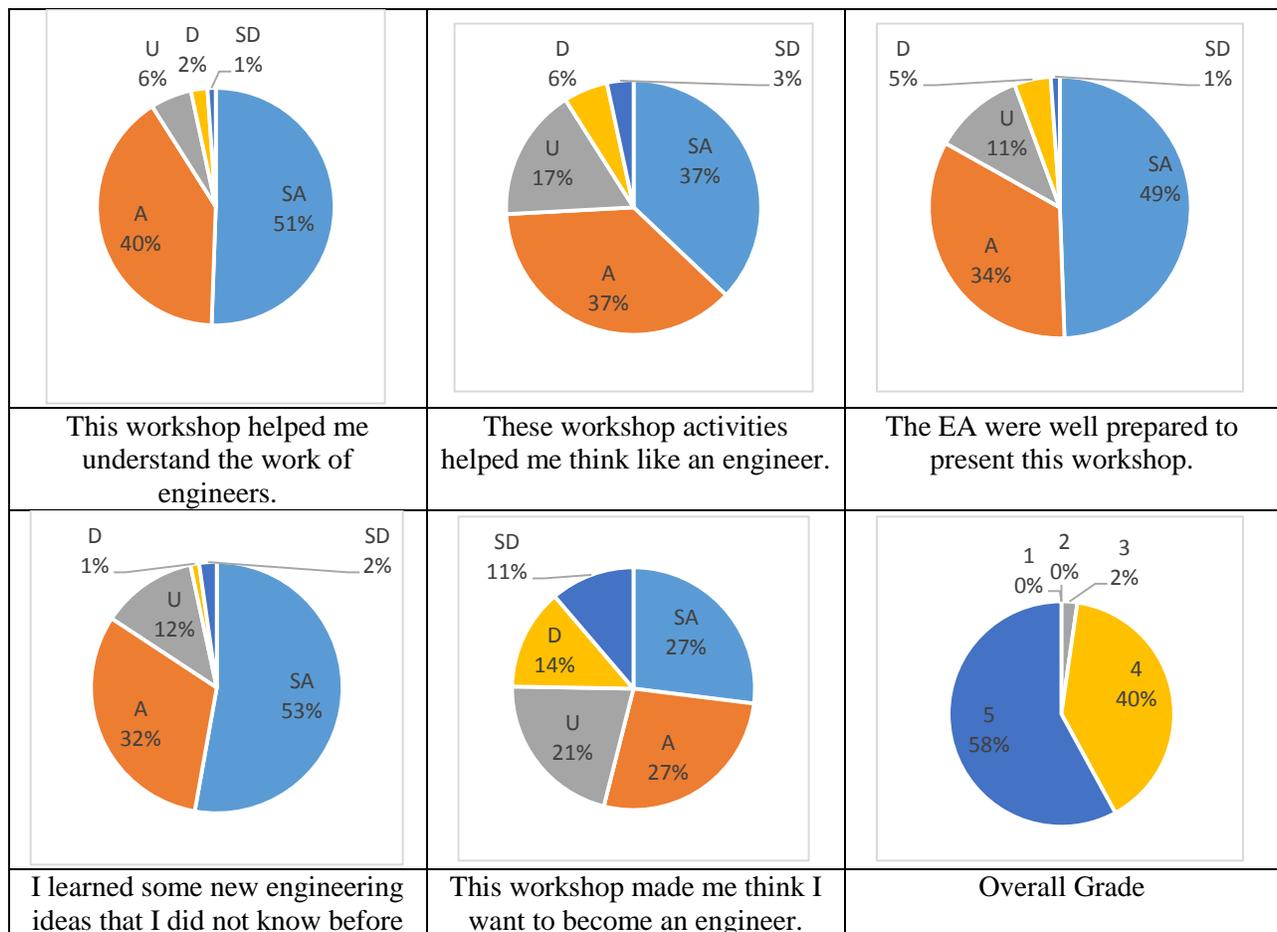


Figure 5: Assessment of Engineering ambassadors visit - 89 students participated

## Conclusion

In this paper we explained the goals, outcomes, challenges and achievements of our engineering ambassadors program. This program impacts engineering education by providing necessary skills of public speaking and presentation skills. It contributes to 6-12 STEM education by educating future math and science teachers about engineering and also provides information session and mentoring opportunity for middle/high school students to encourage them to consider engineering majors.

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