Engineering Ambassador Network: Professional Development of the Engineering Ambassadors

Catherine Talbot
Mr. Michael Alley, Pennsylvania State University, University Park

Michael Alley is an associate professor of engineering communication at Pennsylvania State University. He serves on the advisory board of the Engineering Ambassador Network. With Melissa Marshall and Christine Haas, he teaches advanced presentation skills to Engineering Ambassadors in workshops across the country.

Ms. Melissa Marshall, Pennsylvania State University, University Park
Ms. Christine Haas, Worcester Polytechnic Institute

Christine Haas has worked for non-profits and higher education institutions for the past eight years. As the Director of Operations for Worcester Polytechnic Institute (WPI) Engineering, she managed operations and strategic initiatives for the newly formed Office of the Dean of Engineering. As Director of Marketing for Drexel College of Engineering, she oversaw an extensive communication portfolio and branding for seven departments and programs. Christine currently consults with engineering and science related institutions to advise on best practices in communication, from presentations to print. Haas received her M.B.A. in marketing and international business from Drexel University and her B.A. in English and Film from Dickinson College.

Dr. Sarah E Zappe, Pennsylvania State University, University Park

Dr. Sarah E. Zappe is Director of Assessment and Instructional Support in the Leonhard Center for the Enhancement of Engineering Education at Penn State University. In her current position, Dr. Zappe is responsible for supporting curricular assessment and developing instructional support programs for faculty in the College of Engineering. In her research role, Dr. Zappe is interested in the integration of creativity into the engineering curriculum, innovation, and entrepreneurship. Dr. Zappe holds a doctorate in educational psychology specializing in applied testing and measurement. Her measurement interests include the development of instruments to measure the engineering professional skills and using qualitative data to enhance the response process validity of tests and instruments.

Dr. Joanna K. Garner, Old Dominion University, Norfolk, Virginia

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Introduction

According to a study done by the UNESCO International Centre for Engineering Education (UICEE), employers are seeking graduates with strong verbal communication skills and the fundamentals of visual communication.[1] Ample evidence shows that graduate engineers lack the required standard of communication skills needed in industry. From an ASME survey of more than 1000 engineers and managers working in industry, only 9 percent considered the communication skills of recent mechanical engineering graduates to be strong.[2] Opportunities certainly exist to gain communication, leadership, and teamwork skills in the classroom; however, these experiences are limited. Although many graduates felt they had gained analytical and problem-solving skills as well as subject-specific knowledge, they felt their engineering degrees did not provide them with strong oral communication skills and management skills. These students noted the importance of verbal communication skills in their new work environments.[3]

The Engineering Ambassador Network, which began at Penn State in 2009, is a professional development organization with an outreach mission. Specifically, ambassadors' communication and leadership are developed in a number of ways. Students participating in the Engineering Ambassador Network receive advanced coaching on how to give effective presentations. Two advanced styles of presenting are taught to students: the assertion-evidence approach[4, 5] and the TED-style approach to presentations.[6, 7] Once students are trained, they create and then give outreach presentations on what engineers do at middle and high schools. By the end of one of these outreach trips, each Engineering Ambassador has often spoken to more than 100 middle and high school students.

In addition, leadership skills are developed while creating these presentations. Moreover, in the Penn State program, Engineering Ambassadors are taught the principles of becoming a linchpin in an organization.[8] Likewise, at the Rensselaer Polytechnic Institute program, Engineering Ambassadors participate in activities such as the Archer Center Student Leadership Program.[9]

This paper focuses on how Engineering Ambassadors develop their communication and leadership skills. As examples of this professional development, this paper considers the four member schools of the Engineering Ambassador Network: Pennsylvania State University, Rensselaer Polytechnic Institute, the University of Connecticut, and Worcester Polytechnic Institute. Presented first is a review of other development programs with an emphasis on what distinguishes the professional development of ambassadors in the Engineering Ambassadors Network. Following that is a discussion of our methods for measuring development—namely, quantitative measures such as pre- and post-surveys, and qualitative measures such as interviews and focus groups. Then, the paper presents results of these measures at the four member schools of the Engineering Ambassador Network.

Review of Relevant Literature

The article "Stand up and Communicate" states that communication is a learnable skill.[10] The author, Marc Riemer, states that learning oral communication theories and techniques from textbooks is beneficial; however, studies indicate that experiential methods yielded better results.[1] Several studies have linked outreach programs with professional development. A case study done by Tufts University and the National Science Foundation investigated the skills that graduate fellows learned from doing outreach in K-12 schools that allowed them to excel in academia positions.[11] In addition, Gannon University showed that college students gained teamwork skills and improved leadership and communication skills by participating in a specific outreach activity: teaching students about mechanical engineering.[12] Moreover, biomedical engineering students at Northwestern University also felt they gained valuable leadership, management and communication through developing and teaching a K-12 outreach program.[13]

In the Tufts University study, eight top graduate fellows from Tufts University were given the opportunity to be paired with a K-12 teacher.[11] Participating NSF GK-12 fellows spent 20 hours a week on average working with the outreach project, with 16 hours (2 full days) per week spent in the classroom of their partner teacher. These students did not possess training as educators or significant experience working in schools. Fellows learned effective teaching strategies directly from the students and teachers in the classroom. In addition, fellows became skilled at breaking down complex concepts to present material in an understandable manner. Fellows have given feedback saying that this skill has enabled them to better understand their research by being able to explain it to someone with little or no engineering background.

At Northwestern University, undergraduate students participated in three classroom visits to high school classrooms per academic year.[12] The undergraduates worked with teachers in the classroom to develop modules to teach K-12 students. By pairing undergraduate students with trained faculty, the program focused on improving the understanding of teaching and learning. The undergraduates responded to an open-ended survey saying that the outreach program enabled them to better dissect engineering concepts to explain to students. The undergraduates also gained leadership, management, and communication skills from building and presenting lesson plans.

Each year at Gannon University since 2008, an average of 66 middle school students have participated in the "Mechanical Engineering Day."[13] The ASME Student Chapter, the SWE Student Chapter, and the Mechanical Engineering faculty at Gannon University have hosted the event. Again, the feedback from the participating undergraduate students showed an improvement in leadership, communication, and teamwork skills. In addition to these skills, Gannon reported that their students were also exposed to executing a project with budget and time limitations. The students gained these skills from working in a team to propose an activity showcasing engineering, testing the activity, and creating a budget. The team also created a handout with instructions for the middle school students, and developed scoring criteria to determine

the success of the activity. Once the planning phase was complete, the students participated in the outreach event and determined the success of the activity.

The Engineering Ambassador Network, which has 4 member programs and 17 pilot programs at 21 engineering colleges across the United States, is a professional development organization with an outreach mission. As mentioned, the four member schools are Penn State, Rensselaer Polytechnic Institute, University of Connecticut, and Worcester Polytechnic Institute. What distinguishes the professional development of undergraduates in the Engineering Ambassador Network from the professional development of students in the programs at Tufts, Northwestern, and Gannon is the formal training in communication skills and the development of leadership and organizational skills that occurs through the application of those presentation skills in outreach events.

Development of Engineering Ambassadors: Training and Experience

As mentioned, all ambassadors in the Engineering Ambassador Network receive significant training in communication. Moreover, a number of ambassador programs in the Network provide formal training of leadership skills.

Communication. The Engineering Ambassadors receive communication training and gain experience by giving presentations both at their university and in middle school and high school classrooms.

For instance, all Pennsylvania State University Engineering Ambassadors are required to take either a 3-credit effective speaking course for engineers or a 3-day Network workshop on advanced presentation skills. In addition, ambassadors are required to take a 3-credit advanced engineering communication course.[14] Early in this advanced engineering communication course, ambassadors learn the messages from *Changing the Conversation: Messages for Improving Public Understanding of Engineering,* which is a marketing strategy for recruiting middle and high school students into engineering.[15] The main messages include the following: (1) engineers make a world of difference, (2) engineers help shape the future, and (3) engineering is essential to our health, happiness and safety. Engineering Ambassadors use these message combined with their extensive training on different presentation techniques at outreach events in middle and high schools.[15]

As with all Engineering Ambassadors in the Network, Engineering Ambassadors at Penn State learn innovative presentation techniques such as the assertion-evidence slide structure.[4-5] Challenging the defaults of PowerPoint, Engineering Ambassadors in the Network learn to create assertion-evidence slides for technical presentations. The assertion is a succinct sentence headline that identifies the main message of that slide (or scene). In addition, rather than supporting the headline with a bulleted list as is typical in engineering presentations, the assertion-evidence approach calls for using visual evidence (photographs, drawings, diagrams, films, graphs, or streamlined tables). By using visual evidence rather than bulleted list, the presenter not only avoids cognitive overload, which occurs from having too much text, but also follows the principles of multimedia learning.[18] Shown in Figure 1 are two examples of assertion-evidence slides that

Engineering Ambassadors from Pennsylvania State University created. The sentence headline at the top of each slide is the main message of that slide, and the graphics in the body of the slide provides visual evidence for that message. This approach has been shown to communicate technical information much more effectively.[19]

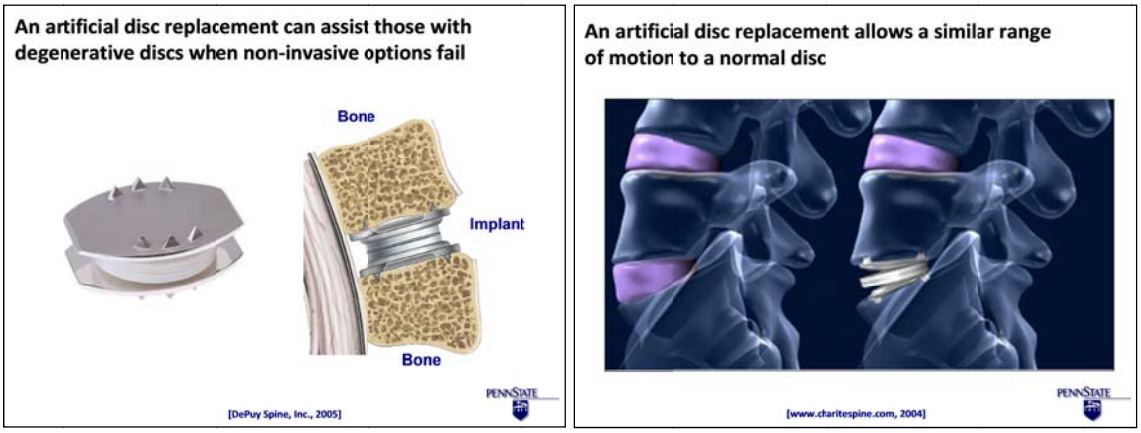

Figure 1: Sample slides from Engineering Ambassador talk. [17]

In addition, in their advanced communication course, Engineering Ambassadors at Penn State learn other alternative slide structures such as TED-style approach.[6-7] Such approaches are especially valuable for improving the communication of non-technical concepts. To learn the TED-style approach, Engineering Ambassadors at Penn State read *Presentation Zen* by Garr Reynolds. [7] *Presentation Zen* teaches Engineering Ambassadors to use simplicity when creating slides by increasing the signal-to-noise ratio, eliminating unnecessary text, and effectively using empty space. It is again stressed to avoid using PowerPoint's defaults and avoid using a bullet point slide structure. Figure 2 shows an example of a "Zen" style slide from Garr Reynolds book. The idea of Reynolds's slide design is not to replicate the speaker's exact words; however, display the main message in a memorable way.[7]

Being an effective member of a team is an additional skill many employers are seeking from recent graduates. Engineering Ambassadors are split into teams to create partner presentations to use for outreach in middle and high school classrooms. Working with a diverse group of engineering students, Engineering Ambassadors are able to come up with new and exciting ways to market engineering while teaching a science or math lesson to students.

Figure 2: Example of Presentation Zen slide.[7]

Beyond learning the theory behind effective communication, Engineering Ambassadors are given experience communicating in outreach presentations in middle and high school classrooms. Engineering Ambassadors have the responsibility to create a presentation tailored to their audience. On outreach visits to middle and high schools, Engineering Ambassadors have to target different types of classes: physics, chemistry, biology, math, and general science.

On visits to middle and high schools, ambassadors speak to two to five classes in a day. The ambassadors create a 20-minute presentation that follows the assertion-evidence approach. These 20-minute presentations demonstrate a fun math or science lesson that can be taken from the classroom into an engineering practice. After the presentation, ambassadors answer questions from the students and the teacher, a presentation situation similar to talks given in the workplace. Additionally, engineering ambassadors often give a presentation on careers in engineering to a general assembly. These assemblies can reach as many as 300 students. Engineering Ambassadors give their outreach presentations to science and math classes in teams of two. The careers assembly presentation is given in teams of four to six, depending on how many ambassadors visit the school. In these careers assembly presentations, the ambassadors have the opportunity to reinforce the messages from *Changing the Conversation.*

Leadership. In addition to communication training and experience, ambassadors gain valuable leadership skills. At Penn State, for example, ambassadors are required to read the book *Linchpin*: *Are You Indispensible*[8] by Seth Godin, and learn what it means to be an indispensible member of any organization. Ambassadors also gain experience as leaders by changing the status quo of how middle and high school students think about engineering using the messages from *Changing the Conversation: Messages for Improving Public Understanding of Engineering.*[15]

Linchpin: *Are You Indispensible* is a text that teaches ambassadors the lesson of going above and beyond the call of duty. The messages in this text concern taking the initiative to change the world. Thinking outside of the box and turning their work into art, ambassadors use these lessons to become leaders not only in the engineering ambassador program, but in the workforce after graduation.

Engineering Ambassadors at Rensselaer Polytechnic Institute receive leadership training by participating in the Archer Center Student Leadership Program.[9] In the Archer Center, ambassadors participate in custom-designed workshops. These programs are designed to strengthen ambassadors' skills as leaders not only as Engineering Ambassadors, but also as future leaders in the work force. Additionally, this program is designed to help student's make the transition from the classroom to the work place. The three main lessons ambassadors learn are to assess their own professional strengths and interests, develop their ability engage and motivate others, and to function in the changing workplace in which a leader operates.[9]

In addition, Engineering Ambassadors at WPI do two four-hour workshops with the associate dean of the business school, where they learn concepts such as leadership theory, leading by influence, and the difference between being a manager and a leader.

Methods

To evaluate the impact of the professional development that the ambassadors participate in, three programs in the Engineering Ambassador Network surveyed current and alumni Engineering Ambassadors. The surveys sought to determine what professional development the ambassadors gained from the program's training and experience.

First, the program at RPI administered a survey to current students who have completed the leadership and communication training. The questions in this survey included questions about the ambassadors' abilities to transfer information using the new communication style, motivation to learn content within presentations, and an increase in confidence while presenting.

Second, the Engineering Ambassador Network administered a pre- and post-survey to the inaugural national workshop for the Engineering Ambassador Network. Sponsored by a workshop grant from the National Science Foundation (NSF DUE-1237353) and funding from the Penn State Electro-Optics Center, the workshop trained 45 Engineering Ambassadors from 17 pilot schools around the country.

Third, the program at WPI administered a post-workshop survey to Engineering Ambassadors after its September 2012 training workshop. This 3-day workshop trained 51 ambassadors from all four member schools on advanced presentation skills.

Finally, the program at Penn State administered a survey to their engineering ambassador alumni. This survey sought to determine what skills that the ambassadors developed in their program they were able to apply in their professional jobs or graduate school positions.

Results and Discussion

The results of all four surveys showed distinct gains for the Engineering Ambassadors in their professional development. In particular, the surveys of current

Engineering Ambassadors in the programs revealed that the training of the advanced presentation techniques led to significant improvements in the confidence of the Engineering Ambassadors as presenters.

First, from the RPI survey given to all thirty of the current ambassadors at RPI about the new communication methods, 72% agreed that the presentation had helped them learn to transfer information outside their area, 83% agreed that they were more motivated to learn the course content, and 94% agreed that the process helped them to develop confidence in presenting engineering content.

For the inaugural national workshop of the Engineering Ambassador Network, pre- and post-assessments were done for those 45 students who participated in the workshop. Students were asked a set of eleven questions regarding their level of confidence with presentation skills. The question stem asked the students, "In a presentation to middle or high school students that communicates the messages of *Changing the Conversation*, I am confident in my ability to do the following." The students were asked to rate eleven phrases using a 5-point scale from Strongly Disagree (1) to Strongly Agree (5). All item means improved from the pre- to the post survey. The averages were significantly different for 7 of the items that were assessed, as listed below:

1. Create content that will engage the audience ($p=0.02$).
2. Establish credibility with the audience ($p=0.03$).
3. Know what details to include and what details to leave out ($p=0.01$).
4. Create slides that help the audience remember the information ($p=0.01$).
5. Select an appropriate slide design: typography, layout, arrangement of details, and level of detail ($p<0.00$).
6. Deliver the content in front of a large group ($p<0.00$).
7. Hold the audience's attention for 15-20 minutes ($p<0.00$).

As seen, these self-response surveys showed that the ambassadors saw themselves developing as presenters because of the training in the program.

At another training workshop, this one at WPI for the four member schools, students responded as having similar post-workshop scores on the communication skills as those in the national workshop. In particular, the students claimed confidence in being able to create content that will engage the audience, organize the information so that it is understandable for the audience, and create slides to help the audience understand and remember the information.

Finally, Penn State administered a recent survey of its Engineering Ambassador alumni to determine what skills they learned as an Ambassador were valuable in their professional jobs or graduate school positions. All 17 alumni who responded discussed the communication skills that they developed as an Ambassador. Given below are three responses:

> Being an Engineering Ambassador changed my life. It not only gave me the confidence to create and give effective technical presentations, but it also opened up a world of opportunity which I never knew existed in engineering; the ability to make a difference. Even after going through years of engineering schooling, I never knew the wide breadth of impacts that engineers have on our world and on

> our futures. I also had the amazing opportunity to present to, interact with, and hopefully change the lives of many eager middle and high school students across the state. These school visits, I believe, [were some] of the most challenging yet rewarding experiences of my college career.
>
> Being a part of the Engineering Ambassador was a key moment in my life –I think of it as one of those "ah-ha!" moments in which I truly began to appreciate being an engineer. Communication, especially as an engineer, has been the best skill set I could have gained as an engineering ambassador. Knowledge is great, but being able to communicate takes it to a level where I have confidence to be a leader and a team player.
>
> Engineering Ambassadors taught me how to become an indispensable part of everything I do. My drive to succeed and make a real difference coupled with the communication and presentation skills that EA helped me develop have jump-started my career. About a year ago when I first started my job, I jumped at the opportunity to create a presentation about Air Liquide's internal social network - EA gave me the confidence to attempt such a task. Soon enough, word of my presentation made it to the Head Office in Paris, France. Because of this international exposure so early in my career, I quickly began to make a name for myself. Since last year I have been able to present before executives, meet with senior management from Paris, attend several exclusive meetings and receptions, manage the internal social network that I presented, and now work directly for the Chief Operating Officer (COO) of the company. Without both the hard skills (presentation development, communication techniques, etc.) and soft skills (confidence, drive for excellence, "linchpinity," etc.) that EA helped me develop, I do not believe that I would be in the same position I am today.

We predict that these Ambassadors will be future engineering leaders in U.S. industries and will help to communicate the importance of the engineering field to the public.

Higher education cannot afford to focus on developing engineering students' technical skills alone. In order to produce engineers that can solve important global problems, engineers need to be able to communicate effectively with lay audiences to persuade, justify, teach, and respond to their concerns. The EA Network approach shows promise in cultivating the types of communication and leadership skills needed by engineers. Moreover, students' practice and refinement of their skills for middle and high school students and teachers serves a broader outreach mission and provides undergraduates with direct experiences of the value of inspiring others to learn more about their chosen career.

Acknowledgments

The authors gratefully acknowledge the support of the Penn State College of Engineering and ElectroOptics Center for their support as well as the support from the National Science Foundation specifically the funding under the NSF DUE-1237353 workshop grant.

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