Outreach Playbook

High School Mentorship Program: Introduction to Engineering

Blue text is intended to function as instructions and recommendations. Please delete before submitting the template.

Metrics:

Grade Level: 9-12	# of Student Participants: 20	Duration (hrs): 1 hour and 30 minutes	# of SWE Volunteers: 10	Partner orgs (if any): N/A

Overview of Activity

Please give a detailed lesson plan for the activity, including: 1) a basic explanation of the activity, 2) the main takeaways for the students 3) a real-life connection to give the activity more context (e.g. new developments in technology, a STEM story in the news, something in student's lives that they can relate to, etc.), and any additional context you think is important for replicating your activity.

The Drexel SWE Outreach committee hosted an Introduction to Engineering event for their High School Mentorship program. It was intended for students within the high school mentorship program and their mentors. However, this event could be applied to any group of high school age students. The purpose of the event was to allow the mentees to explore the different sectors of engineering through various demos and experiments. The goal was to introduce the different types of engineering to the students and help them gain a better idea of what they might want to pursue a major in. Before the event, the mentees were able to select from ~~various~~ different demos that each related to a specific type of engineering. They were allowed to pick two demos to participate in during the event. This event was held virtually, so there were two different breakout room sessions within the hour and a half period, one for each demo the mentees chose. The mentors, who are studying the specific type of engineering the demos were related to, volunteered to help run them.

Outline and Script

Give a detailed description of the steps and optional talking points for those utilizing this activity, leading them through the entire process of the activity. Include clear references to when different materials are used and good questions/points to get the students thinking. Include any resources about the topic (such as links to websites) that could be useful to others.

To start off the 'Introduction to Engineering' event, the girls were welcomed and engaged in chatting about their days to set a comfortable stage for the event. After this, a PowerPoint presentation was used to communicate the agenda for the event. After this, the purpose of the event was reiterated together with the different engineering principles that the participants had the choice of learning more about. This was done to open potential conversations about potential switches in arrangements of demonstration assignments in case anyone had changed their minds about what demonstration they wanted to participate in. This also allowed for the opportunity for participants who did not give prior notes about what demonstrations they wanted to participate in to indicate their preferences. As this event was part of a mentorship program, some announcements were made upon the conclusion of the two demonstrations the girls participated in, including a link to a feedback form to improve this event.

Attached here is the link to the PowerPoint slides used for the introduction: https://docs.google.com/presentation/d/1r0U60VsintMtpSrndy8pmDynxossjZ3Q2ESp1ATUBQ8/edit?usp=sharing

Attached here is the feedback form used: https://forms.gle/hF6ucEfCr4MAgcyb8

As discussed before, there were multiple different demos conducted during this event. We have included scripts for each demo below.

Robot Hands:
Biomedical engineering is truly the field where medicine and engineering intersect to improve the quality of life. To introduce this important aspect of this engineering field, a demonstration called "Robot Hands" was used. Before diving into the activity, a discussion was opened discussing what biomedical engineering is and what the core values of a biomedical engineer are. The biomedical engineering field focuses on advances that improve human health by using the knowledge of modern biology in the process-design process. Examples were discussed to reiterate this as well, such as prosthetics that are developed by biomedical engineers. This served as a nice introduction to the related demonstration. Before getting into the demonstration, the materials needed for this specific demonstration were explained. This gave the girls and the volunteers some time to gather the materials before the activity started in case they had not gotten the chance to do so already. This also was an opportunity for people to bring up concerns about if they did not have some of the materials; we worked with the girls to come up with alternatives to materials while also taking this as an opportunity to show them that engineering is also based on a creative problem-solving process. The materials included gloves, a blind fold, popsicle sticks, masking tape, and pliers. For example, the girls did not have pliers, we suggested the girls use their index and middle fingers to mimic pliers. After the materials were gathered, the girls were asked to run the demo together. The core value of the demo was to show the participants how limitations of how you design a prosthetic can limit the mobility of the design. This was demonstrated by implementing different limitations on the hand while trying to tie shoes. Following this, the following reflective questions were asked which opened up further discussions of what biomedical engineering is: What did you notice when you tied your shoes blindfolded; what did you notice when you tied your shoes with gloves; what did you notice when you tied your shoes using popsicles; what did you notice when you tied your shoes using pliers. Through facilitating questions, different conclusions were made through collaborative discussions

through the group with both volunteers, the participants, and the facilitators. The conclusions are as follows: a robot with few joints is not very flexible; a robot without sensors is unable to feel or see anything; and therefore, how a robot is designed limits the sort of job it can do.

Attached here is the link to the demonstrations slides:
https://docs.google.com/presentation/d/1Gv1_h4gyzxY3M2W-WDGphho4m0Rp-m0Q0GsjjgIe_CY/edit?usp=sharing

Attached here is the link to the demonstration write-up:
https://docs.google.com/document/d/1RemCzG7koi3dnJjKvORwXmQmg5ThbqPt8Xo_VjE0x9M/edit?usp=sharing

Virtual Face Tracker:
Computer engineering, electrical engineering, and computer science are very similar fields that are often confused by many, including pre-collegiate students. This can make it difficult to choose between these disciplines to declare as a college major. This is why a demonstration was conducted among most probably the most misunderstood of this combination, computer engineering. Before the demonstration was started, the discipline was explained by differentiating it from the other two; the definition that was used includes the following: ‘Computer engineering is the branch of engineering that integrates electronic engineering with computer sciences.’ A discussion was followed up after this, allowing for the opportunity to clarify what computer engineering is. After this brief discussion, the activity was started. The activity was to design a virtual face tracker using JavaScript. This was done through a compiler that also took the participants through every line of code and every step to code the face tracker, which is called VidCode. This platform has many other tutorials that the girls were free to explore after this event as this platform is free to all! The facilitator walked the participants through every step and added facilitating questions regarding changing properties of the face tracker in the code. The volunteers were given the roles of teaching assistants to help facilitate the lesson and to allow for the participants to ask any questions. This activity reiterated that in computer engineering, engineers use electrical and computer science to develop new technologies.

Attached here is the link to the demonstration slides:
https://docs.google.com/presentation/d/1yMNJ_VWYXfT4b1DZgiIFzN3CEyNBE8eNw-9bkjxZcco/edit?usp=sharing

Attached here is the link to the demonstration write-up:
https://docs.google.com/document/d/1JrcRYZ7sjhQo-R97I-Iw8M152TztVYWh3ILISnOL8eA/edit?usp=sharing

Wind-Powered Cars:
To introduce the demo, we first talked about mechanical engineering and what a mechanical engineer does. We asked the students if they had any idea of what mechanical engineers do and the types of projects they work on. We explained that mechanical engineering is concerned with the study of objects and systems in motion. It is one of the most diverse and versatile engineering fields. It deals with virtually every aspect of life, even the human body!

Mechanical engineers play key roles in many industries including automotive, aerospace, biotechnology, computers, electronics, energy conversion, robotics, manufacturing, and many more! We made sure to emphasize the various opportunities in mechanical engineering. Then we got into the demo! First, we explained the materials they will need for it and asked them to get them if they did not have them ready. Then we went through the instructions on the slides. Each slide has detailed explanations of the instructions on how to make the wind-powered car. We went slide by slide and made sure that everyone was done the steps on one slide before moving to the next. We asked the students to share how their construction process was going throughout the demo. Once we got through all the instructions we asked everyone to show their cars. We asked them to show us if they worked with a fan or hair dryer blowing at them. If their car did not move, we asked them why and what they could do to change it so that it does work. There are some follow-up questions you can go through and they are listed below:

- Experiment with your car, can you make it faster? What did you change to make it go faster?
- What would happen if you made the sail a different size or shape? Would a bigger sail be better?
- What other materials could you use for the wheels?

Attached here is the link to the PowerPoint slides for this demo:
https://docs.google.com/presentation/d/1GOdIM--sf7H2pR_OAEb83B2v3ONp_NtVCewkaI_v41c/edit#slide=id.g11fb7df2023_0_2638

Attached here is the link to the write-up for this demo:https://docs.google.com/document/d/1pzNIy195CpI80UwIKIIJkNA9tY5yCqFbabsLXHkz5FQ/edit

Tower Competition:
To introduce the demo, we first talked about Civil engineering and what a civil engineer does. Before getting into the slides, you could ask the students if they have an idea of what a civil engineer does. Then move to the second slide, the link for the slides is attached below. Civil engineering is arguably the oldest engineering discipline. It deals with the built environment which includes buildings, bridges, roads, subway systems, and airports. Civil engineers must have a good understanding of forces to ensure that any structure they build stays standing. Then you can talk about strong building shapes. You can ask the students why a triangle may be a better shape to build with versus a square. Then you can explain why a triangle is stronger. From there you can explain what infrastructure is and just emphasize how the work civil engineers do is all around us. Then you will get into the Tower Competition demo. Explain the materials they will need for it and ask them to get them if they do not have them ready. You can emphasize that the students can be creative with their materials. If they do not have straws or toothpicks they could use crayons, markers, pencils, etc. Just emphasize that there are multiple materials to make the tower out of. Then move on to the instructions for the demo. You can ask the students how they are going to build their tower, what they are going to start with, and if they have a plan for how to build the tallest tower. Explain the instructions and keep the students engaged while they are building their towers. You should build one with them and you can walk through what you are thinking as you are building your own.

Continually check in with the students to see how their construction is going. If you would like you could play music while they are working to avoid any awkward silences. We gave them a total of 30 minutes to work, with 10 and 5 minute warnings. Once the 30 minutes is up, have them share their towers and explain the decisions they made along the way. There are some follow-up questions you can go through and they are listed below:

- What are some ways you could change your tower to make it taller?
- What are some important considerations you made when making your tower?

Attached here is the link to the PowerPoint slides for this demo:
https://docs.google.com/presentation/d/13s0SECzgBgDvzWSnTczQyY30-5n5XKC0g320l6AI-qM/edit#slide=id.g11fb7df2023_0_2638
Attached here is the link to the write-up for this demo:https://docs.google.com/document/d/1zkYV6xc2_iBtq6gxIPvIAtcjCG5PrOUgjRuYZ-OtCrw/edit

Lessons Learned

Share things that worked well when you executed this activity, helpful tips, do's and don'ts, and other best practices. What would you do differently if you did the activity over again?

After the event concluded, the team participated in collaborative reflection of this event to improve the structure for such future events. The girls were very engaged, as the structure of the event allowed students to participate in fun activities through learning what the focus is of the respective engineering focus by completing a hands-on activity. A part of the reason the girls were very engaged is because they were able to choose what specific engineering disciplines they wanted to learn more about. As described earlier, the girls were also encouraged to participate in an active discussion through facilitating questions after the active hands-on demonstration they completed. The organizing team noticed that these active conversations enhanced the purpose of the event: the facilitating questions sparked conversations about what engineering is, including exposing the various aspects of engineering such as collaboration, critical thinking, and problem solving. What enhanced this is that current college students of different engineering disciplines were able to participate in these discussions. As many of the college students were also able to participate in engineering internship roles, a perspective of what engineering is like in the field was also brought up. They were also able to in addition to the facilitators give their personal perspectives on why they chose their specific engineering major and what they hope to do with it, which in turn also sparked conversations as different engineering majors were discussed. The demonstration helped the girls learn more about what the focus is of different engineering fields, whereas the discussion among college students and themselves helped them understand the broader idea behind the different engineering fields. This was the core value of the event.

Through this collaborative reflection, the team identified some steps that were taken during the planning process that contributed to the success of this event. This planning process started two months prior to the event, which ensured that all the necessary materials and documents were obtained well in advance. This also ensured that gaps were identified before the event. The necessary materials included the different PowerPoint presentations for the introduction of the event and the different demonstrations, the materials for the demonstrations, and the demonstration write-ups. Another aspect of the planning process that went well was volunteer engagement. The college students who volunteered to help facilitate the demonstrations were engaged a week before the event. In these meetings, the structure of the event was explained, including the different demonstrations, the demonstration write-ups, and the deliverables of the event. The volunteers were also given the opportunity to choose what demonstrations they wanted to help facilitate relating to their level of comfort with the engineering discipline. In this manner, the volunteers were also given ample time and opportunity to ask any questions about the event and the demonstrations. Another major factor of the event was evaluating the appropriateness of difficulty of the demonstrations in the event. As one of the ultimate goals was for the girls to be engaged, it was important to not have an activity that was too simple, especially considering that the audience was high school girls from the 9^{th} through the 12^{th} grade. Therefore, the decision was made to add level-appropriate facilitating questions about the activity after the hands-on part, to reflect on the activity at a level that was appropriate for their age group.

Nevertheless, the team did also identify some gaps in the planning process. If these areas were addressed upon, the team believes that the event could have been a greater success. This room for improvement includes earlier communication with the target audience (the high school aged girls) and the volunteers of the event. The mentees were notified about the different demonstrations and the materials needed for the event approximately two weeks prior to the event. This could have led to a greater turnout for the event, of both the volunteers and the audience. This would have allowed for more girls to learn about the different engineering majors prior to their post-secondary educational endeavors. This also could have brought more volunteers of different engineering principles. Most of the volunteers were studying chemical engineering. It would have been more helpful for the girls to learn more about the engineering principles that were not represented, such as electrical or computer engineering. In turn, this would have been more helpful to the participants (the high school aged girls). This advance communication would also have prevented the struggle of both volunteers and the participants having a lack of materials. Due to this problem, some volunteers were not able to fully participate in facilitating the demonstrations, and some students were not able to fully grasp some concepts as they did not get the opportunity to learn about the engineering principles in a way that allowed them to explore hands-on. However, at times, the volunteers were able to overcome this limitation by suggesting alternative household items. In some sense, this exposed the participants to the problem-solving aspect of engineering.

Accessibility Adaptations

Provide examples of ways to adapt this activity with a smaller budget, lack of internet access, with students that are completely virtual, with ESL students, or any other important accommodations that your group has experience with. If your group did not offer any accessibility accommodations, do your best to come up with at least one.

This event was held virtually, so we did a lot of work before the event to make sure everyone was aware of the materials and demos that would be happening during the event. It was helpful to have Zoom so that we could share our cameras and see what each mentee was doing. Additionally, because it was virtual we could not provide the materials for the girls so there were a lot of creative ideas for different materials to use during the event. For example, someone used pencils and markers to create their tower instead of plastic straws. We also tried to make sure that all the materials were common household items so that no one would have to buy too many things for the event. For ESL students we could provide the demo instructions in different languages. They could work through the demo on their own because the instructions explain most everything about the demo. If the event was held in person, the people running the event could provide the materials to the students and help them with each step of the design, development, and analysis aspects of each demo.

Materials and Costs

List out each item/material used in this activity, cost for each item, purchase location, and total cost of the activity. If used, include any local grants (or similar funding) utilized or online resources that were helpful.

All materials were materials that you could find at home, so we did not purchase anything for this event. However, if it was held in person we would have. For the virtual face tracker demo you do need a computer. Below we have listed the materials necessary for the demos and their average costs.

Item	**Quantity**	**Where to Buy (link if applicable)**	**Total Cost**
Box of Spaghetti/Plastic Straws/Toothpicks (pick one to build with)	1/1/1	Any grocery store near you, or dollar store	1.58/1.25/3.79

Tape	12 rolls	https://www.amazon.com/Transparent-Refills-All-Purpose-Glossy-Office/dp/B08QMRQXSX/ref=sr_1_2_sspa?adgrpid=1344703291894685&hvadid=84044194299109&hvbmt=be&hvdev=c&hvlocphy=62511&hvnetw=o&hvqmt=e&hvtargid=kwd-84044314347921%3Aloc-190&hydadcr=22794_13492992&keywords=tape+rolls&qid=1653399459&sr=8-2-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExQlZTMEtXTk40WUpZJmVuY3J5cHRlZElkPUEwMDI4OTk0M1U0Vkk1NFNaT0RGSCZlbmNyeXB0ZWRBZElkPUEwMjM0MjkyUFdBUExFTDNPSFY2JndpZGdldE5hbWU9c3BfYXRmJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ==, or any dollar store	10.29
Cardboard	1 box per student	Can use recycled boxes	
Construction Paper	96 pieces of paper	https://www.amazon.com/Crayola-Construction-Classic-Projects-Classrooms/dp/B003W0PBR2/ref=sr_1_7?keywords=construction+paper&qid=16533	2.46

		99509&sprefix=construction%2Caps%2C118&sr=8-7	
Wooden Skewers	2 skewers for each student	https://www.amazon.com/BAMBUU-Bamboo-Skewers-12Inch-Sizes/dp/B07X7LYDD3/ref=sr_1_1_sspa?crid=2PAU7SBB064KO&keywords=wooden%2Bskewers&qid=1653399561&sprefix=wooden%2Bskewer%2Caps%2C186&sr=8-1-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzSzJaUzc0VVhLU1NFJmVuY3J5cHRlZElkPUEwNjAyOTQyM1BNQVgxTEJONjFXQyZlbmNyeXB0ZWRBZElkPUEwODU1MzQ2M0hDVjhSV0QzME0yNCZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU&th=1	7
Plastic Bottle Caps	4 caps for each student	Use recycled bottle caps from water bottles	
Fan or hairdyer	1 or 2 (depends on the amount of students)	https://www.amazon.com/Handheld-Portable-Operated-Rechargeable-Personal/dp/B07QMC6SN9/ref=sr_1_4_sspa?crid=3P8W5IVYVVIUI&keywords=small+handheld+fan&qid=1653399632&sprefix=small+hand	14.99

		held+%2Caps%2C127&sr=8-4-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzNEI0TFMzOEZCWUJQJmVuY3J5cHRlZElkPUEwMTYyOTMwMlNETjlVOFQ3SzREMCZlbmNyeXB0ZWRBZElkPUEwMTU0NjI5MlRZSFJZQjc1N0lMNiZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=	
Gloves	1 pair for each student	https://www.amazon.com/Disposable-Blue-Nitrile-Gloves-Large/dp/B08MKZW65H/ref=sr_1_2_sspa?crid=7NG1D5BS05OR&keywords=medical+gloves&qid=1653399671&sprefix=medica%2Caps%2C1286&sr=8-2-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzRzhSM1c4MDQ4R0lGJmVuY3J5cHRlZElkPUEwNzc4OTA0M0NSOVNDMjkwTVFBMCZlbmNyeXB0ZWRBZElkPUExMDMyMTUxN0ZJQkpUNVgzMlVCJndpZGdldE5hbWU9c3BfYXRmJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ==	11.88

Popsicle sticks		https://www.amazon.com/Wooden-Multi-Purpose-Popsicle-Sticks-Crafts/dp/B09325532F/ref=sr_1_1_sspa?crid=3JBFGAECFGPQ4&keywords=popsicle+stick&qid=1653399708&sprefix=popsi%2Caps%2C163&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyQTlPNzdSMTNDMDExJmVuY3J5cHRlZElkPUEwMjIwMjc0M0RPTkVSWU01N0w3TyZlbmNyeXB0ZWRBZElkPUEwNjc2MjQ5M0dMWVdZMUlQWlM1RCZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=	4.99

Describe any additional funding sources outside of section budget (if applicable):