A Fat Foil Vortex Induced Vibrations Energy Converter for Alaskan Coastal and Island Communities

Marine Energy Collegiate Competition 2024

WEBB INSTITUTE

Ashmore, B., Calli, W., Coppi, M., Erdos, K., Freischlag, K., Heidenreich, D., Kanemasu, B., Kawabata, E., Kealey, B., Mullan, A., Ng, A., Nicoletti, L., Sanchez, M., Sir, D., Wolfe, W.

Advised by Webb Institute Professors Martin, M. and Royce, R.

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1 After-Action Report

1.1 Overview of Actions Taken

In the completion of the Webb Institute MECC Team's 2024 submission, the team completed several large outreach projects in parallel with the business, technical, and build challenges. The main focus and theme for this year's Community Connection's Challenge was K-12 education. The team collectively and successfully ran a large educational event on April 27th called Engineering Day, a smaller scale educational event the following week with the local Girl Scouts of the USA troop, and developed a laboratory exercise for sciences and engineering classes.

1.1.1 MECC Engineering Day

Engineering Day is a yearly Spring event hosted at Webb Institute with the goal of inspiring local students grade 4th – 6th to get involved in the field of engineering. This year marks the second annual event since the COVID-19 pandemic. The event is entirely student lead and garners massive involvement from the Webb community, with 50 of the 105 total enrolled students at Webb Institute helping out on the day of the event. During the event, students rotate in groups between three stations with different hands-on engineering challenges. Each station involved marine and renewable energy engineering at the core. Each station also involves instructional time before the challenge to educate the students on various marine energy topics.

The main challenge to be highlighted is the Vortex-Induced-Vibrations (VIV) energy generator lab. This challenge is a small-scale model version of the energy generating device the team designed and tested for this year's MECC competition. This same lab was also used in the Girl Scouts event. The VIV station challenged students to use custom laser cut stands and a variety of craft materials to design a hydrofoil to generate the most motion when placed in the stream of a large fan.

Overall, Engineering Day 2024 was a success in that a wide variety of schools and geographic locations were represented. The positive feedback received and metrics that are included in the following sections indicate that Engineering Day is growing, and the word of the event is spreading in the area. The team is optimistic that Engineering Day at Webb Institute will continue to run annually and grow in size and scale.

Figure 1. Webb Institute President Alongside MECC Team Members Welcoming Attendees and Their Families to Campus

Figure 2. Event Attendees Testing Their Designs

Figure 3. MECC Team Member Demonstrating How a Foil Works

Figure 4. Presentation to Attendees Explaining Marine Energy and its Importance

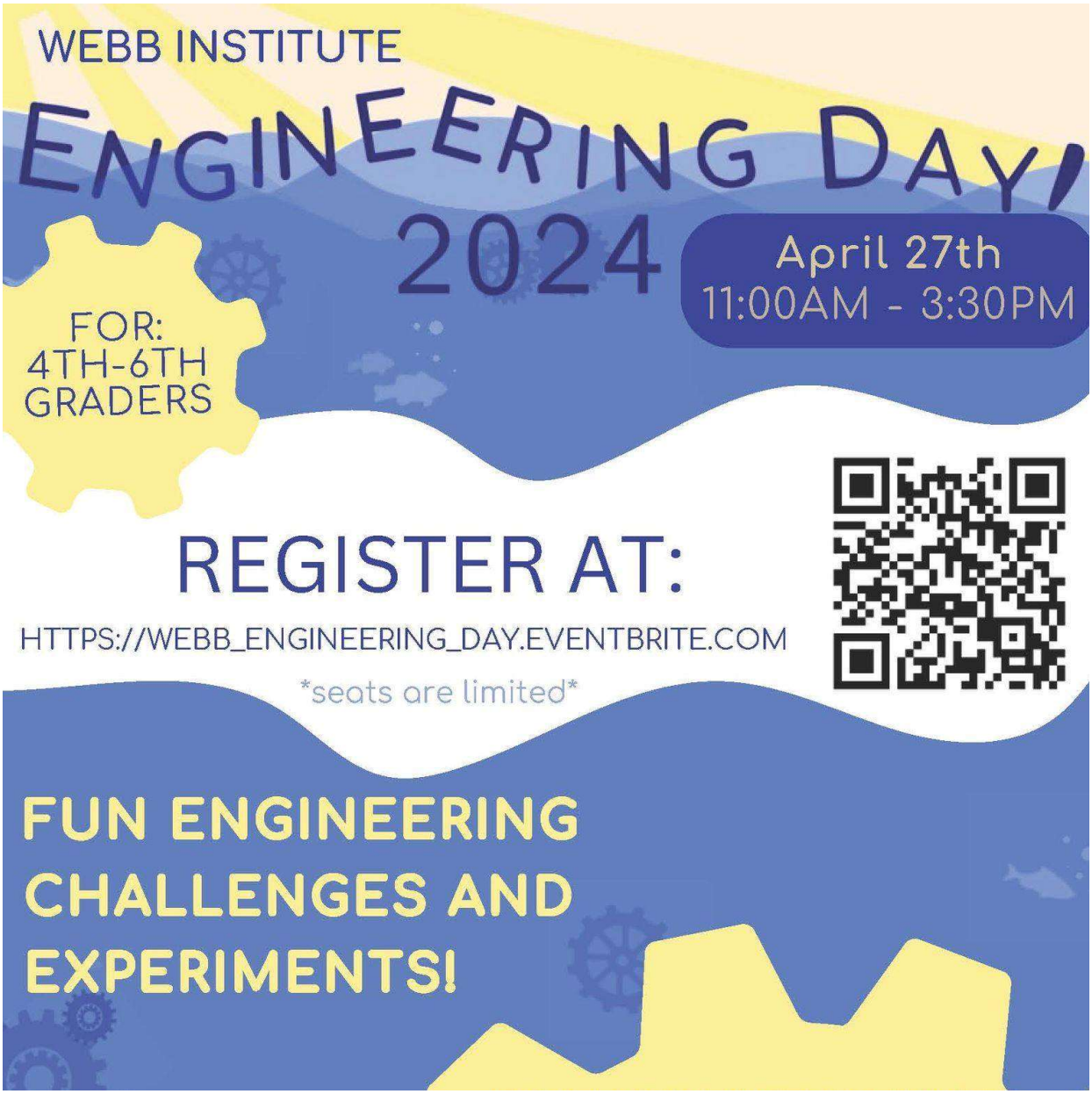


Figure 5. Poster Used to Advertise Event

1.1.2 Girl Scouts Event

This year, the team brought back another annual event with a whole-day educational session with Girl Scout troop 4018. The event took place on May 4, with 12 scouts in attendance. The day had three sections. First, an instructional session on marine energy was held. Then, the same VIV energy generator laboratory was conducted, with the Girl Scouts being given plenty of time to build hydrofoils, test them with the fan, and redesign them in an attempt to generate more motion with the foils. Finally, the Girl Scouts and their families were given a tour of Webb Institute's Haeberle Laboratory. Here, everyone was shown the full-scale model and demonstration of testing being done in Webb's circular flow channel and various other marine engineering testing equipment.

The goal of the event was to inspire the future of marine energy by not only running marine energy challenges, but also to correlate the classroom experience with large scale testing experiences. In this way, the team was successful in reaching a broader group of K-12 grade levels while providing a more in-depth experience than a large-scale event like Engineering Day.

Figure 6. Group Picture After Event

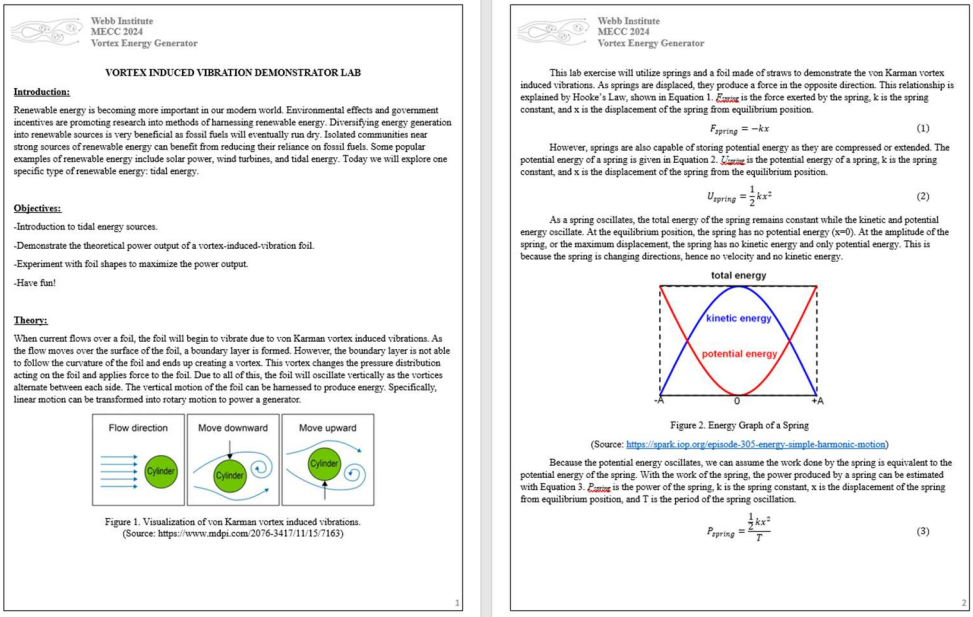
Figure 7. Full Size Testing Apparatus Demonstration

Figure 8. Small Scale Hands-on Demonstration

1.1.3 Lab Exercises

To reach a larger number of students all over the country, a laboratory exercise and worksheet was developed. This lab has two versions, one meant for the elementary to middle-school level, and one for the high-school level. The lab is based on the classroom exercise run with both Engineering Day and with the Girl Scouts. It is developed strongly based on the recommendations from interviews conducted with educators that the availability of marine energy related laboratories is not widely available.

The lab in both of its versions were distributed through the Webb MECC team website and was sent to educators both on Long Island and to schools Webb students had contact with. The first pages of the lab are shown and the team has additional lab kits available to ship to educators. The team is currently awaiting feedback on the lab exercise.



Webb Institute
MECC 2024
Vortex Energy Generator

VORTEX INDUCED VIBRATION DEMONSTRATOR LAB

Introduction:

Renewable energy is becoming more important in our modern world. Environmental effects and government incentives are promoting research into methods of harnessing renewable energy. Diversifying energy generation into renewable sources is very beneficial as fossil fuels will eventually run dry. Isolated communities near strong sources of renewable energy can benefit from reducing their reliance on fossil fuels. Some popular examples of renewable energy include solar power, wind turbines, and tidal energy. Today we will explore one specific type of renewable energy: tidal energy.

Objectives:

-Introduction to tidal energy sources.

-Demonstrate the theoretical power output of a vortex-induced-vibration foil.

-Experiment with foil shapes to maximize the power output.

-Have fun!

Theory:

When current flows over a foil, the foil will begin to vibrate due to von Karman vortex induced vibrations. As the flow moves over the surface of the foil, a boundary layer is formed. However, the boundary layer is not able to follow the curvature of the foil and ends up creating a vortex. This vortex changes the pressure distribution acting on the foil and applies force to the foil. Due to all of this, the foil will oscillate vertically as the vortices alternate between each side. The vertical motion of the foil can be harnessed to produce energy. Specifically, linear motion can be transformed into rotary motion to power a generator.

Figure 1. Visualization of von Karman vortex induced vibrations.
(Source: https://www.mdpi.com/2076-3417/11/15/7163)

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Webb Institute
MECC 2024
Vortex Energy Generator

This lab exercise will utilize springs and a foil made of straws to demonstrate the von Karman vortex induced vibrations. As springs are displaced, they produce a force in the opposite direction. This relationship is explained by Hooke's Law, shown in Equation 1. F_{spring} is the force exerted by the spring, k is the spring constant, and x is the displacement of the spring from equilibrium position.

$$F_{spring} = -kx \quad (1)$$

However, springs are also capable of storing potential energy as they are compressed or extended. The potential energy of a spring is given in Equation 2. U_{spring} is the potential energy of a spring, k is the spring constant, and x is the displacement of the spring from the equilibrium position.

$$U_{spring} = \frac{1}{2}kx^2 \quad (2)$$

As a spring oscillates, the total energy of the spring remains constant while the kinetic and potential energy oscillate. At the equilibrium position, the spring has no potential energy (x=0). At the amplitude of the spring, or the maximum displacement, the spring has no kinetic energy and only potential energy. This is because the spring is changing directions, hence no velocity and no kinetic energy.

Figure 2. Energy Graph of a Spring

(Source: https://spark.iop.org/episode-305-energy-simple-harmonic-motion)

Because the potential energy oscillates, we can assume the work done by the spring is equivalent to the potential energy of the spring. With the work of the spring, the power produced by a spring can be estimated with Equation 3. P_{spring} is the power of the spring, k is the spring constant, x is the displacement of the spring from equilibrium position, and T is the period of the spring oscillation.

$$P_{spring} = \frac{\frac{1}{2}kx^2}{T} \quad (3)$$

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Figure 9. Small Scale Hands-on Demonstration

1.2 Discussion of Challenges Faced

The largest challenge the Webb Institute MECC team faced in the completion of this year's competition was related to the size of Webb Institute. As a specialized four-year undergraduate school, Webb Institute has a total enrollment of 105 students as of 2024, with every student studying and receiving a dual degree in naval architecture and marine engineering (NA-ME). As such, there are no specialized majors besides NA-ME represented within the team. Instead, the team of 15 students (representing 14% of Webb students) each took on unique roles based on their interests. For example, students are given a choice of elective each year, and several team members chose to take courses in Business and Oceanography.

Another quirk of Webb Institute is that during the months of January and February, all students are required to complete 8 weeks of a technical internship within the marine field. As such the whole Spring semester is shifted two months back, with it ending in late June. The timing of the final competition and the timeline of work to be done is greatly accelerated with respect to our semester, especially for the build and test challenge.

1.3 Reflections on Goals and Challenge

In conclusion, the Webb Institute MECC Team was successful in running two major outreach events, distributing laboratory exercises, and creating resources to further K-12 education and awareness of the marine energy field. The challenge opened up opportunities for the team to connect with industry contacts and educators with similar interests and helped with connecting with the local community.

2 Metrics Report

2.1 Industry Interview Outcomes

Number of Interviews Performed: Four
Types of Interviews: Two K-12 educators, two industry contacts, all in-person.
Who attended interviews: Kohta Erdos
Contacts:

1. Mattheus Faria: Green Energy Data Scientist at Eversource
2. Carrie Hitt: Senior Director at Vineyard Offshore
3. Jeremy Morris: Engineering Teacher at AMSACS
4. Sarah Harrington: Science Teacher at AMSACS

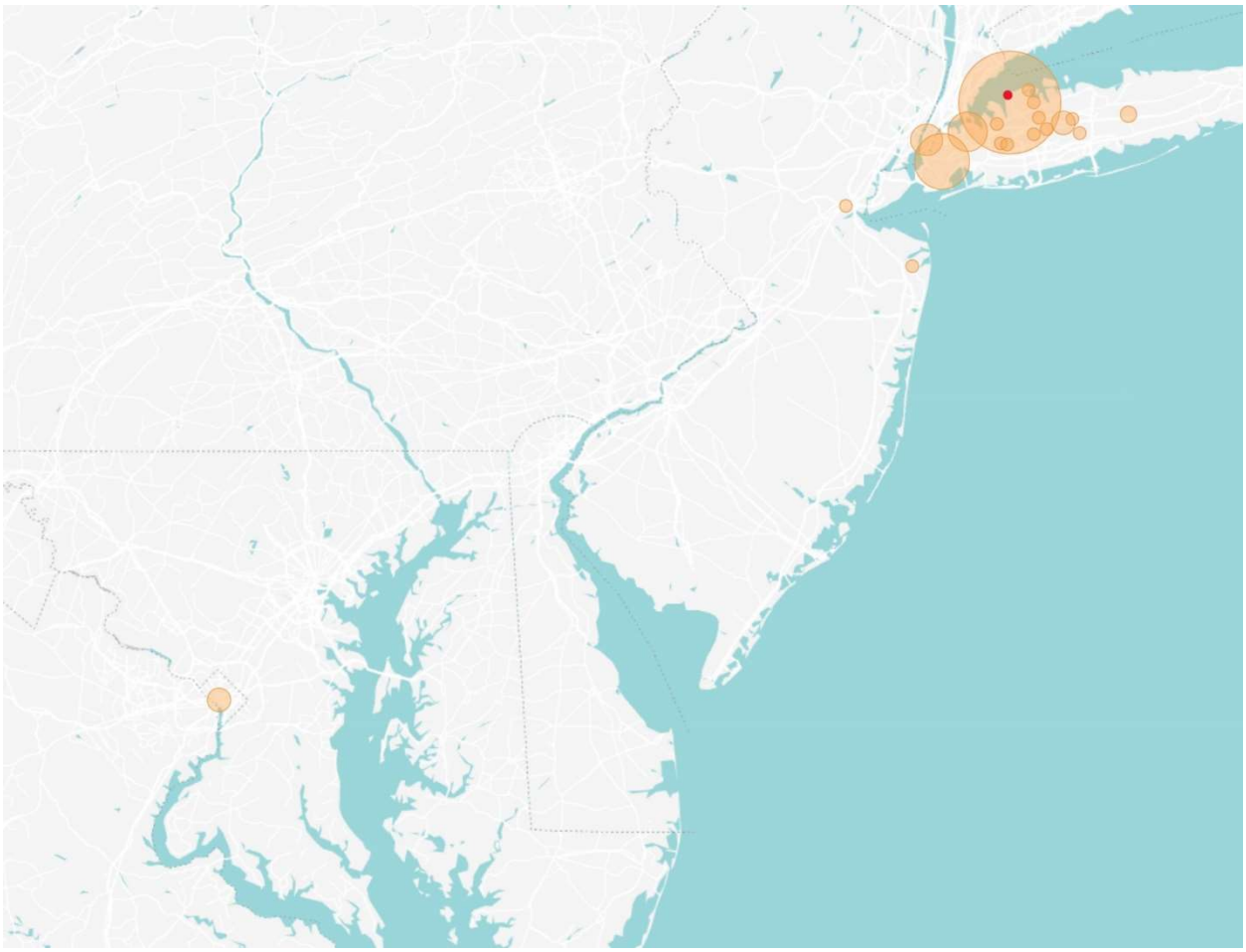
3 Action Outcomes

3.1 Event Outcomes

Total numbers of events: 2
Types of events: Engineering Day and Girl Scouts

3.1.1 Engineering Day

Number of attendees: Forty-two attendees
Types of attendees: Fourth through sixth grade students coming from twenty-four different schools
Geographic regions represented: Participants came from New York, New Jersey, and Washington, DC. Webb Institute is indicated with a red dot in the following graphic which shows where the attendees originated.



Metrics on team attendance: Our entire MECC team of fifteen students facilitated the event and had participation from an additional thirty-five Webb students who helped run the event day of. 50 out of 105 total Webb students got involved in helping to educate the next generation of innovators.

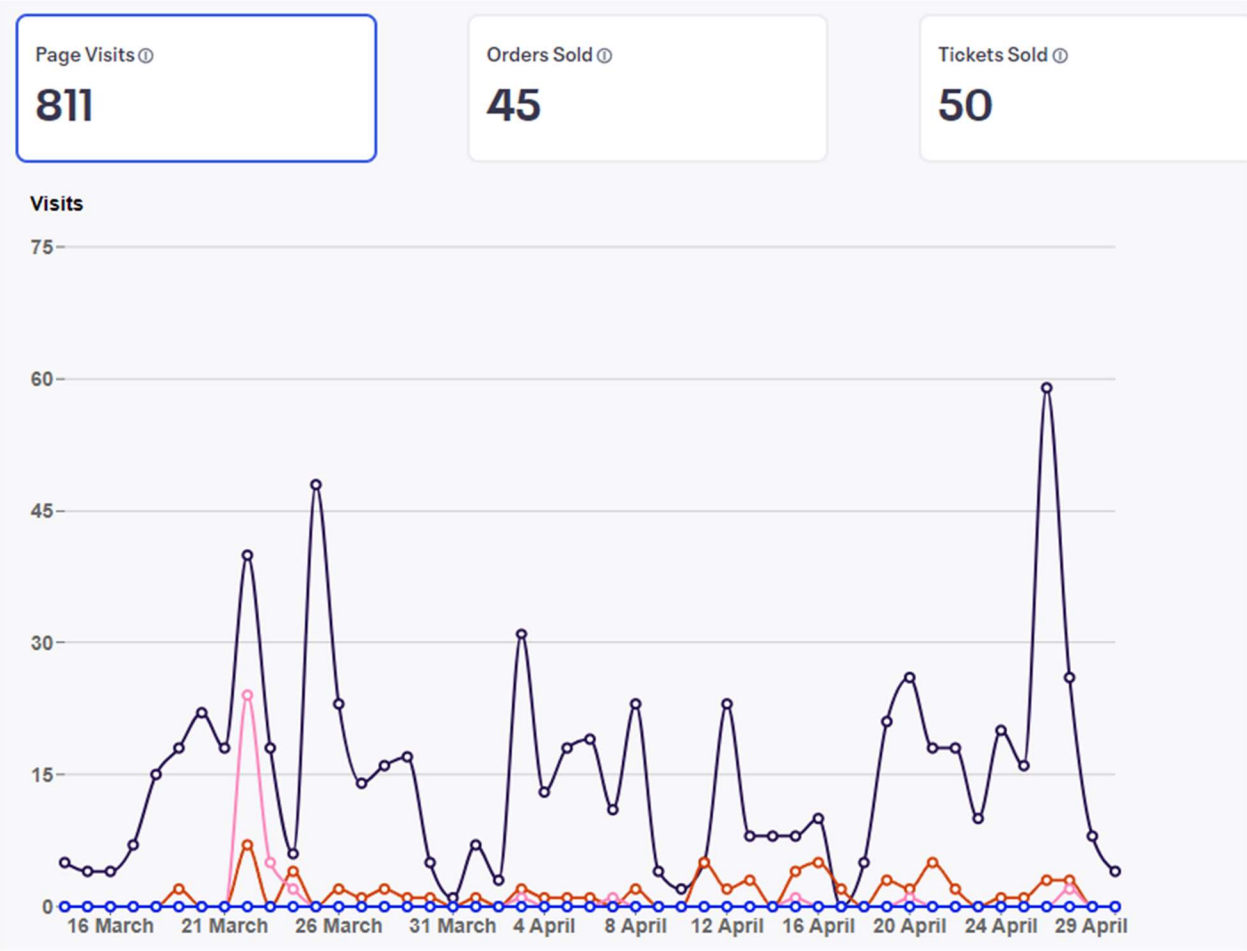
3.1.2 Girl Scouts

Number of attendees: Twelve attendees
Types of attendees: Local girl scout troop event with ages ranging from kindergarten through eighth grade
Geographic regions represented: Participants all came from the Long Island region.
Metrics on team attendance: With the smaller group of participants, we had six MECC students involved in running the event.

3.2 Communications Outcomes

3.2.1 Engineering Day

Locations where materials were distributed: Eventbrite, Facebook, LinkedIn, Instagram, Twitter, directly through local New York schools, 50 physical posters in the local libraries.
Number of people directed to Eventbrite page: 811 visits
Percent of direct traffic (from links on posters/social media): 87%
Number of signups: 50 conversions (6.17% of views signed up)
Location of viewers: Majority of viewers came from New York and New Jersey with a handful of viewers coming from Connecticut and Washington, DC.
Graph of views over time leading up to the April 27th event:



3.2.2 Girl Scouts

Invite sent to the entire girl scout troop of approximately twenty girls. Ultimately, twelve were able to attend our event.

4 Strategy Outcomes

4.1 Outreach Strategy Outcomes

Number of people engaged through outreach: Exact metrics unknown.
Types of outreach: Communications and informational materials (posters/fliers) with schools, word of mouth through community and school connections, social media postings, large-scale events, educational laboratory exercise distribution, educational and industry contact interviews.
Reflection on outreach strategy, best practices, and lessons learned: Meeting with teachers and community leaders proved to be very effective at spreading the word about the educational opportunities we provided. Online event registration gave very good metrics on participant data. Hands-on activities are much more effective at engaging students of all grade levels and backgrounds than instruction. Combining the two proved to be very effective and fun for the students.

4.2 Social Media Strategy Outcomes

4.2.1 Twitter – Webb Institute

Posts about events: Four
Number of page clicks: 284 views

4.2.2 Instagram – Webb Institute

Posts about events: Eight
Page followers: 1,786 followers
Number of page clicks: 611 total likes

4.2.3 Facebook – Webb Institute

Posts about events: Six
Page followers: 3,100 followers
Number of likes: 281 total likes
Shares: 9 shares including by local glen cove event pages

4.2.4 Linkedin – Webb Institute

Posts about events: Six
Page followers: 3,000 followers
Number of engagements: 100 total likes
Reposts: Five reposts from linkedin users with a combined following of 5,000 additional followers including a senior vice president at Shell Shipping company.

4.2.5 Reflection

The team's plan unfortunately hit an unforeseen road bump this year. Initially, the plan was to continue to utilize the previous year's well established social media accounts. Webb Institute IT's department changed the way our email system functioned, and it resulted in the loss of all our MECC social media accounts. To overcome this challenge, we collaborated with our school's PR department and had them post our content to allow for a large audience to be reached. This proved quite effective as we were able to reach a much larger audience than if we had to restart from scratch. In coming years, we plan to partner heavily with the school's PR department and work to regrow our own MECC dedicated social media accounts.