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Engineers on Wheels: A Mobile Engineering Outreach Program

Ms. Bhumi Mevawala, Engineers on Wheels

I am a senior Civil Engineering major at Rowan University focusing on the studies of young students and engineering in the nearby public schools since the beginning of 2017. As a researcher, I am tasked with surveying the students at the beginning and at the end of the program to calculate how many students interest in engineering has changed over the weeks after multiple activities and simulations. Engineering is a very big part of my life and I would like to share my experiences and knowledge with younger students to spark their interest in this topic.

Ms. Angeliqe Tucker, Engineers on Wheels

Ms. Angeliqe Tucker is a senior civil engineering major at Rowan University and has been involved with the EOW program for two years. She has been to many different schools where she met many different students that she has enjoyed working with throughout her time on the team.

Ms. Amanda Rose Basantis, EOW

I am a junior Civil Engineering major at Rowan University. I have recently been focusing on the studies of middle school students and engineering in the public schools nearby. The students complete an initial survey to determine their knowledge of engineering before hands on activities and projects are completed. The goal is to spark students knowledge in engineering at a young age by performing experiments and activities. A final survey is given after the activities are conducted to understand how much the students have learned about engineering.

Elizabeth Beatty, Engineers on Wheels

I am a senior civil engineering major at Rowan University. I have participated in the Engineers on Wheels clinics since the second semester of junior year.

Joseph Egan, Engineers on Wheels

I am a junior at Rowan University, currently studying Mechanical Engineering. My research is focused on increasing interest in STEM education in grades K-6 students. We achieve this primarily through interactive, hand-on activities that we bring into local classrooms. These activities engage the students and increases their interest in math and science courses at a younger age. My passion for engineering comes from my childhood interest in robotics and I want to give other students similar experiences.

Dr. Kauser Jahan, Rowan University

Kauser Jahan, is a Professor of Civil and Environmental Engineering at Rowan University. She received her B.S.C.E. from the Bangladesh University of Engineering and Technology, an MSCE from the University of Arkansas, Fayetteville and a Ph.D. from the University of Minnesota, Minneapolis. Her passion as an educator and mentor has been recognized by many professional organizations over the years. She is the recipient of the Gloucester County Women of Achievement Award, Lindback Foundation Teaching Award, the NJ ASCE Educator of the Year award, the Gary J. Hunter Excellence in Mentoring Award, the ASEE Environmental Engineering Division Meritorious Service Award, the ASEE Women in Engineering Division Sharon A. Keillor Award and the WEPAN Women in Engineering Initiative Award. She has been instrumental in establishing the Attracting Women into Engineering, the Engineers on Wheels and Engineering Clinics for Teachers programs at Rowan University. She has served as the Institutional Representative and Advisory Board Chair for the Women's Professional Network at Rowan University for six years and currently is an advisory board member of the New Jersey Chapter of the American Council on Education (ACE) Office of Women in Higher Education (OWHE). She received a Fulbright award in 2015.

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Abstract- Engineers on Wheels (EOW) is a mobile engineering outreach program sponsored by Rowan University. Each semester, a group of 4-6 interdisciplinary engineering students is tasked to bring lessons that cover science, technology, engineering and mathematics (STEM) to a number of elementary and middle schools in the surrounding area, focusing on students from grades 5-8. On a weekly basis for a span of approximately six weeks, visits are made to the various schools to promote continuous learning and provide a more detailed look at the various disciplines in engineering. The repeated visits also allow the EOW team members to develop a rapport with the students that they are working with to enable them to provide mentorship and guidance in advising the children on a path to a successful career within the STEM field. Each discipline is spotlighted through a traditional classroom lesson which is then paired with a creative and thought-provoking hands-on activities and experiments. The activities are intended to spike student interest in STEM and facilitate a deeper understanding of the impacts that engineers have on their everyday lives. Founded in 2010 under the direction of Dr. Kauser Jahan, the outreach program has shown great success in maintaining and generating young student interest in STEM disciplines. The program begins and ends with an anonymous survey to allow the EOW team to quantify the changes in general knowledge and interest in pursuing engineering careers. The results over the years have consistently shown positive results. It is anticipated that these mobile efforts will result in increasingly diverse classes of engineering at Rowan University as generations of past student participants approach the college age.

I. INTRODUCTION

Beginning in the early 1990's, the implementation of STEM (Science Technology Engineering Mathematics) has increased greatly in grade schools from K-12. Many researchers have found "that when engineering is part of elementary instruction, students become more aware of the

diverse opportunities for engineering, science, and technical careers—and they are more likely to see these careers as options they could choose." [1] To enhance the interest of children in math and science, it is essential to introduce the idea and concept at the grade school level.

Due to the many challenges of incorporating engineering into the curriculum, it has made it difficult to allow it to begin in every grade school. Over the years, it has become clear that the biggest issue amongst all of the schools is the lack of funding. It is difficult for every elementary, middle and high school to have the correct equipment to teach the five main engineering disciplines. Other concerns include the lack of interest the students may have, the knowledge the teachers have for the subject and the lesson/laboratory space that would be required. One resolution that college professors and students have come up with is having engineering student's travel to the various grade schools in the surrounding area to promote and teach about the many engineering disciplines.

Rowan University's Engineers on Wheels program does just that. Its main focus is to bring various engineering activities to K-12 classrooms during the school day for 5-7 weeks at a time. Not only does the program benefit the young students but also the collegians because it allows them to express their passion for engineering and work on their presenting skills. The goal for the outreach program is to spark interest in engineering education and to create simpler ways for teachers to explore the subjects within their classrooms. Each visit consists of a quick lesson and demo, done by the collegians, and then the students are ready to get involved, hands on. The Engineers on Wheels program is used to bring engineering to schools in a fun and easy way.

The most rewarding part about the program is that it is done completely by collegians that want to teach others what they love learning about. For the college students participating with EOW, nothing is more satisfying than hearing a 5th or 6th grade student that knew nothing about engineering saying they want to become an engineer when they grow up.

II. DESCRIPTION

A. Problem Description

Engineers on Wheels is an outreach program that brings engineering concepts and practices to K-12 classrooms. It is a program offered by Rowan University that allows its students to get involved in the program, sharing their knowledge and experiences with younger students in hopes of sparking their interest in engineering. It is important to show younger generations that engineering is a part of their everyday lives. The main goal is to eliminate the initial thought that engineering is too difficult and uninteresting. The program aims to increase awareness about who an engineer is and what they do by providing a variety of hands-on projects for the students to participate in. The different activities and demonstrations cover the various engineering disciplines and are taken directly from Rowan University to different K-12 schools using the Engineers on Wheels van.

Some of the activities that the students will participate in are: Creating Lip Gloss (Chemical Engineering lesson), Snaptricity Kit (Electrical Engineering lesson), Egg Drop (Civil Engineering lesson), Elephant toothpaste (Demonstration), Creating a Water Treatment System (Environmental Engineering lesson), etc. It is important to spark the interests in young students by demonstrating innovative, hands-on, and exciting activities. The demonstrations and activities focus on explaining the engineering process, design, and methodology. The main goal of these activities is to introduce both boys and girls into engineering and eliminate the preconceived notions of the difficulties encountered within engineering. In hopes that some of the young students will see that a career in engineering can be obtained by anyone with an interest and determination in their desired field.

B. Preparing for Engineers on Wheels Visits

Before each scheduled school visit, the collegians had to ensure that all of the materials and presentations were prepared. First, the Engineers on Wheels must decide on the activities and demonstrations based on the classroom setting. Variations of the activities can be done based on the age and advancement level of the class. For example, if the demonstration is Oobleck, the explanation of what is occurring would differ between an advanced level class and an average class. For the average class, the demonstration of Oobleck would be explained by the different material properties and how it relates to the material that engineers need to understand in different buildings. However, in a more advanced or older class, the viscosity and non-Newtonian fluids would be discussed and explained.

Once the activity and demonstrations are properly selected for the corresponding class, the Engineers on Wheels team

must ensure that all the materials needed are present. It is extremely important that the team has a sufficient quantity of all of the materials necessary so the students can easily complete their task. Supplies should be checked regularly to guarantee that they are working properly and are in suitable conditions. Materials that need to be obtained such as eggs for Egg Drop or Rowan Pond water for the Water Treatment activity cannot be forgotten. Once everything is obtained and ensured to be properly functioning the Engineers on Wheels team is ready to present to the K-12 classes.

III. CONTRIBUTION

A. Engineers on Wheels Materials

When Engineers on Wheels began, a brochure was developed to help pique interest in the program and engineering, in general. The brochure gives general information about the program along with illustrations of the activities. The brochure could be placed in the main offices of school buildings and more. With the contact information on the brochure, it helps Engineers on Wheels network and find potential schools to visit in the future.

Social Media is also used to help spur interest in the program. The University's Engineering program uses Instagram and Twitter to advertise EOW. By posting pictures of the schools we have visited and the children, with consent, doing the activities it spreads awareness of STEM in the elementary level education system.

B. A Typical Engineers on Wheels Trip

In order for a visit to be successful, the Engineers on Wheels team must first collect data regarding information such as, but not limited to; the school year the student currently is in- in order to facilitate appropriate discussion, the number of students- in order to ensure adequate supplies are provided, the length of the class time- in order to ensure that the students have enough time to complete activities, and the technology present in the classroom or available for the Engineers on Wheels team- in order to ensure the presentation is effective and completed in a timely manner.

The Engineers on Wheels team arrives to each school at least 15 minutes in advance in order to set up for the lesson, demonstration and activity. The EOW team carries the supplies to and from each school for every visit. The team does an introductory presentation on general engineering, including the different types of engineering and the fundamental jobs that correlate to each engineering discipline. On the first day, many short demonstrations are conducted in a number of fields of engineering in order to get the children familiar with the different types of engineering that exist. A base survey is conducted during the introduction class in order to gauge the preliminary knowledge and interest of the students.

Throughout the program, each week, the collegian team focuses on one type of engineering, performing a hands-on experiment with the children. This helps to show the diversity within the different types of engineering. Per semester, the Engineers on Wheels team typically visits up to four schools, for about six weeks each. In addition to exposing the kids to diversity, the program is intended to demonstrate the importance of teamwork. During all of the activities, the children are asked to work in small group settings. On the final day, the children complete the same survey again in order to assess the difference in knowledge and interest.

IV. ASSESMENT

Throughout the Fall 2017 semester, the EOW program provided activities over a 6-week span to each school that was visited. The impact on students is best measured from the survey results. The main focus this semester was the 6th grade science class at Orchard Valley Middle School where 41 students were analyzed. At the school, a brief survey was conducted to assess how much the students knew prior to their participation in this STEM program, if the program was effective in bolstering their education, and whether or not the students would consider engineering as a career. After tabulating the results, a significant growth in interest and knowledge was shown.

The class was composed of an equal amount of both boys and girls and the general knowledge before beginning the program was more impressive than previous programs. The initial survey had 66% of the class that scored at least 50%. Of that 66%, there was an equal percentage of boys and girls who were knowledgeable. This grew to 80% on the final survey with an exact split of boys and girls. It was found that many of the students did not have knowledge of what engineers did and many common phrases included “fix things”, “engineer”, or simply “I don’t know”. Many students also did not know the skills it takes to become an engineer and simply stated: “You have to be smart”. Other students did not know the engineering fields either. Through the surveys, the EOW noticed an improvement in the 6th graders knowledge about engineering.

The percentage of those interested in possibly becoming engineers was the most significant growth, from 32% to 50%. However, the make-up of those interested consistently showed a higher percentage of males. The most common reasons for why not in the beginning survey was because they did not know what it meant to be an engineer. After the program, those who were still not interested had other careers and interests in mind. Some of those careers included the medical fields and athletics. Others said that they simply did not enjoy science and math. Those who were interested gave the reason of already being interested in science and once a greater understanding was achieved, found field specific reasons for entering into an engineering program. An example of this is cosmetics (Chemical Engineering) and

helping the earth (Environmental Engineering). All “maybe” responses were counted as yes since they showed some level of interest.

The Engineers On Wheels program has demonstrated that earlier exposure to STEM activities positively impacts students’ perceptions. The survey results showed a positive increase in every question asked and an encouraging jump in interest in engineering and science as a whole.

V. CONCLUSION

The overarching goal of Engineers on Wheels is to increase the interest level in engineering education of elementary and middle school students. This is done through interactive activities that are brought into the student’s classrooms by the college students who are participating in the EOW program, through Rowan University’s Engineering Program. These activities are intentionally selected to be both engaging for the age group, while still stimulating an interest in engineering education. The collegians serve not only as facilitators of EOW sessions, but also as role models, allowing the elementary and middle school students to envision themselves pursuing engineering an a higher education.

As shown by the assessment process, the EOW program has been proved successful. The students that complete the program show a documented increase in knowledge about the basics of engineering principles and the five main engineering disciplines. College students participating in EOW will continue to visit local elementary and middle schools to share the knowledge and passion they have generated in their own fields of study with the next generation of future engineers.

ACKNOWLEDGEMENT

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REFERENCES

- [1] <https://eie.org/overview/engineering-children>

VI. APPENDIX

A. Demonstrations, Experiments and Lessons

Oobleck- Oobleck demonstrates the different states of matter to students, leading into a non-Newtonian vs Newtonian fluids discussion. Oobleck is a mixture of cornstarch and water that has both liquid and solid characteristics. It is a runny substance that acts like a liquid until stress is applied to it, and then it suddenly acts as a solid, which is known as a Non-Newtonian fluid.

Snaptricity- Snaptricity provides students with safe electrical circuit experiments to demonstrate electrical engineering projects. EOW specifically talks about the differences between parallel and series circuits and how it will affect the outcome electricity. This activity also requires students to work in teams, communicate and work well together, as engineers do in the field.

Lip Gloss- Lip gloss demonstrates chemical engineering to the students. We give a presentation about chemical engineering, discussing their involvement in the development of pharmaceuticals, makeup, etc. We introduce the experiment and discuss the purpose of each ingredient. For the experiment, a small cup of vegetable oil sits in a warm water bath. The kids stir in powdered coloring and essential oil scents of their choice. The kids have the option of adding mica for shine. Finally, melted wax is added and the kids stir it in quickly. Then the mixture is poured into a small lip gloss container and it must cure for at least 10 minutes.

Elephant Toothpaste- Elephant toothpaste is a chemical demonstration after we introduce chemical engineering. For this experiment a bottle is placed in a bucket and the bottle is filled with hydrogen peroxide and dish soap. Food coloring is added to the bottle. In a cup, yeast is mixed with water. The cup of water and yeast is added to the bottle with the hydrogen peroxide mixture. The mixture foams up and oozes out of the bottle. We discuss that the yeast is a catalyst that helps the reaction take place between the hydrogen peroxide and yeast. The reaction is exothermic, so we discuss that it produces heat.

Conductive Dough- Conductive dough is a very exciting electrical engineering demonstration. The dough is used in place of wires to allow kids to build circuits. The dough is made with common household products which include: water, flour, salt, lemon juice, and vegetable oil. Food coloring can be added to distinguish different batches of dough. There were two key purposes of using the conductive dough. The first is a safe, simple replacement for bread boarding. Children have difficulty with bread boarding and using small components in a restricted space; therefore, the dough is an easy replacement for wires and the board.

Secondly, shows the kids that different materials are able to conduct electricity. This leads into a safety lesson about electricity and how different materials can still be unsafe. Conductive dough lets kids practice circuits and learn basic concepts, as well as, safety when dealing with electricity.

B. Photos of Demonstrations Taken By EOW Team

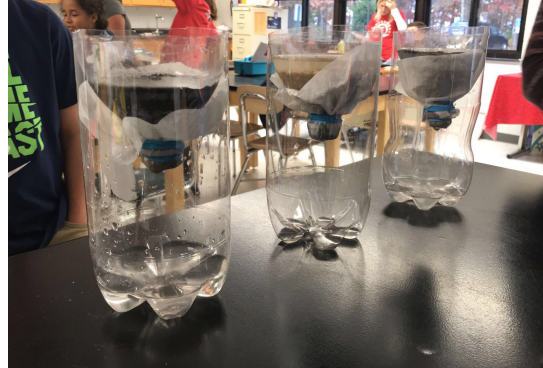


Figure 1: Water Filters
Image of comparing various Water Filtration Systems for the Environmental Engineering lesson.

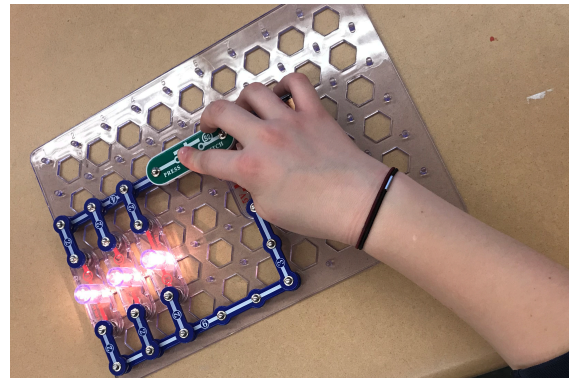


Figure 2: Snaptricity
Image of a student testing a Parallel Circuit to see how strong the lights are, for the Electrical Engineering lesson.

C. Survey Data

School	Gender	Before		After	
		Correct answers > 75%	Interested	Correct answers > 75%	Interested
A	Boys	87.5%	75%	100%	100%
	Girls	90%	40%	100%	62.5%
B	Boys	36.4%	59%	75%	90%
	Girls	40%	20%	76%	60%