Initiating Engineering Learning for Minority Students in Elementary Schools

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Abstract

Efforts to raise student interest in science, technology, engineering, and mathematics (STEM) careers have increased in recent decades. The goal of such efforts is to satisfy the urgent need for scientists, engineers, and technologists due to the consistent growth of innovative engineering products, such as smartphones, autonomous vehicles and so on. Educational research shows that the efforts to interest students in STEM majors and careers can be as early as in the elementary school level, the time when students begin to develop interests in engineering products around them. In this paper, we present one approach towards organizing an engineering workshop for elementary school students, particularly minority students, by educating them on how to build an engineering product: a speaker. After the workshop, the students not only learned the basic concepts of engineering and engineering product development, but also held and enjoyed a self-made product at home. The students' responses indicate that while they had fun building the small device, they also understood the essential process to design and implement an engineering product. This could be of significance because it may bolster interest in engineering and inspire further exploration that may eventually draw students onto the path of an engineering career.

Keywords: Learning Engineering, Minority Students, Elementary School

Introduction

In the United States, the Bureau of Labor Statistics projects nearly three million new jobs in STEM by 2020[1], which requires capable individuals with educational backgrounds in STEM to fill the positions. However, in 2009, the U.S. Department of Education stated that only 16% of US students obtained a STEM-related degree out of 1.6 million bachelor's degrees[2]. The lack of creativity and perspectives in STEM from the limited labor pool becomes a serious concern for the society. The reason for students to be less willing to pursue a STEM degree in college can be various, for example, lack of quality preparation in mathematics and science or lack of financial support. Among the factors, an important reason is the lack of general knowledge regarding engineering for students in elementary schools or even middle/high schools. Researches indicate that children are deciding on those subjects they like or dislike as early as elementary school[3]. Lack of knowledge in engineering can cause children to deter from it just at the beginning of choosing a field to study. Furthermore, aside from the above factors, the fear of failure for minority students could be a major reason for their reluctance to choose engineering as a career[4]. Based on the above analysis, the students in Vaughn College's Chapter of the Society of Women Engineers (SWE) decided to hold an engineering workshop. The purpose of the activity was to introduce engineering and engineering concepts to school age children and then have the students apply these concepts in the form of a working speaker. In order for Vaughn's Society of Women Engineers to focus on minority students, a Title 1 Elementary School, i.e. a school with high numbers or

percentages of children from low-income families and therefore requiring assistance from the government, was chosen.

This paper will present the rationale behind the choice of building a speaker as an engineering workshop topic, which is arranged in the second section. Secondly, the content of the workshop and how it was introduced to the students shall be provided in the third section. The result of the workshop and its conclusion shall follow in the last two sections, respectively.

Development of Workshop Ideas

A large part of STEM Outreach is not just the content, but choosing an engineering project that's worth remembering. If a child enjoys the workshop, they'll be more inclined to remember the engineering concepts or the field itself. This is why the members of Vaughn's SWE Chapter worked hard to develop a project idea that would best fit the background of the students. The workshop should be able to spark engineering interests in young minds. It should be simple, fun, and most importantly, educational, i.e. visible and understandable.

Music can be seen as a universal language because of its presence in every culture, religion, or region. According to Ian Cross, Faculty of Music at the University of Cambridge[5], it is suggested that music, like speech, is a product of both human biology and social interactions; that music is a necessary and integral dimension of human development. Music's common presence within today's society allowed a speaker to be practical, correlating to a lower possibility of the project being set aside and unused. If the built product could be regularly seen or used in the household, the experience and concepts learned during the workshop would become more memorable. No matter the cultural or financial background of the children, music's diversity made the speaker project a great choice for their diverse backgrounds.

The speaker project also helped to convey an important aspect of engineering: teamwork. Each student walked away with his (or her) own speaker, but they were required to split into teams of two. They worked together on the first one, applying what they learned toward the building process of the second. This allowed for fewer errors and an environment similar to the one experienced by a professional engineer. One of the reasons for a minority student not to peruse the engineering field is the fear of failure. In order to address this issue, the SWE Vaughn College members showed the students how to resolve engineering problems by troubleshooting the speaker. This action showed the students a key aspect of engineering; Mistakes happen all the time. In fact, the more they happen, the better the engineer becomes. Engineers learn from their mistakes and so did the workshop attendees.

What one student understood may not have been what his (or her) teammate understood. Engineers always work in a team. Teamwork is the critical factor to a successful project, since what one student may miss, the other can catch. The work environment created allowed students to bounce ideas off of each other. This limited a number of errors and the chance of "failing" at the speaker project. Teamwork enhanced the overall understanding of the project and conveyed its necessity within the field.

Unlike other possible workshops, almost all of the speaker components were readily available at local hardware stores or electronic stores. If the students wanted to build another speaker or

customize what they already had, the components could be found easily. Financially, the components added up to be under twenty-five dollars per speaker. Having cheaper components allowed the students to be able to afford these modifications. The students were also allowed to keep the materials given for future reference. Furthermore, they were encouraged to continue expanding upon their engineering knowledge after the workshop was over.

Figure 1: Students working on speaker

Hosting the Speaker Workshop

Presenting the engineering terms and components used for the speaker in a matter that all the students would understand can be a challenge. Not all students learn at the same pace. Therefore, information was presented visually via a PowerPoint and supplementary explanatory packet, kinesthetically through hands-on building, and through spoken word along with one-on-one guidance and instruction. Employing these three learning types allowed for a better overall understanding for the students.

I. Introduction to Engineering

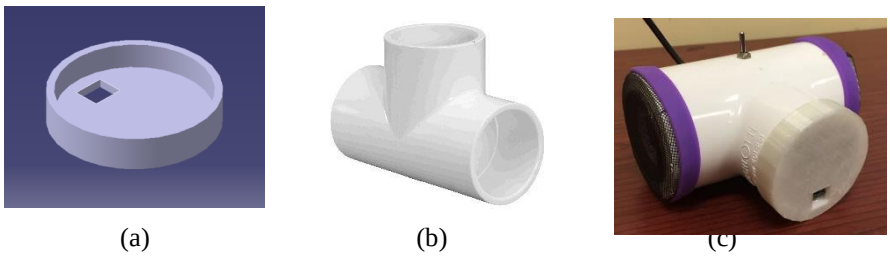
(a) (b) (c) (d) (e) (f)

Figure 2: Internal speaker components
(a) Charging module (b) Battery (c) Capacitor (d) Speaker (e) Amplifier (f) Switch

The concepts explained throughout the PowerPoint encompassed the very basics of electrical engineering. The knowledge was then reinforced through its building process and instructional packet.

(1) Charging Module, Battery, and Capacitor
The Charging Module, as seen in Figure 2(a), allows for power to be transferred from a single battery to the outlet of the speaker battery. A battery is a container that stores cells, where chemical energy is transformed into electricity and used as a power source for the circuit. Similarly, a capacitor, shown in Figure 2(c) stores energy. However, the energy to be stored in a capacitor is less than that for a battery.

(2) Speaker, Amplifier, and Switch
The speaker and amplifier used in the workshop are displayed in Figure 2(d) and 2(e). A speaker is defined as a transducer that converts electromagnetic waves into sound waves. The sound from a speaker is produced by frequencies and amplitudes. Frequencies define how low or high pitched the produced sound will be. An amplifier is an electronic device for increasing the amplitude of electrical signals. Simply put, it increases the volume of the speaker. The switch shown in Figure 2(f) was used in the workshop. A switch is a device used for making and breaking the connection in an electronic circuit. When turning on a switch, the circuit closes and allows the flow of current. When turning the switch off, the circuit opens and stops the flow of current.



(a) (b) (c)

Figure 3: External speaker components (a) Speaker cap (b) PVC pipe (c) Assembled Speaker

(3) 3D Printed Speaker Cap and PVC Pipe
3D printing is a manufacturing process where plastic is printed in the third dimension using a 3D printer. Plastic is printed by an extruder and is layered repeatedly, creating a 3D object over time. For the workshop, the speaker cap, which is shown in Figure 3(a), was designed and printed by the 3D printers at Vaughn College. The PVC (Polyvinyl Chloride) pipe as displayed in Figure 3(b) was used as the housing for the speaker. PVC is a plastic pipe utilized in water lines all around the world. Figure 3(c) presents the assembled speaker.

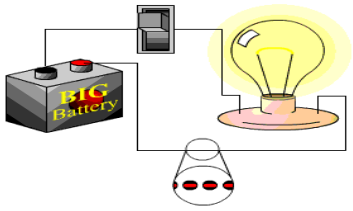


Figure 4: Current and open/closed loop circuits

(4) Circuit Loop and Current
Figure 4 shows the circuit loop, which was used to explain the working principle of current. Current is an important engineering concept to describe how the portable speaker works. It is defined as the flow of electrons through a closed-loop circuit. To visually demonstrate this, a light switch was turned on and off. If the light was switched on, there was current flow through the circuit. If the light was switched off, current was not flowing in the circuit. Teaching this concept allowed the students to better understand the electrical functionality of the speaker.

II. Assembling the Portable Speaker

The students were each given a bag with necessary materials to build a speaker and an informational/instructional packet, which contained step by step instructions on how to properly assemble the speaker. The building process using the provided materials reinforced the engineering concepts that were explained through the PowerPoint presentation beforehand. If the students had questions or needed help, the Vaughn College SWE members were readily available for them.

The workshop lasted about three hours. This also included the time for students to customize their speakers. Screens were glued around the outside of both speaker ends for their protection. To hide its seams, however, colored bands were distributed to be placed around them. Permanent markers for decorating the white PVC were also distributed and shared with the sole purpose of allowing for personalization of the final product.

Results of the Workshop and Discussions

After the completion of the speaker workshop, the Vaughn College SWE Chapter received very positive feedback from both students and staff. The 5^{th} and 6^{th} grade participants wrote handmade cards, where they boasted about how much they learned and wanted to pursue the field of engineering. One student wrote "*Thank you for coming to our school and teaching us. I hope that I can study at Vaughn College one day. I hope you can come back to our school and teach us more about technology*." Another student wrote "*I learned about current and the many sections of engineering. Thank you for teaching us how to build speakers. When I grow up, I want to be an engineer just like you*!"

Students have very little tactile opportunities to learn engineering while in elementary school. Presenting the students with the workshop and letting them work with SWE Vaughn Chapter members allowed them to have a better understanding of what it's like to be in a practical and hands-on field.

Conclusion

In this paper, developing a workshop to teach engineering for a Title 1 elementary school was discussed. During the workshop, the elementary school students were given the task of creating a speaker through a hands-on building process, which provided the students an opportunity to gain engineering experience and enhance their experimental skills. Through this project, the students also learned the importance of working in teams. Furthermore, the experience gave them the confidence to successfully develop an engineering product that could be used in their daily lives. Upon completing the workshop, the students were encouraged to bring the materials home, where

they could share the knowledge they learned in the workshop with others. From the students' responses, it can be seen that the workshop can have a noteworthy impact on the students when they consider pursuing a career in the future.

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