Board 182: Using of Esque Box for STEM Education of Pre-college Students (Work in Progress)

Mr. Wesley David Klehm, Oral Roberts University Engineering Program

Wesley is from Tulsa, Oklahoma, and is 20 years old. Since he was a kid, he was always interested in how things worked and how they were made, with many disassembled toys to prove it. This curiosity inspired Wesley to pursue a degree in engineering to further satiate this desire. In 2021, Wesley Klehm and Jordan Swan founded Esque Box while students at Oral Roberts University to teach a new generation of kids what they wished they knew at the same age.

Dr. Pavel Navitski, Oral Roberts University

Dr. Pavel Navitski is Associate Professor at Oral Roberts University from 01/2020 after a stint as a Fulbright Visiting Scholar at Oklahoma State University, where he was researching drift detecting using sensor systems for field spraying and guest lecturing. He is originally from Belarus, where he was the head of the department of agricultural machines at the Belarusian State Agricultural Academy. The Belarusian State Agricultural Academy is where he earned his B.S., M.S. and Ph.D. degrees. Dr. Navitski's professional interests are mostly in modern agricultural machinery: setting the main types of agricultural machines for quality work; device features of configuration of new agricultural machinery; perspective cropping systems; precision agriculture; modern machines for chemical plant protection; renewability and bio-energy. He represents Oral Roberts University at ASME and Tulsa Engineering foundation.

Jordan Matthew Swan

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Introduction

The need to deliberately educate pre-college students in engineering practices is recognized in American primary and secondary schools. Engineering education starts in elementary school using Next Generation Science Standards given by the National Research Council [1] as a framework for early exposure to engineering practices of designing and building. Many children become highly developed in building structures using toys and blocks which is early engineering practice. Through formal educational experiences, those children can be taught how to better design and build, thus promoting their engineering interest. Ultimately, that is why Esque Box was developed. The purpose of Esque Box is to develop a way to simplify the concepts of formal engineering training and teach future generations ideas that technically savvy younger students are ready to learn. Training in engineering presents challenges based on the intensive math and physics that engineers are required to learn in college. This can seem quite daunting to pre-college students. Hands-on learning is a proven way to increase metacognition, a term first coined by Flavell [2], in pre-college students according to Fiteriani [3]. Hands on learning is useful in many fields as Heigley [4] makes the case in agriculture and the trades and its benefits are widely touted by many educators such as Moore [5] of St. Edmund's College. Tanner [6] demonstrated the use of metacognition in science by practicing thinking about what students were learning by using active learning. Sneider [7] has found that hands-on learning is very important in the engineering education of pre-college students. The active learning experience provided by the Esque Box is the vessel through which metacognitive learning is achieved in a fun, hands-on, positive classroom experience. The aim of our research is to show that the Esque Box seeks to be an answer to finding ways to get students applied practice in engineering basics to alter their perspectives, opinions, and interest in engineering to consider it as an accessible, possible future career.

Esque Box Design

The design of the Esque Box consists of a dual-wheeled robot body powered by two modified servo motors. The robot body also consists of two headlights and four indicator lights

to show the direction the wheels are spinning. A physical cord connects the robot to the controller which utilizes a pair of two-way momentary switches and an on-off switch to control the motors and headlights respectively. The Esque Box is powered by a 9V battery. A set of colorful, detailed instructions is provided in each box (and is accessible online) to assist in building and wiring the robot as well as educating the user on what the components are, what they do, and how some of them work. The instructions are a particularly important part of the learning aspect Esque Box provides. The instructions are a blueprint for how students can tear down the Esque Box and reuse the individual components. The LEGO corporation serves as the inspiration for this idea, using a fun detailed set of instructions to show how the individual components can be reuse using a little ingenuity. That is the idea applied to the Esque Box kits; the inspiration to reuse the kit to create new and fun builds with the existing components. There are other companies that offer products that use engineering principles to construct "science toys". Many of these companies are a subscription service that provide a different surprise kit each month instead of an "off the shelf product" that a consumer may choose. There is no surprise factor with the Esque Box. The kit advertised is the kit the consumer gets. Individually sold "science toys" suffer from the unfortunate symptom that their instructions can be confusing and only are designed to build one thing. Esque Box is designed to be torn apart when the robot has run its course and be utilized to make something entirely new, and affordable at only $30.

Esque Box in the Classroom

The Esque Box has been used to teach students about electronics and how they work with younger children and upper middle school age children. In a third grade classroom two Esque Box kits were used and the students helped to put the kit together. During the activity, the third graders were taught, the basics behind the breadboards, resistors, switches, motors, and LED lights. While the full range of the subject matter was a little advanced, the students had no trouble grasping the concept and were helpful in assembling both robots successfully, along with assistance. One outcome from this session was an improvement and simplification of the instructions making them easier to understand. Virtual models of the box and its components were constructed to aid in this process using Dassault System's Solidworks. (A Computer Aided Design software that intuitively allows ideas to become three dimensional models according to

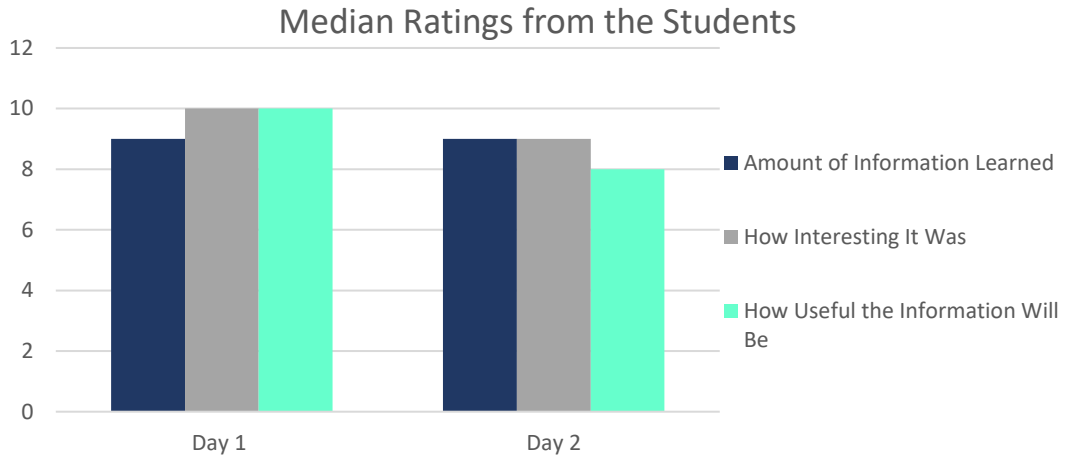
Design/Engineering [8]) Another outcome from this session was that multiple students in the class expressed interest in engineering as a possible career to pursue. This positive anecdotal record prompted a more deliberate educational use of the Esque Box kits with older students.

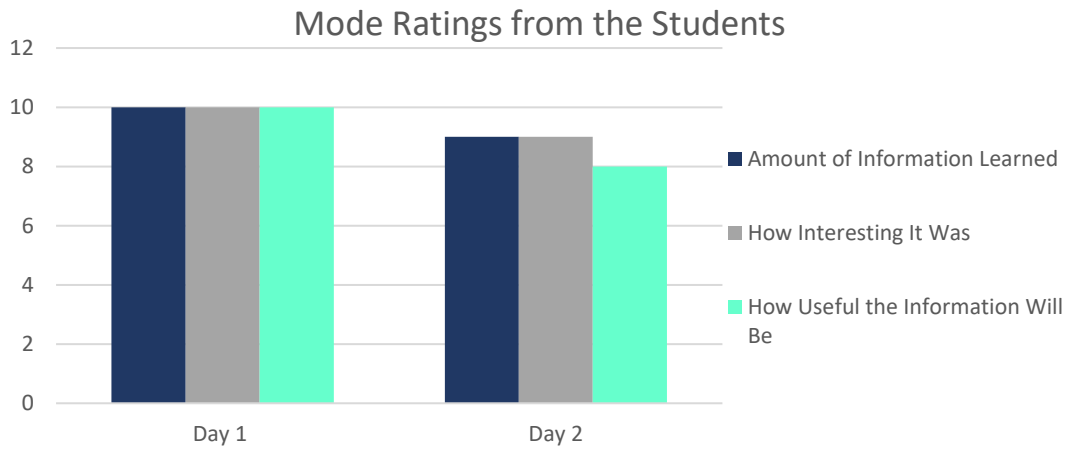
The other setting where the Esque Box has been used and tested was in a Summer Academy sponsored by the Oklahoma State Regents for Higher Education. (An organization that "prescribe[s] academic standards of higher education, determine functions and courses of study at state colleges and universities, grant degrees, and approve each public college's and university's allocations, as well as tuition and fees within the limits set by the Oklahoma Legislature." About the State System of Higher Education [9]) In this Summer Academy, open to select students from the entire state of Oklahoma who were entering their 8^{th} and 9^{th}-grade years of education, students were taught how to build the Esque Box kit and how the individual components of the box worked, supervised by the Esque Box creators and Academy Professors. The 40 students, comprised of 18 girls and 22 boys, constructed the controller and robot body, with a competition at the end for prizes. The competition was to increase the participation of the students who didn't seem particularly interested in the engineering aspect and this seemed to work to increase engagement with all students. A trend observed in the groups was that the one who did the most of the building did not race the robot. The students worked in randomly assigned teams of two in groups of 20. Over two days in two separate one-hour long sessions, 90% of the robot kits constructed were functional. This is a remarkable achievement with novice students, many of whom had professed extensive Robotics Competition experience but had never constructed a circuit.

Results

Following both days of robot construction (the first day being the controller and the second being the robot body and the competition) the students were asked to score the activity based on the amount of information they learned, how interesting it was, and how useful the information will be to them in the future on a scale of one to ten. The graphs show the median and mode responses polled from the students. The mode scores from the students of straight

three tens the first day and a nine, eight, and ten showing that most of the scores were very positive toward what they learned. The median scores show that the middle scores about the class were also very high and that even those who gave the median scores still overwhelmingly viewed the learning positively. Comments about the class were welcomed in the poll as well.





Some specific comments the students made are verbatim with corrections made for spelling.

"This class-- this class was so much fun. To build and design with our hands in a short period to create a tangible piece of simple mechanical engineering."

"I loved this class I learned what a breadboard was."

"This class was so cool. It was very interesting, and it made me aspire even further to be an engineer."

"I liked this class because I learned about something I didn't have insight in before"

Many of the students had robotics experience with their school robotics team. Several of these students with previous robotics experience commented that they loved the lessons the Esque Box

taught because it goes further than just coding but goes into the design and construction of electronic circuits using breadboards.

Future Research

This summer camp has been funding for another year of STEM enrichment and the Esque Box robotics kit build is invited to participate again, with some modifications. In ensuing Summer Academies, the new ideas for implementation are to research the impact of the Esque Box on students' interest in engineering. These include the following:

- Polling the students before and after the Academy activities as to their interest in engineering both as a passing interest and a future career
- Test the students on the knowledge they have upon entry and after the instruction
- Expanding the time the students have to build the kits in order to have more time for testing and competition as well as a more fun obstacle course.

The Esque Box is a bridge that allows students entry into the engineering world and these modified practices and ideas are meant to measure the impact of the Esque Box. The Esque Box is a tool that educators and parents can use to teach students principles in engineering that can seem mystifying but at their core are easily understood if the effort is made. In the future, the Esque Box creators would like to implement more kits to demonstrate more principles of engineering using hydraulics, or the generation of electricity.

Conclusion

The Esque Box is a tool that educators and parents can use to give students exposure to basic engineering concepts and alter their perspectives, opinions, and interest in engineering as a potential career. Engineering principles seem complicated and the heavy math that accompanies a degree can keep students away from studying engineering. A hands-on approach through the Esque Box can prevent apprehension by fostering a desire to pursue the making and creating side of engineering to make the world a better place. This is the aim of the Esque Box, to initiate the inspiration of prospective engineers to pursue a career in engineering.

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