Turbine Engineer: E-STEM Lesson

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Abstract: Developing enthusiasm and creativity to resolve world energy problems is a dilemma facing educators. How can educators bring the excitement of real-world issues into their classrooms? What kind of affordable equipment can they use? This project seeks to develop materials and means through which Middle and High School students can creatively engineer solutions to existent problems. What kind of turbine, in a gravity-fed system, would generate the most energy? Results from an engineering thought survey and turbine energy production are presented in this session.

Keywords: 3d, hydropower, turbine, middle school, high school, engineering

Introduction

Hydroelectric power (aka hydropower) is utilized throughout the world. Gravity-fed hydroelectric power originating from glaciers is used heavily in South America, Europe, and British Columbia, Canada (Pelto, 2011). Hydropower is a form of renewable energy that uses the water stored in dams or flowing rivers to create electricity. The water is moved through a turbine that spins a generator that converts the mechanical energy into electrical energy. Hydropower utilizes the head (slope) and velocity of water. A good explanation of hydropower is available at https://www.youtube.com/7e26eb15-55cf-4d9f-86d9-a0bd6eeb3b96.

Most of the hydropower generated in the United States is in the Pacific Northwest. About 13% of the renewable energy in the United States comes from hydropower. Hydropower has many advantages: It does not (1) pollute water or air, (2) adversely affect fish migration, (3) increase carbon dioxide emissions, nor (4) cause unnecessary removal of plants and animals.

There are several types of hydropower projects. Impoundments, such as Hoover Dam, are the most common, with 2,400 of the 80,000 existing dams producing power. Diversions, like Niagara Falls, are also known as *run-of-the-river* producers. Pump storage was the model for this project. Like the dam in Silvette, Austria that stores glacier water, this project utilized gravity-fed water to tank storage.

Glacier run-off is of specific concern as it heavily influences at least half, or more, of all hydroelectric production in these nations. Water is a readily accessible resource for schools. It is also an incredibly dynamic source for exploration in biology, chemistry, physics, and engineering. Solving problems in delivering more energy from limited resources, such as glaciers, is a prime example of goal fulfillment with STEM education and Next Generation Science Standards (NGSS).

Literature Review

Hydropower is an excellent exemplar for the NGSS. Grubbs and Deck (2015) chronicled an experiment that responded to climate change by conserving energy. In this experiment, the turbine mechanism was altered, however, the materials used prevented precise measurement of energy conservation. Most experiments detailing turbine alteration involve wind machines and their production of energy.

Lent, Brown, and Hackett (1994), based on Bandura's (1977) theories of self-efficacy, produced a seminal work regarding social cognitive career theory. In it, three areas influence ultimate career choice: 1) development of basic academic and career interests, 2) determination of academic and career choices, 3) obtainment of academic and career success. Self-efficacy toward a career in engineering has been linked with undergraduate student interest and excitement (Mamaril, 2014).

Methodology

In this developing project, Middle and High School students used Solidworks (http://cad.about.com/od/CAD_CAM_Software/bb/Solidworks-2012-Review.htm) Educational Edition, to create propellers for water turbines. Students were given basic instructional tutorials within the program for SolidWorks. Students printed their original turbines using either a Statysys Fortis 250mc (http://www.stratasys.com/3d-printers/design-series/fortus-250mc) or Mojo 3D (http://www.stratasys.com/3d-printers/idea-series/mojo) printer. The design for hydropower was gravity-fed with electrical support from solar panels. Students tested their designs, measuring the energy output to determine which design was most productive. ABS filament was used for both printers. The design of turbine (Kaplan or propeller design) directly effected the amount of energy these systems could produce. This project allowed the design of the following propeller elements:

- Pitch
- Size
- Number of blades
- Shape
- Scoping of the blades

Results

Final results are not available at this time, but will be prior to the SITE conference. Nineteen students, 13 male and 6 female, individually completed a pre- and post- engineering thought survey. Pairs of students designed turbines and tested their pump storage turbine design. Final results from the engineering survey and testing of turbine designs will be available by March 2017.

The project is set to conclude February 2017. Preliminary results indicated that teaching specifics of the software for 3D printing varied among student groups. SolidWorks Education Edition is not design intuitive, but it is user-friendly for Middle and High School aged students. Observations and ad-hoc questioning of students in the lab setting indicated that both males and females had basic conceptual understanding of the propeller design process, gravity-fed systems, and elements of the SolidWorks software.

Pre-experiment student responses to the questions "*Engineering is"* and *"A Career in Engineering is"* yielded results indicating that both males and females, middle and high schoolers, regarded engineering similarly (Figures 1 and 2).

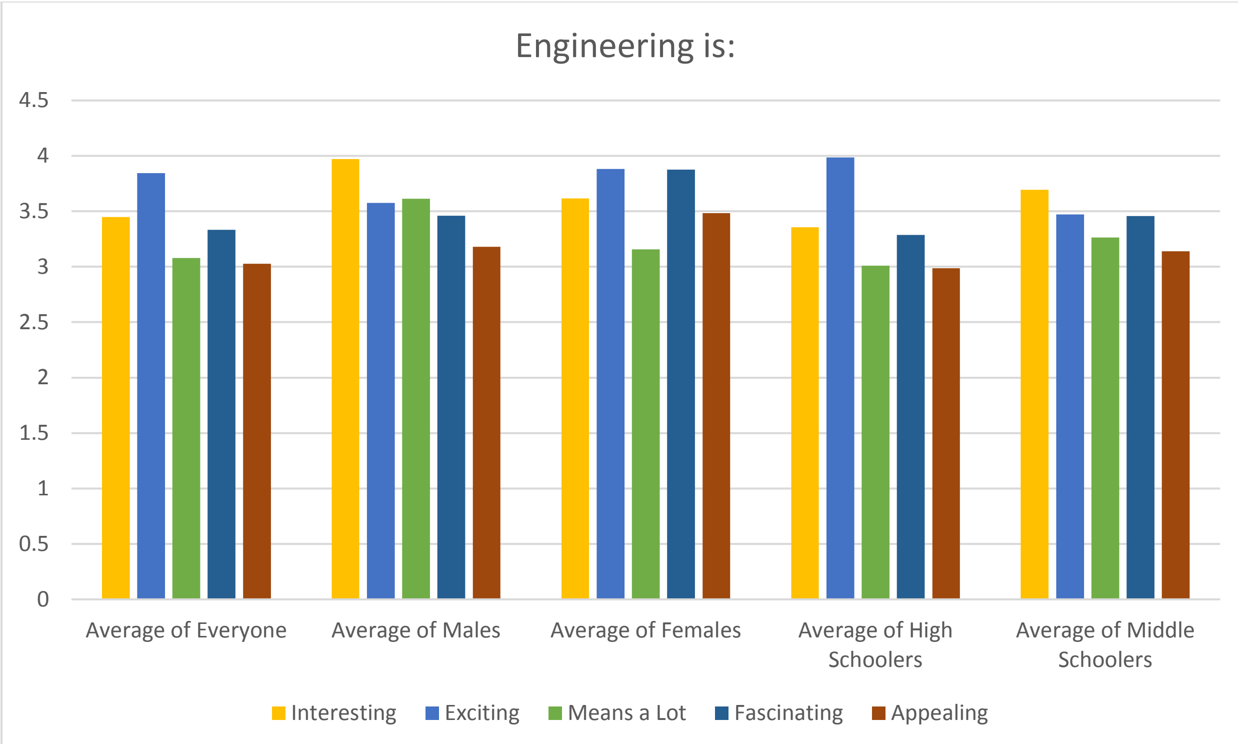

Figure 1: Engineering is …

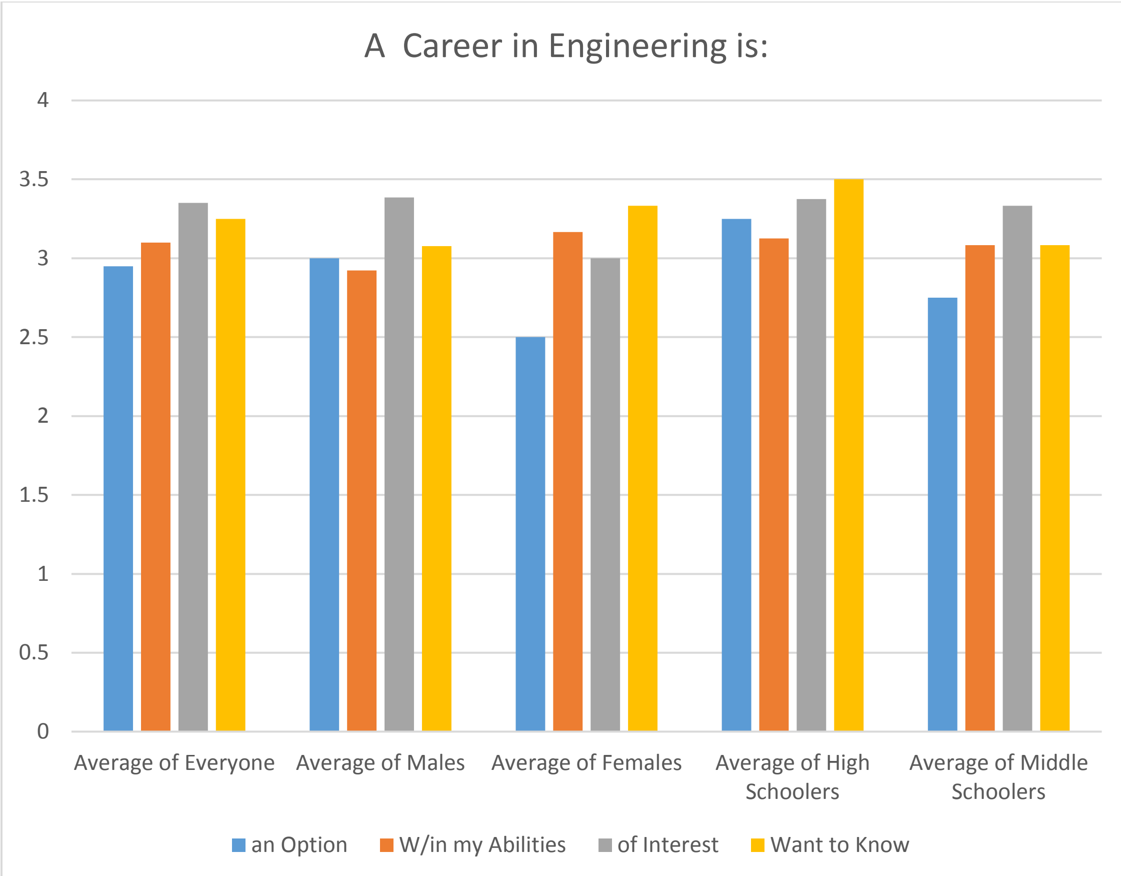

Figure 2: A Career in Engineering is . . .

The data retrieved from post-survey will be most interesting. Students will have had the chance to test their turbines and discuss the process of engineering solutions for real-world problems.

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