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Engaging Young Students to Construction

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Abstract

How do we interest students in construction education and ultimately pursue a career in construction? Students form their individual career interests in their school years beginning as early as elementary school. As they progress in their educations, students are encouraged to seek higher education for varied professions. Construction offers a challenging and secure future to those who choose to enter into practice. However, it is a career that is often overlooked by students.

As part of engineering forums that are offered in our area for regional school age students and their families, the Construction Engineering Technology program at the University of Maine (UMaine) sets up an informational table about our program along with a STEM activity. We engage students as young as elementary age by having a "hands-on" activity to build a tower as tall as they can only using supplied materials. These towers are built from uncooked spaghetti and mini-marshmallows. Students have seen these everyday materials, but had never tried to build anything with such items. Guidelines are minimal and students are allowed to use as much as they need. Through self-discovery, students find out what the best shapes are in constructing viable towers. They learn about tension and compression; they learn about brittle and malleable substances. Students readily adapt to make the towers work. Students of all ages can relate to the activity and can build with minimal direction.[5]

Through 10 years of using spaghetti towers at student forums, the author has anecdotal observations of student interactions in constructing a defined project with unconventional materials. These tower projects engage students and their parents to build structures with constraints that challenge them. This simple project interests students and begins the dialog at young ages as to what engineers design and professional contractors build.

Introduction

At the University of Maine, construction education is under the School of Engineering Technology in the College of Engineering. Though construction is a very visible occupation, potential students do not realize construction education is a viable academic pursuit. To recruit potential students, the construction engineering technology department at our university actively participates in recruitment opportunities with regional and local schools at varied age levels. As part of our informational table, we often use an interactive construction activity through building tower structures. "Today's hot new toys are teaching kids how to innovate."[1] Research suggests that building toys hone spatial skills and that kids as young as 5 can grasp many of the concepts needed to build.[1] Our tower project is received very positively by participating students and is a great example of a STEM (Science, Technology, Engineering, and Math) activity.

For over 20 years in Maine, several professional engineering societies such as the American Society of Civil Engineers (ASCE), the American Society of Mechanical Engineers (ASME), and the Institute of Electrical and Electronics Engineers (IEEE) have partnered with the

engineering schools and industries that employ engineers in Maine to form the Maine Engineering Promotion Council (MEPC). This non-profit organization has two primary goals: to promote the work and contributions of current engineers and to encourage the ideas and ambitions of future engineers. The MEPC strives to publicize the work of engineers and to create aspirations for young people to enter into the engineering profession through the promotion of STEM education.

The MEPC coordinates an annual Engineering Expo held in conjunction with the national recognition of Engineers Week. The Engineering Expo is a large gathering of interactive and informational displays about various types of engineering. These exhibits are created by the various engineering societies, university engineering departments, engineering firms, and industrial partners that are within Maine. The expo is a day long event held on a Saturday and is open to the public. Both electronic and print media advertisement is used to publicize the event in the social media and in the schools throughout our state. Students at all levels are encouraged to attend and attendance has steadily grown in the past few years. In Maine, the expo geographically alternates annually between the University of Southern Maine in Portland and the University of Maine in Orono. By alternating the location students from all parts of Maine are able to learn about engineering as a potential career. This exhibit is open to all ages and attracts students from k-12, their families, and those generally interested in engineering.

The UMaine Construction Engineering Technology program also has a booth at a statewide construction all trades fair held in the fall for students from vocational regional high schools and other construction trade programs. These students are trade students who plan to enter the construction industry. We set up a booth to encourage these trade students to consider entering a construction engineering program to learn the management of construction. We use our STEM activity to engage students in a dialog as to what construction education covers and demonstrate how team work will be part of the process to be an effective construction supervisor. Students in these programs are primarily at a sophomore and junior level.

Our program also annually goes to a local elementary and a middle school to participate in their respective science fair nights. These programs focus on STEM activities. Our tower projects are often well visited by students who try to build a tall tower. Students seem to enjoy these projects as they participate in the science fair.

We use these opportunities to interact with students at all ages to promote construction education. We have found the spaghetti tower projects to be universal.

Towers

What type of activity can engage a young student to think about engineering? More specifically, what types of activities may make students think about construction engineering? Construction is all about building various projects. We came up with the idea of building towers and have used this interactive exercise in our 10+ years of involvement in public outreach.

Because of the unknown attendance at the forums we attend for student engagement, it is often difficult to know how much material to bring to share with participants. Commercially produced student building kits are expensive even if purchased in mass quantities. Simple items can be used to create the same experiences. We found that dried spaghetti strands and miniature marshmallows are very economical and effective for use in building tower projects. These items are readily available in supermarkets.

Each student that participates in building the towers is given access to unlimited spaghetti and marshmallows. Direction is minimal and is given as "build a tower as tall as you can." The only limit is that the tower projects are measured each hour. The tallest tower in that hour time block is awarded a prize. (Figure 1)

Figure 1.
Student starts building a spaghetti and marshmallow tower. Unlimited materials are available.

Students are not given any assistance in building the tower and can do whatever they wish within the hour time block. They are allowed unlimited attempts at building the tower. We allow this unlimited access to material and unlimited attempts to give the students the ability to innovate. Education researcher Christine Cunningham conducts several engineering projects for elementary students at the Boston Museum of Science. She believes "such simple exercises hold great value: the students learn how to navigate a challenge by trying, failing and rethinking their designs and then trying some more. 'The idea that failure is good can be a radical concept in the schoolroom, and it can be a new experience for students, but it's how engineering works.' Each failure informs a future design that brings the engineer one step closer to success."[3]

Students need to be able to reason through a project to understand how to build it. The spaghetti tower is a non-threatening activity that allows students to engage in the success and failure of a design. Research in STEM is incorporating the engineering design process (EDP) to formalize how students learn. Billiar, et.al. discusses how the EDP is used in designing STEM curriculum development in a collaborative study with middle school teachers in Massachusetts. In developing the curriculum, the EDP is defined through a series of steps:

1. Identify the problem.
2. Research and rank objectives and constraints.
3. Develop solutions.
4. Select best solution within constraints.
5. Construct a prototype/model.
6. Test and evaluate.
7. Communicate the results.

8. Reassess and revise.[2]

In defining lesson plans through the EDP, Blier observes that the feedback loop within the steps can be modified to make continual changes for progressive improvement. The result of the study showed that teachers found the EDP process helpful in devising more interactive and engaging lesson plans.

In presenting the spaghetti tower challenge to the students, the EDP becomes part of how the project is executed. The first 4 steps stated above are set up in the challenge of the building the project. "Build the tallest tower you can," sets up the problem open to whatever solutions are brought forward. The constraints are only in the amount of time that is given for the exercise in the 1 hour time block. The hands on exercise of building the tower give the student the challenge of constructing a prototype. The continuous adjustments needed to build the tower serves as the test and evaluation step and leads to the reassess and revision needed to make the tower stand. Though not formally stated to the students, the continuous improvement part of the project allows the student to directly experience the EDP. Students also create immediate feedback loops as they work with the materials to build the towers. Often the students realize that they need to make immediate adjustments to prevent tower collapse. Though not stated either way as allowed or not, many students work in teams to better build the project. This team collaboration demonstrates to the students the importance of teamwork. Team building is important in construction education as teams are an integral part of the construction process. Figure 2 shows students working together as a team to try to build a tower.

Figure 2
Students work together to create a successful tower

Observations

After several years of using the spaghetti and marshmallow tower project at the engineering expo and other student forums, there are several observations that are made on the use of the EDP and motivating students to follow a career in construction.

1. Dry spaghetti strands and miniature marshmallows are economical and unconventional materials to use in construction. Students start with a different paradigm on these items as foods and not as building materials. Young students are receptive to trying these "foods" to build a project. In using the materials students quickly learn two important material properties: brittleness and malleability. Dried spaghetti easily breaks and has

limited ability to bend. Many students will have several failures to put together a tower as they experience the quick snap of one of the support members. The miniature marshmallows are quite malleable. Students learn that if these marshmallows are handled too much, the marshmallows become extremely soft and lose integrity as a connector unit for the spaghetti members. These lessons are not quantified by the technical terms, but students learn that some materials are better than others in building. Figure 3 illustrates what kind of failure happens with excessive handling of the materials.

2. The physical arrangements of material have structural integrity based on the shapes that form the final structure. Triangles can support a tower better than squares and rectangles. With minimal prompting, students tend to build squares and rectangles with the materials. They soon experience the structures leaning and collapsing. Immediate action to correct the leans leads to cross bracing: triangles. Some students recognize that the triangle is a better structural support and readjust their designs to build a tower with greater integrity. They experience the greater load distribution with the triangle as the towers are built to greater heights. As a facilitator at the forums, many of our construction students give the younger students help in determining the importance of the shapes used.
3. The average heights that students will build towers to are around 3 feet. This height is usually reached with many unusual additions and salvaging of tower components. Students will focus on getting height as they work on the project. Most don't recognize that manipulating the marshmallows too often weakens the marshmallows integrity. Heat is one of the properties that students don't understand during the construction process. Figure 4 shows a tall tower of 6 feet built by construction engineering technology students.
4. Working in a team helps in building the towers more effectively. Team mates can hold components as one makes connections to create the structure. Balance is a key to creating the tower. Failure is sudden and very difficult to recoup.
5. Prizes at the end of each time block are a motivator to build the tower quickly and efficiently. It serves as an incentive to keep focus for the goal; creating the tallest tower.

Figure 3
Spaghetti and marshmallows readily collapse

Figure 4
Tall tower built
by CET students

6. Female students in the elementary grades seem to be more focused and build better towers than male students at the same level. Female students will quickly revise their tower to make the structure progress within the time frame given. Male students will quickly destroy the tower if it fails and will either "walk away" or try to build another. They do not seem to focus on revision. Towers built by the female students usually are taller and more proportionate. These towers stand straighter. This phenomenon is difficult to authenticate in the literature. One entry that may start supporting the observation is based on Bettina Chen and Alice Brooks who founded Roominate in 2012. This company markets components for dollhouses and have found that other items are actually built. Chen notes, "it's open ended, it lets girls build anything they can imagine."[1] Chen and Brooks are graduate students at Stanford and remember playing more with their brothers' Legos and Lincoln Logs. Figure 5 shows two female students working together to create a tower.

Figure 5
Female students put together a tower

7. Young students will spend significant time building tower projects. Several students have their parent or guardian assist them as they try to build a tower. The adult usually explains to the child how to make the tower work and shows the student how to make the triangles needed to give strength to the tower. The child learns through the parent and models how the parent instructs to do the work.[4]

Conclusion and Summary

Design challenges such as the dry spaghetti and miniature marshmallow towers are an effective hands-on project to introduce young children to construction. These students are willing to try to build a tower using their own innovation rather than instruction. Students are willing to continue building through revision and perfecting their initial approaches. Though they don't fully comprehend the scientific principles, young students are engaged and accepting of the challenge. Older students also accept the challenges of the project and use a more systematic approach through team work. Older students revise the project to gain greater heights as they strategically work together to hold and manipulate the spaghetti for free standing structures. Overall, the shear process of building the project gives the student, either younger or older, a better sense of construction and its challenges.

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