Nova Engineers to the Rescue: Bone fixation example for classroom or outreach activity

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Statement of Purpose:

The directive from many national funding agencies is clear, the need for engineering outreach is crucial. K12 students exposed to STEM activities can inspire a new generation of engineers. The challenge then, is how to bring complex concepts to an elementary or secondary education level. One such method is to use an impromptu design exercise (IDE), as the example bone fixation IDE given here. IDE are commonly used as ice-breakers at engineering student gatherings [9]. In a typical impromptu design exercise, students are given a simple design task capable of being completed in a short amount of time (15-60 minutes). In addition to a needs statement, description of the problem, and scoring metric, students receive a “grab bag” of materials to be used in solving the problem (e.g. office or craft supplies). Working in teams, students approach the problem as they best see fit with minimal assistance from the professor, e.g. students may employ methods such as trial or error and design-build-test-redesign. When complete, the professor and students evaluate the designs according to a predetermined metric to establish a “winner”.

These IDE’s allow students of all ages to build, test, practice teamwork, use their creativity and understand some of the issues an engineer would face. The challenge for Biomaterials researchers is to create a library of such IDE’s on biomaterial specific projects. One such project used for both outreach through a Villanova sponsored outreach program at local Philadelphia area middle schools, as well as in an undergraduate level Biomaterials course is presented here[1].

Methods: The following problem statement is provided to the students at the beginning of a 50 minute lecture.

The dilemma: A class field trip to visit a remote lab with novel biomaterial research has gone very wrong. The airplane taking the entire class to the remote lab has broken down and everyone is now stuck on the island. Unfortunately, in trying to fix the engine, Dr. Comolli has fallen off the wing and broken her leg. Her right fibula is now not only exposed through the skin, but has lost a piece and needs immediate attention. Simply stabilizing the leg would still leave a whole in her leg’s support (see picture).

Your Team’s Challenge: *Dr. Comolli has faith that her class can successful fix the bone back together!* Using only the provided materials, each group must design a way to repair the weight bearing function of Dr. Comolli’s leg. Keep in mind this must be completed quickly! (35 minutes) Dr. Comolli also hopes her students remember what she has just taught them about material bulk AND surface properties to determine their best choice for their design.

Requirements of your design:

Using two pieces of wood as the model “bone” you will have to affix them and prove it can support the weights during testing. Only the materials provided can be used. Things to consider include: corrosion/degradation of the material, fouling of the surface, cleanliness of the material (what do you propose you could do to clean it?), strength, wear, etc.

Students are then allowed to look at the materials, and asked to form a team. They can plan and build their design over the next 20-30 minutes. The materials provided include: a piece of fractured “bone” (a 2x2’ piece of wood cut on a diagonal at the middle), bamboo, fake palm leaves, stones of assorted sizes, chewing gum, plastic cups and silverware, hand sanitizer, napkins, rubber bands and saran wrap. Designs are tested during the last portion of class by bracing the bottom portion of the “bone” on clamp to a ring stand. Several textbooks are then added to the top of the “bone” to see which design can hold the most weight.

Results: The activity has been done over several years in class and as an outreach activity. Results have varied greatly depending upon the “materials” provided. Shown in Figure 1 are a few of the resulting “bones” students have made in the Biomaterials class.

Figure 1. Students with their final designs.

On average the students can hold 2-3 textbooks on their bone. Students also tend to be lost at first, gather as many materials as they can, and slowly begin to evaluate which will work best. The longer time they take in constructing, most often results in a better overall design.

Conclusions:

Although the actual example is far-fetched, the concepts the students gain from this experience are still valuable. Students are able to evaluate everyday materials for different uses, and focus on the concept of material tensile strength. Survey’s given before and after the IDE indicate most students recognize the desired concepts and learn some design from the experience.

References:

1. Wojcik, T.G., et al., *The Value of Impromptu Design Exercises as an Approach in Design-Centric Engineering Education.* International Journal of Engineering Education, 2012. **28**(4): p. 892-903.