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Engineering Design project

Gluep: A Chemical Engineering design project

This project was done with 10th graders in the BioChem Tech program at Saunders Trades and Technical High School. This program covers advanced topics in Biology and Chemistry so these students have more lab experience than most 10th graders.

The engineering design project was presented to the student as a real-world chemical engineering problem. They have been tasked by a toy company who is dissatisfied with the recipe for their product Gluep. The engineers are asked by the toy company to change the formula of Gluep to give it more bounciness and stay with in a given budget and time frame. The engineering team that has the bounciest Gluep and stayed within the constraints will be awarded a contract to produce Gluep.

The students are presented with a purpose and introduction:

"Purpose: A company has recently come to your team in search of a better recipe for bouncy Gluep. Your team is challenged to use scientific method to improve the polymer recipe and to make a bouncier Gluep, all while staying within the company budget and time constraints.

***Introduction*:** Polyvinyl acetate (from white glue) is mixed with a water solution of sodium borate ($Na_2B_4O_7$, found in some soaps) to form Gluep. Gluep has some properties of a liquid such as flowing and dripping, and it has some properties of a solid such as bouncing and shattering. By altering the ratio of the ingredients in the recipe, the properties of the polymer can be altered. Gluep is actually a cross-linked polymer. First, a polymer is a long strand of chemical units linked together. Think of your class forming a big line and then holding hands to link each person together. Now for cross-linking, if two polymers are side by side and another chemical comes along and connects, or links, the two polymers across the middle, we now have a cross-linked polymer. Think of two classes lining up next to one another and a teacher who stands in the middle holding onto to one student from each class crosslinking the two class chains. In the case of Gluep, sodium borate dissolves in water to form borate ions [$B(OH)_4^-$] which then can form bridges between the polyvinyl acetate chains.**"**

The students doing the project have not been formally introduced to polymers but many of them are familiar with the "Gluep" concept or some sort of polymer like it.

Students begin with this problem:

> "Your team's task is to systematically test different recipes of Gluep to determine and explain which ingredient(s) are responsible for the "bounce factor" of Gluep (water, sodium borate, or glue) and to determine the optimum recipe/procedure for bouncy Gluep. Your team will receive a maximum budget of $8.00 to order materials. You will be allowed one free order at the beginning of lab for your 10:10:10:10 recipe.

1. In one container, dissolve 10 g of white glue in 10 g of distilled water. (You can assume that the density of water is 1.00 g/mL if you want to use a graduated cylinder rather than a balance for water.) Make sure that you note this assumption in the errors section of your report.

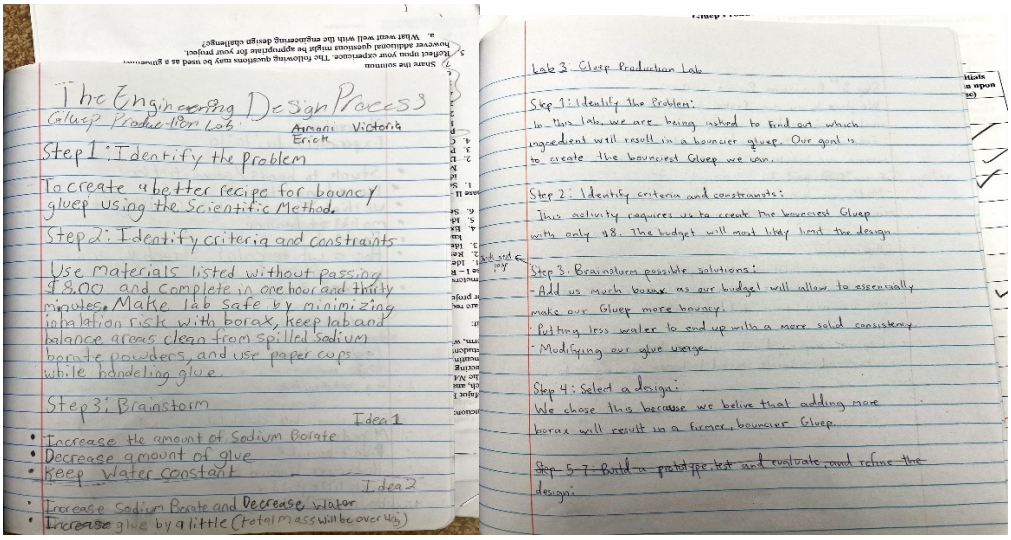
2. In a second container, dissolve 10 g of sodium borate in 10 g of water.

3. Mix the two solutions together by adding the glue mixture to the sodium borate mixture. Knead the mixture for several minutes. This is called the 10:10:10:10 recipe.

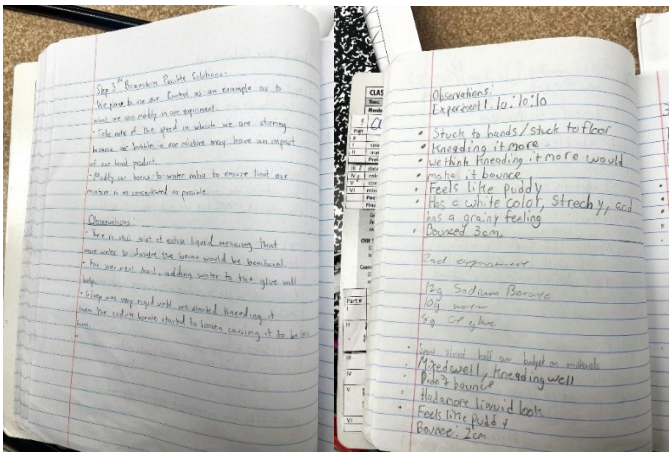
As you were told earlier, the customer was not happy with this recipe for Gluep. You need to spend some time writing a research plan to achieve your goals keeping in mind your budget constraints. Hopefully you have done some of the initial planning before entering the lab to minimize your lab time overhead costs."

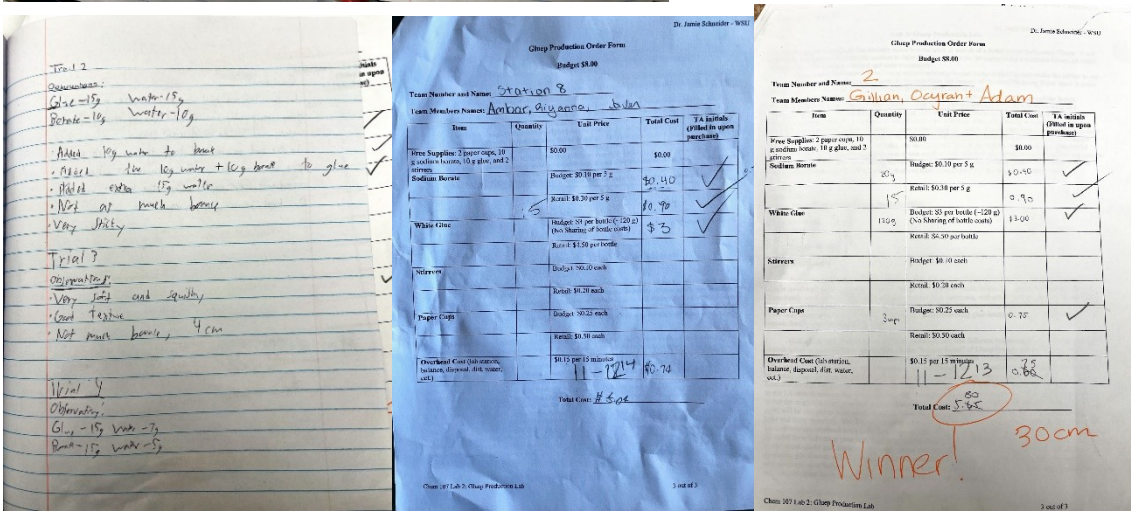
Students used NASA's engineering design process in their lab notebooks:

1. Identify the problem
2. Identify criteria and constraints
3. Brainstorm possible solutions
4. Select a design



5. through 7. Build a prototype, test and evaluate, and refine the design





8. Share your design!

"A bounce-off will take place to determine which team will be rewarded with the contract. Bounciness then will determine the winner (teams over budget cannot win). You must know and be ready to share the exact recipe/procedure of the ball that you enter in the bounce-off, and you must know your total budget."

The winners are in the first photo. Their Gluep bounced 30 cm.

Summary:

Standards addressed:

HS-ETS-1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

ETS1.A: Defining and Delimiting Engineering Problems

ETS1.B: Developing Possible Solutions

ETS1.C: Optimizing the Design Solution

All in all, the engineering design project went very well. My students we receptive to doing it but seemed nervous and unsure about being given a task with no procedures to guide them. This is not the first time they have done an open-ended project, but they were still unsure about their abilities to complete the project. In the time span given, some students changed the recipe three times and others only once. They enjoyed going to the "store" to purchase items. It was a new experience for all of us. Another science teacher and an administrator (who was a science teacher) came by to observe and we received nothing but glowing reviews! They both noticed that the kids were engaged and work well in their groups (of three or four).

I don't think I would change anything. If I did this with some of my other students, I would probably leave out the order form. Since the group I did the design project with are in a technical program, I thought that the order form and time constants really showed the real-world engineering process.