**Lesson 04: Build Your Prototype**

**Problem statement:** In this project you and your group will design, build, test, and improve (if needed) a running car that is powered from alternate energy sources.

This lesson begins the students on the building part of the design process of their car.

**Learning objectives:** Students will calculate the cost of their car and create a physical prototype based off their diagram.

**Lesson standards (NGSS, CCSS, CTE):**

**NGSS:**

* A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)

**CCSS:**

* Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers (7.NS.A.1)
* Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers (7.NS.A.2)
* Solve real-world and mathematical problems involving the four operations with rational numbers (7.NS.A.3)

**Soft skills:**

Collaboration, creativity

**Connections to career and educational pathways:**

You will want to bring up the engineering design process during this lesson and explain how building a prototype and dealing with failure fits into the process. It’s important that students understand how different jobs use this process and not just “engineers” as they see them.

**Materials:**

* Group design from previous lesson
* Raw materials for car design
* Tools (scissors, glue gun, ect…)
* Materials cost spreadsheet for each group (you may want to do this on a larger piece of paper)

**Lesson preparation:** You will want to have a “store” prepared with all of the supplies that the students will be using. If you have stored their designs from the previous lesson, you will want to have those ready for the groups as well.

**Time required:** 90 - 120 minutes

**Grouping of students for instruction:** (same as lesson 1)

Students will be placed into groups of 3 and 4 by the instructor. These groups will be mixed skills and mixed grade levels if possible.

Groups will be given the following roles: Document control (recorder, brainstorming), Materials manager, Project manager (keeping on schedule, keeping on task, etc.), Communication Specialist

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

1. Students will be using their designs from the previous lesson in order to build a prototype today. Discuss the engineering design process and where this lesson falls in the process. You will want to emphasize that it is completely possible that their cars will not run today and that’s completely ok. They will be redesigning their cars to make them better so they will have time.
2. Have every group get our their design from the previous day and take one more look at it. You should give them about 5 minutes in order to work with their group and make sure they are satisfied with the design. They can make final changes at this point.
3. Hand out a larger version of the materials list to each group (1 per group). Based on their design, they will need to fill out the materials list (with a pencil) and calculate the cost of everything they need.
4. When students have completed it, they are to send their materials manager to the store with the budget. If approved by the store, they may gather up materials for their group and bring them back to the table.
5. Students work in their teams to build their cars per their design. It is the responsibility of the project manager to keep the group on task and make sure everyone is working.
6. Some groups are going to finish faster than others. If they are done early, they should attempt to get the car to run. If they find their car does not work, they need to go back to their design and analyze what could be inhibiting it from working. They will need to fill out a “Root Cause Analysis” form in order to buy more parts to solve the problem. Every team will be getting a chance to redesign in another lesson but most teams should get their car to run in this lesson.
7. If a group decides to add a part to their car after filling out the “Root Cause Analysis”, they must add it correctly to their design and to their materials list in order to purchase it from the store.
8. At the end of the lesson, the Project Manager needs to deliver their prototype to the teacher and the group needs to clean up their area.

**Accommodations:** Some groups will need to send their communications manager to work with other groups to solve some of their problems. The teacher will need to support specific groups who are struggling.

**Extensions:** None needed. Provided in lesson

**Assessment:**

Formative Assessment in the Lessons

* Completion of prototype car

**References/Resources:**

Material Cost Worksheet

Root Cause Analysis Worksheet