MakerSpace Lesson Plan Sample

Lesson Title: The Catapult Project

Length of Lesson:	**Materials Needed:**
4-5 class periods (55 Minutes each) **Prior Knowledge:** - Quadratic Functions -Definition -Solving -Graphing	Prior to the start of the project, students were given the opportunity to make a list from the following materials they will need for their catapult model: MakerSpace Tools and Materials and Consumable Materials Materials also included/needed per group: - Rubber band variety pack - CBR 2 Motion Detector - TI Calculator - iPad - Pencil/Composition Book - Stopwatch - M&Ms or Skittles (projectiles awarded after design is approved by teacher) - Blue painters tape (to mark "hits") Teacher will need a cooking pot for final target competition.

Key Vocabulary:	**Essential Question(s):**	**Differentiation:**
-Quadratic Functions -Velocity -Gravity -Time -Distance -Catapults	- What are variables affect the accuracy of your catapult? - What data will you need to collect in order to determine the quadratic function that models the path of your catapult? - Can position your catapult to hit the final target using your quadratic function?	– Provide students with choices in order to add depth to learning – Provides students with additional resources (websites of catapult examples, hard copies of step by step instruction, keywords to research, etc.) that match their levels of understanding

Learning Target(s):	**Common Core Standard(s):**	**Mathematical Practice(s):**
A5b. I can solve quadratic equations. c. I can graph quadratic functions. d. I can model quadratic functions.	N-RN.3; A-SSE.1, 3; A-CED.1-3; A-REI.1, 4, 7, 11; F-IF.4, 7a, 8, 9	1. Make sense of problems and persevere in solving the. 4. Model with Mathematics. 5. Use appropriate tools strategically.

Lesson:

Overview:
Your students will design, construct and test a catapult. On the last day each team will compete with the other teams in the class to determine which catapult is most effective by hitting your target (a cooking pot works best). Each team will also need to create and present a quick 2-minute movie clip of the project journey from their design to the final launch.

Introduction/Building Background:
Students will have prior knowledge of quadratics but will now need background on catapults. You will need to introduce them or have your students do the research themselves to what catapults are and how they can be built. Below are some helpful links for you or your students:

- **http://www.globalspec.com/Trebuchet/**
- **http://www.catapults.info/**
- **http://www.stormthecastle.com/catapult/index.htm**
- **http://www.instructables.com/id/How-To-Build-A-Catapult/**
- **http://hubpages.com/hub/How-to-Build-a-Catapult---An-Illustrated-Guide**
- **http://www.howtobuildcatapults.com/**

- **http://www.virtualtrebuchet.com**

Students also need to be introduced to the standard Projectile (Vertical) Motion formula. Explain if an object is thrown, a certain amount of initial velocity accompanies its launch. The formula to model the height or "h" of an object *t* seconds after it has been thrown where h_0 represents the initial height, v_0 represents the initial velocity, and -16 represents the acceleration in feet per second due to gravity is:

$$h = -16t^2 + v_0 t + h_0$$

Ask them what type of function this represent and why it might be important to the catapult project. Get them to discover it is a quadratic and they will need to find some of these pieces of data to determine their catapults quadratic model. Continue this dialog with them throughout the modeling and group activity portions of the project.

Modeling:
Show your students the following video as a model of their projects.
https://www.youtube.com/watch?v=9REQKE_aje4

You should have a catapult that you created using the same list of materials the students were given. Explain your design of your catapult and use this time for students to ask questions about building catapults. Then ask them the following probing questions:

- What are some things that are necessary when building a catapult?
- What are variables that may affect the accuracy of your catapult?
- What data will you need to collect in order to determine the quadratic function that models the path of your catapult?
- Can position your catapult to hit a final target using your quadratic function?

Lastly, be sure to show them how to use a CBR 2 with their TI calculators in regards to your catapult and the piece of candy as the projectile. Explain how they can determine the velocity and the distance of the projectile. Ask the students how this data might be useful for their project? Below is a helpful link that gives a quick overview of how to use a CRB 2 if you are unsure.
https://www.youtube.com/watch?v=yTc_v8h0dbk

Group Activity:
Place students in groups of four and describe group expectations of each member:

- Facilitator/Launcher: Makes sure that every voice is heard. Focuses work around the learning task. Launches catapult precisely while expressing thoughts of possible changes needed to be made to create overall goal of accuracy.
- Time Keeper/Errand Monitor: Encourages the group to stay on task. Announces when time is halfway through and when time is nearly up. Uses the stopwatch to obtain the time of each launch from release to hit. Briefly leaves the group to get supplies or to request help from the teacher when group members agree that they do not have the resources to solve the problem.
- Note Taker/Data Collector: Compiles group members' ideas, designs, and data in a group journal. Measures the height of the cotton ball and distance of the launch.
- Recorder: Video records imperative moments as well as each launch from beginning to the end of the project. These recordings will be used to create a 2-minute video of the group's overall journey of the project.

Student Procedures:
Day 1-2:
1. Design a catapult with the materials available from MakerSpace and Consumable Materials lists. The materials can be manipulated in anyway necessary to meet your design.
2. Your design must be approved by your teacher before you start to build your catapult. In your design, be sure to explain how your catapult will work.
3. Once your design has been approved, you may begin to build your catapult.
4. After your team has finished constructing the catapult, you may ask for the projectiles to test out your machine.

Day 2-3:
5. Your team may make any changes to your catapult if necessary, but be sure to note any alterations in your group journal.
6. Record and write everything down. The goal is to have an accurate catapult that can eventually be placed in a particular spot that will then accurately hit a target placed by the teacher.
7. Follow guided worksheet to create the quadratic function that models the path of your catapult and be sure to get your function checked off by the teacher.
8. Have fun!

Presentation:
Day 3-4:
1. Once all teams have developed their quadratic models for their catapults, there will be a competition where each team will need to position their catapult precisely in order for the projectile to directly hit the target set in place by the teacher. The team that gets the closest to the target will receive a candy prize!

Day 4-5:
2. Finally, each team will need to organize all of their data collected from start to finish. They will use this information as well as the video recordings they documented to create a 2-minute video documentary of their teams' journey, including both good and bad events, throughout the project timeframe. The video should be detailed with data information, design development including any alterations, reasons for alterations, the discovery of their quadratic model, and 5-10 launches with final launch. Each team will then display this video in front of the class.

Assessment:
The students will be graded based off of their data collected within their group journal, the catapult design, the information included in their guided worksheet, their quadratic function that models their catapult, the documentary, and group participation.

The Catapult Project

Group Name: _____ Catapult Quadratic Function: _____ Period: _____

- Facilitator/Launcher: _____ - Time Keeper/Errand Monitor: _____
- Note Taker/Data Collector: _____ - Recorder: _____

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Derive the quadratic equation of the path of your projectile using math.

If an object is thrown, a certain amount of initial velocity accompanies its launch. The formula to model the height or "h" of an object *t* seconds after it has been thrown where h_0 represents the initial height, v_0 represents the initial velocity, and -16 represents the acceleration in feet per second due to gravity is:

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What is the initial height(h_0) of your projectile?	What is the initial velocity(v_0) of your projectile?	What is the time in seconds of the projectile path?
Insert the data above into the formula and solve for the height:	Catapult Quadratic Function:	