**Date: Jan. 25th, 2016 School: Marysville Coop at Marshall Grade Level: 5**

**Unit: FOSS Variables Pendulum Investigation , PBS Kids Zip Line Challenge**

 **Concepts:**

**Rationale for this lesson study:**

**STEM Professional: Pat Burnett, Edmonds CC**

**Lesson refinements to observe selected student learning traits:**

1. All students engage intellectually in important science and engineering content.
2. All students participate in science discourse with peers (equitable, accountable talk).
3. All students use evidence to demonstrate conceptual understanding.

**Teaching for Conceptual Change**

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| Days \_\_\_ Days \_\_\_  | **1**  Elicit each student’s initial ideas. | Conceptual Storyunit = FOSS VariablesInvestigation = Pendulum inquiry* reading (force and motion)
* design an investigation (class determines manipulated variable #1 will be the drop angle)
* test
* graph
* write
* redesign procedure for variable #3 ( type of string)

Engineering Design Cycle***The Zip Line Challenge!***Tues: Tinker TimeWrite Key Question List our class criteria and class constraintsWed: Thurs: |
| **2**  Prompt possible dissatisfaction with old ideas, and surface the range of students’ new ideas that make sense with their new observations. |
| **3** Narrow the range down to the one new idea that is most plausible in this situation. |
| **4** Reflect back to initial ideas and how each student’s understanding has changed. |
| Days\_\_\_\_ | **5** Apply the new idea to test how it holds up in new situations.Engineering Enhancement |

**Standards:**

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

**Science and Engineering Practices:**

 **1.** Asking questions and defining problems

 2. Developing and using models

 3. Planning and carrying out investigations

 4. Analyzing and interpreting data

 5. Using mathematics and computational thinking

 6. Constructing explanations and designing solutions

 7. Engaging in argument from evidence

 8. Obtaining, evaluating and communicating information

**Performance Expectations -**

**ETS1.A: Defining and Delimiting Engineering Problems**

Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

**ETS1.B: Developing Possible Solutions**

Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)

At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)

Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

**ETS1.C: Optimizing the Design Solution**

Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

**Crosscutting Concepts**

**2. Cause and effect:** Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

**4. Systems and system models.** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

**6. Structure and function.** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

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| **Apply the new idea to test how it holds up in new situations.****Engineering Enhancement** |
| **Engineering Problem:**Design and build a device that can carry a Ping-Pong ball from the top of a zipline string to the bottom in more than four seconds and less than eight. (PBS.org/designsquad.) Backstory: NASA needs a way for astronauts to escape from the space shuttle to safety if the launch is scrapped at the last minute. (Youtube - [Escaping from a Space Shuttle](https://www.youtube.com/watch?v=--QoLPzvXOQ))\*\*Teacher note: If students bring up the idea of a stopping system at the end to protect the passenger. For this problem another engineering group is designing the stopping system.**Learning Target:** Scientists will carry out an investigation by analyzing the cause and effect to help them understand engineering design.**Success Criteria:** In the process of optimizing, kids are thinking, talking and writing about their process.Every child will chart and record their own data and observations. Using data in thoughtful ways to optimize.**Students will be able to:*** Chart and record their own numerical data.
* Record observations.
* Use data to optimize their car design.
* Provide evidence to support their thinking.
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| **What aspect(s) of ED will students attend to?** * Define the problem or challenge (APPD)
* Define Constraints (APPD)
* Define Criteria for Success (APPD)
* Develop Solutions (APPE)
* Test and Optimize Solutions (APPF)
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| Criteria **Teacher controlled:** The person in the carrier needs to be safe, so the ping pong ball can’t fall out. The ball needs to be removeable. Device removed easily from the string time : 1st design success criteria = 5-8 seconds final optimized design = 5 secondsDistance ***Prompts to elicit student-generated criteria:**** ***Why would it be important for to have the design not go too fast? Too slow?***
* ***What would be the optimum time for the device within the time window? If 4-10 seconds is the window, what would be best 4, 5, 6, 7, 8, etc.?***
* ***How far should the device travel?***
* ***How do we define/ mark the beginning and end of the testing zone?***
* ***Why is it important to define the distance the device travels?***
 | Constraints**Student controlled (**Sample list of itemsavailable):large paper clipsstrawswashers/weights of some kindhole punch scissorscardstock (students may use this as a sail)masking tapefishing line for zip linestringrubber bandsballoons different sized cups, \_\_\_\_\_\_\_\_, binder clips to attach line from end to endping pong balls to use as a passengerClass uses agreed upon materials***Prompts to elicit student-generated constraints: (Teacher intervention only if/when necessary)**** ***What materials would you need for your design to be successful? Support material choice with reasoning***
* ***Should groups be allowed to use as much materials as they want? Why would it be important to limit how much of each material groups can use?***

3. Time \_\_ |

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| **Detailed Lesson Progression: With prompts and possible student responses***What will the students be doing? Teacher?*Day 1 DEFINE the problem → begin to generate solutions1. Elicit students’ initial ideas (15-20 min)

Scenario - Most rockets have their own built in escape system. Space Shuttle does not, they rely on the zip line outside to allow them to escape should a problem arise prior to liftoff.class Watch the video of NASA zip line -- make some observations: (5 min)* ***Why is time important? Why would you want to move quickly? Why not too quickly?***
* 2’s (T-P-S 1 minute)  ***What features did you notice about zip-line?***

note: teacher writes these on whiteboard/chart- ie: sloped line between two stationary objects; car for people to ride in; slowing mechanism of some kind; * 2’s (Turn and Talk) ***What other zip-lines do you know about? Have you ever been on a zip-line?***
* 2’s (T-P-S 1 minute)  ***What other uses are there for zip-lines?***

 2’s Tinker Time -- generate some Ideas about materialsOutcome - Be able to come back to the constraints to develop together. As a group students will develop the constraints for testing system.\*\*Students will be given a “prototype” of the car, a simple design - Cup with straw or paper clip attached and a pingpong ball inside.\*\*\*This is not a time to solve the problem but to experiment with the variables that affects how the zip-line system works.Noticing and wondering:Elicit students’ what would be the best testing set up.What do you notice and wonder about length of string, type of string, height of string, angle of string?(this is in the student engineering notebook- not shared with class)

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| NOTICING | WONDERING |  |
| 1. When you lower slope, the speed of the car \_\_\_
	1. Increases
	2. Decreases
	3. Stays the same
2. .
 |  |  |

*(Number or name the different zip lines around the room so you can refer to them in discussions.) Suggested setup: Fish line at 22 and 45 degree angle, and lengths of 3 feet and 6 feet and cloth type string of 22 degrees and 6 feet in length.*Show students the zip -lines (different slopes and length), chart choices and the available materials* ***How does the length of string affect the zip-line?***
* ***How does the height affect the zip-line?***
* ***How does the angle affect the zip line?***
* ***How does the type of string affect the zip-line?***
1. Discuss and make a public record of criteria and constraints

whole class Use the prompts from student-generated criteria/constraints section.Day 2 SOLUTIONS → scientific investigation of each variable (collect data) “Fail fast to succeed sooner!”1’s Create own design and make a diagram - Quiet think time Diagram should include labels, measurements, materials list or labeled parts. Diagram should be full notebook page.2’s Combine ideas: agree on a design to make, together1. Questions to help guide students through variables that may affect results.
* ***How does the car attachment affect the zip-line?***
* ***How does the mass of the car affect the zip-line?***
* ***How does the type of cup affect the zip-line?***

*\*\*Option: Specialist - Each group tests a different variable and then in the design, each group has a specialist.*1. Build and Test and record data:

Anticipated student variables: Type of cupNumber of cups, Attachment (Paperclip, straw), Mass,

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| --- | --- |
| Variables: Aspects of Each Design | Trials (Seconds) |
| Cup | Clip | Mass |  |  |  | 1 | 2 | 3 | 4 | Average time |
| same | same | add 6gMore/Less |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | clip | 0 |  |  |  |  |  |  |  |  |
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Day 3 OPTIMIZE → further testing and get ready to present final design decisionsWarm up with cross cutting concept: * ***Cause and Effect: watch the video of one of your paper tables.***

 ***What happened and why?***

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| --- | --- |
| ***cause*** | ***effect*** |
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1’s Private think time and write on white board.2’s Take turns. Tell your idea. Listen to your partner’s idea.Did anyone use numbers?Today’s challenge:* ***As engineers, we think this way: what is the cause and what is the effect we see? You are going to think this way to design your zip line.***
* ***If you are within the window of our criteria of 4-8 seconds for the zip line, today try to optimize for 5 seconds.***

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| Test # | Design change | Observations | Trial 1(in sec.) | Trial 2(in sec.) | Trial 3(in sec.) | Trial 4(in sec.) | Trial 5(in sec.) | Average Time(in sec.) |
| 1 | Initial design → diagram in science notebook |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |

2’s: Stations for zip lines:* ***Turn to your designs in your science notebooks. Have data chart ready.***
* ***Test your design with 3 trials. Record your data.***
* ***Repeat→ Redesign. Test with 3 trials. Record.***
* ***As an engineer, you need to keep track of what you are trying.***
* ***3 trials are done. So now it is time to analyze. To optimize your design, ...what are you going to change next?***
* ***What is a test and what is a trial? Test your design with 3 trials. before you change to the next design. Why do engineers do more than 1 trial?***
* ***You are wondering if you could go back to an earlier design→ Well, when might an engineer might want to do that? Ok, now what does your team want to do next?***
* ***How does the \_\_\_\_\_\_\_\_\_\_\_\_affect the zip-line?***
* ***car attachment***
* ***mass***
* ***type of cup***
* ***What other variables affected how the car went down the zip-line?***

Teacher prompts during work time:1’s Claim-Evidence-Reasoning:On a white board students record their responses to each of the following questions. Purpose of this is to find commonalities/patterns between variables using data and incorporating their data and ideas into their final optimal design.1’s Private think time and write on mini white boards:* ***What changes did you make \_\_\_\_\_\_\_\_\_ in optimizing the design?***

***The cause of this change was \_\_\_\_\_\_\_ .*** ***The effect in the system are caused by \_\_\_\_\_\_\_\_\_\_\_\_\_.******Evidence to support my explanation is \_\_\_\_\_\_\_\_\_\_.***Example - The more washers you add to the car the faster the car will go and get to the bottom faster. My evidence is when we used 1 washer the time was 10 seconds average, with 2 washers the time was 7 seconds average and with 3 washers the average was 4 seconds.two groups of 2 Mid-workshop interruption -- Think and Turn & Talk:* ***So far...What are the biggest changes you have made to your design and why?***
* ***Now...Think about creating a new design to meet the 5-8 second criteria, what combination of the variables would meet the criteria best?***
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| **Considerations** |
| **Reflection notes - things to consider when teaching the lesson:***How did your students engage in the lesson?**What did the student work and performance in the assessment show about student learning?**What tips would you offer to other teachers?* |
| * Supporting all learners – modifications for English Learners, Special Education, Advanced Learners:
 |
| * Suggested Unit Adjustments – “Ripple Effects”
	+ *Consider: How does the timeline and content of the rest of the unit need to be adjusted to fit this enhancement? What other lessons need to be dropped or enhanced? Are there specific adjustments to other lessons?*
 |
| * Integration (optional)
	+ *Consider: How does this lesson connect with other content areas, including CCSS, Math, ELA and 21st Century Skills.*
	+ *Real World Connections (How does it connect with social, family, and community happenings?)*
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**Generalizations to Practice**

**Students determine the criteria and constraints for the Engineering Design Challenge**

Jan 2016 5th grade district team

**Student Learning Expected**

x

**Instruction Details**

NGSS Engineering Design Cycle: DEFINE PROBLEM and set criteria and constraints

1.

2.

3.

**NGSS Links**

x

**Research Links**How People Learn\_\_\_\_\_     Cognitive Demand x

**Photos / Samples of student work on back:**

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**Cause and Effect sentence starters**

Jan 2016 5th grade district team

**Student Learning Expected**

x

**Instruction Details**

NGSS Cross-cutting Concept, “Cause and Effect”

1.

2.

3.

**NGSS Links**

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**Research Links**How People Lear x   n      Cognitive Demand x

**Photos / Samples of student work on back:**

**Insert supporting resources here (pictures, student sheet, copy masters, etc.):**

[Space shuttle zipline escape](https://www.youtube.com/watch?v=--QoLPzvXOQ)