PLANETOPIA STEM CHALLENGE

2nd – 8th
NGSS Aligned

Planetopia Plants

DIGITAL/PAPERLESS VERSION

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I look forward to your feedback. If you have questions or suggestions, please do not hesitate to contact me through any or all of the links below:

Thanks & happy teaching!

~ Kerry

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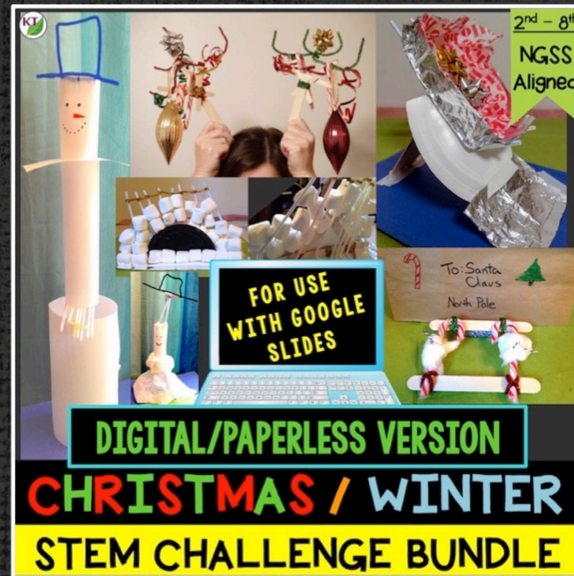

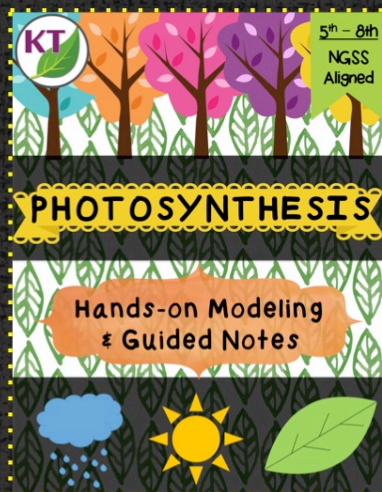

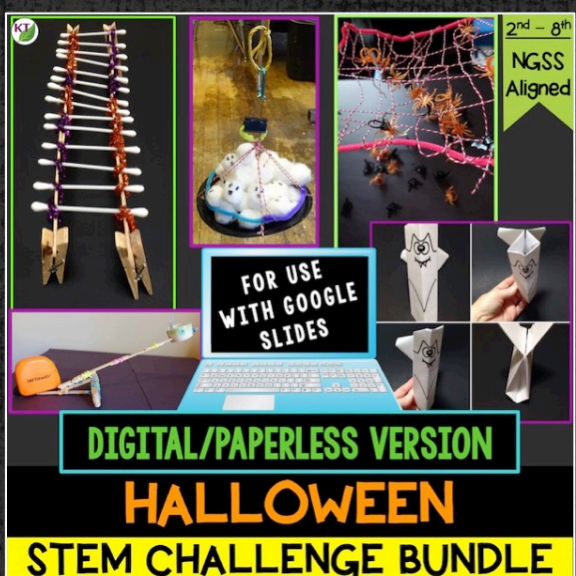

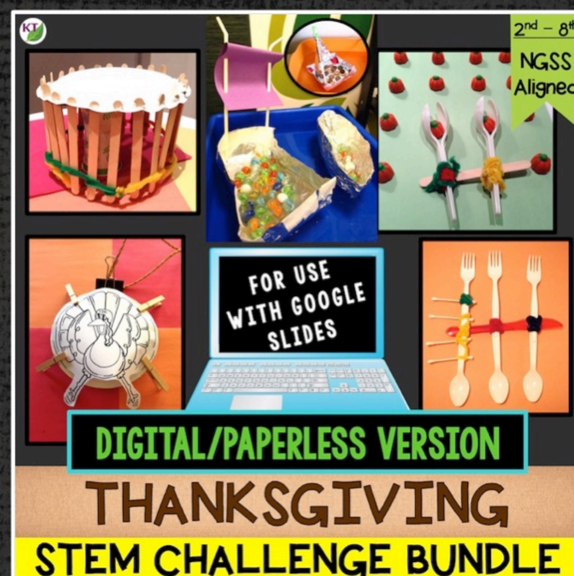

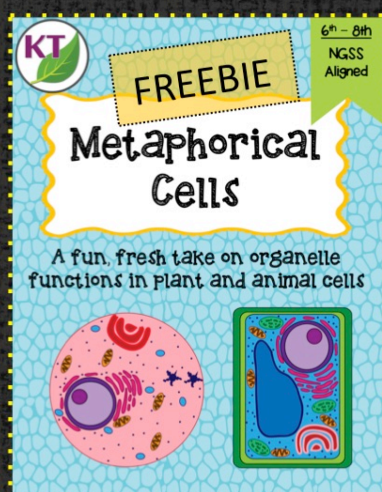

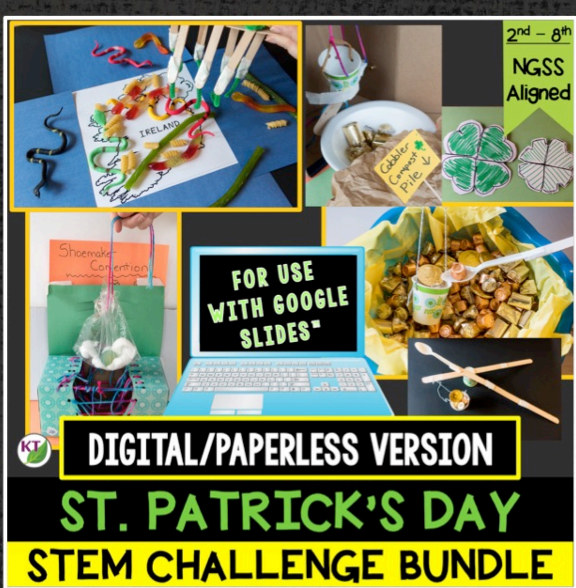

PLANETOPIA PLANTS

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Click on any entry below to navigate through the document.

CLICK HERE TO GO STRAIGHT TO THE MASTER FILE IN GOOGLE SLIDES.

GETTING STARTED

1. Your students will need their own Google accounts to access the file in Google slides. If you need help setting up Google Classroom, search for how-to videos on YouTube. I found this one helpful, but there are plenty to choose from!

2. Review the Teacher Tips for this challenge in the following pages.

3. Create a copy of the master Google Slides file. Rename this file "Teacher" or "Master" copy. There is a video on slide 1 that provides a quick explanation of the file contents/layout.

4. Create a second copy of the file for your students. This way, you always have a master copy with all the slides available. In the student file, delete any pages you don't wish to have students complete, or consider breaking the large file into smaller chunks (Day 1, Day 2, etc.) prior to sharing the file with your class.

Planetopia Plants Materials

Select from the list. Materials can be purchased at you local dollar store or Target/Wal-Mart, etc. Make sure students have an equal amount of each material provided.

There are many options for materials! I've done this challenge with just construction paper and pipe cleaners, and I've also rolled out many of the items you see below. As with all challenges, the more varied your starting materials, the more variety you will see in students' designs.

Recommended for each student or group:

- Construction paper or card stock
- Pipe cleaners
- Cardboard scraps
- Tissue paper
- Foil
- Rubber bands
- Paperclips
- Toothpicks
- Scissors
- Single hole punch
- Glue and/or tape

Optional

- Crayola Model Magic or clay
- Sequins, beans, pasta
- Paint
- Craft sticks
- Plastic beads
- Pom poms
- Yarn
- Sand Paper
- Cotton
- Small cups
- Felt pieces
- Hot glue gun

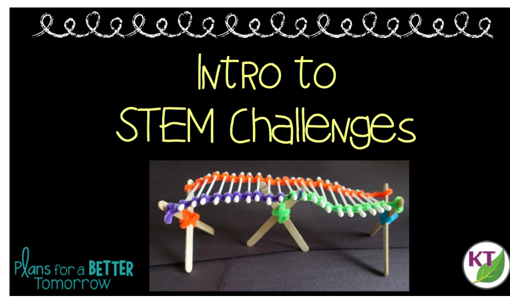
Note to Teachers

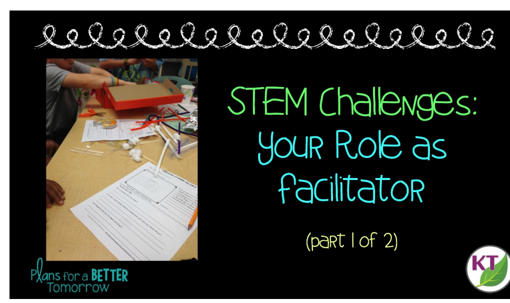
The beauty of STEM Challenges is that they are open-ended and require critical thinking and problem-solving. This is why we don't give students directions to build a specific design. In keeping with the engineering design process, a criteria & constraints list is provided to give students a framework of the design problem and goal. How they choose to address the problem and goal is entirely up to them.

You can tailor the challenge to your students' needs using the editable list provided, but don't make it too easy! Be bold and embrace the *challenge* – it's in the title after all! Understand that the potential to fail is an inherent risk, and in fact, when you're prepared for that possibility, a "failure" can turn into a far richer lesson than a success. Check out the first video linked below for more on what you can do to prepare for – and even look forward to – a potential "fail"!

Videos & PD

Video is such an effective way to share tips and examples for running fantastic STEM Challenges! I've linked a few below to help get you started and cover some troubleshooting topics as well.





You can also find my full video library & newest PD on:

If you have any questions, please feel free to reach out via email or social media!

Video Walk-Through

The image below is linked to the video walk-through of this challenge.

For more Planetopia Project STEM Challenge Videos,
check out this playlist.

- **Premise**
  - Individually or in partners, students will design a never-before-seen plant that can be found on a fictional planet (Planetopia).
    - Students become attached to their plants, so it's a good idea to let each create a design to keep! If students design with a partner, they can create two versions of their plants: a seedling and an adult or one that displays dominant features and the other, recessive.
    - Group option: Student groups first agree on a few different regions/climates for Planetopia (can be done a day or more prior to the challenge). Then each creates a plant with unique adaptations for one of the regions/climates of Planetopia. Task groups with creating at least one feature that unifies all their plants and one feature that makes each unique.
      (Use the second Criteria & Constraints list for this approach.)
  - Plan to give students approximately ~25 min. to design, ~15-20 min. to measure and share results, ~15 to complete design analysis slides, and ~15 minutes for group discussion. Additional time will be needed if you are assigning extension activities.
    - You may prefer to split the design over two days if you are having students use Crayola Model Magic or paint. This gives them the chance to form the base shape of the plant on one day and add finishing touches the second.

- **Set Up**
  - Watch the challenge walk-through video.
  - If you are new to STEM challenges, watch one or more "how-to" videos.
  - Typically, I would not recommend that students research prior to the first iteration of a STEM Challenge, because it results in replication over innovation. However, with this challenge, I have found letting students do a quick Google image search for "unusual plants" prior to the challenge has inspired a greater variety of never-before-seen plants. Just a minute or two is plenty of time to set aside for the image search.
  - Think about where you will store the students' designs. If you choose to provide Crayola Model Magic, many designs will be light enough to support on a bulletin board. You might even create a secondary STEM challenge for students to make a bulletin board shelf for their plant (see video for photo example).

- **Criteria/Constraints**
  - Decide whether you will make adjustments to the Criteria & Constraints List ahead of time. (The Criteria & Constraints List slide is editable.)

- **Criteria/Constraints (continued)**
  - You will want to consider storage carefully, especially if you are planning to do extension lessons. You may want to add a size constraint, e.g. must fit inside a container measuring 8x12x6 in. inches or on a piece of cardboard 6 x 6 in.
  - To *increase* the difficulty of the challenge:
    - Have students design a plant custom-built for a particular need or threat.
      - A plant with flowers that must be reached by walking insects, but not by flying organisms.
      - A plant that needs protection from leaf-eating beetles.
      - A plant that needs the ability to root down, but also pick up to move to a better location.
    - Have students design a plant custom-built for a particular climate or biome.
      - If you are having students work in groups, add a requirement that they must create a feature that unifies all of their plants and at least one feature or adaptation that makes each unique.
        (Use the second Criteria & Constraints list for this approach.)

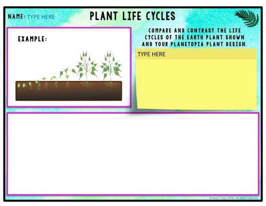
- **Measuring Results**
  - Students should verify they have met all listed criteria/constraints.
  - There are four areas listed on the design analysis sheets for the students to record:
    - Protection from climate
      - A way to survive regular or severe weather, changes in temperature/season, or any other climate concerns students imagine exist on Planetopia. It is fine for students to describe a behavior (e.g. stem grows darker in winter to absorb more energy from the sun), in lieu of a feature in their design.
    - Protection from animals
      - A way to avoid being eaten or trampled. It is fine for students to describe a plant behavior. It is fine for students to describe a behavior (e.g. trigger hairs shoot out thorns), in lieu of a feature in their design.
    - Obtain energy
      - All living things need energy for their life processes. Students may decide to stick with photosynthesis for their plants, but it's fine for them to come up with something completely imagined.
    - A way to reproduce
      - Students may stick with seeds. Push them to explain where the seeds come from/how they are created. It's fine to let them make up something on the spot. Use your extensions an opportunity to have students review pollination/flowers/fruits/seeds and compare/contrast with their plants.

- **Measuring Results (continued)**
  - Students will either record Y/N for each criterion, or give brief details. For example:
    - Protection from climate: During droughts, shuts down most life processes, powering only its central system.
    - Protection from animals: thorns, bad taste, poisonous or super sticky leaves
    - A way to get energy: shoots laser at animals passing by and absorbs their life force
    - A way to reproduce: Mini versions of the plant shoot out of its kertle (similar to a flower). Minis that receive just the right amount of blerk (a purple liquid, rich in nutrients) grow into new plants.
  - As you and students' peers are asking questions about designs, encourage students to create answers on-the-spot. For example, a presenting student may share the piece about reproduction above. A peer might ask, "What triggers the release of minis from the kertle?" The student can make up an answer − even if it isn't shown in the design (e.g. the plant senses when the temperature is ideal). S/he may also indicate the need for time to think about it more or do "research" before sharing more details.
  - In addition, you may choose to discuss with students what they think constitutes a successful design for this challenge. For example, the structural integrity of designs − small details can be difficult to hold up and keep positioned correctly. As part of your whole-class discussion, before students complete their individual design analysis, prompt students for some ways to judge success.
    - Sample answers
      - Structural integrity
      - Most interesting or unique designs (Which would you choose and why?)
      - Using materials unexpectedly
      - Use of color, texture, or other art elements

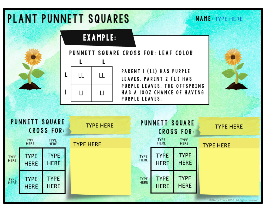
- **Post-Design Options**
  - Design analysis (handouts included in regular and larger spacing for primary)
  - Discussion questions (handouts included)
  - Re-design and re-test (consider incorporating new, student-suggested materials)
  - Extension activities
    - As students dive deep into describing their plants and learning more about plants on Earth, they may want time to add some features/adaptations to their designs. Consider providing time for design modifications.
    - Create a map and/or 3D model of Planetopia and label the regions, landforms, and where the plants live. (If you did the Create-ure challenge, label where the create-ures live too.)
      - If desired, have students include labels for other groups' create-ures & plants.

- **Post-Design Options**
  - Extension activities (continued)
    - Have students make Planetopia plant folders or booklets. See “Extension Templates” section for slide options.
      - Plant basics

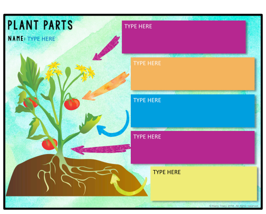
        - » Note: “Size” is the size the plant would measure in real life, and “Needs” does not need not match needs of plants on Earth.
      - Plant adaptations/features
      - Identify habitats/climates on Earth where the plant could thrive
        - » Note: this site may help students select appropriate habitats

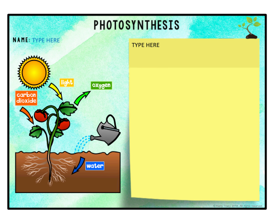


      - Diagram plant life cycle
      - Identify dominant/recessive traits
      - Use Punnett squares to predict offspring



      - Do a Google Search for “Science Field Notes” and click on images to give students a sense of how scientists use diagrams and text to record information. Have students create field notes for their plants as a stand-alone assignment, or included in the booklet/folder.
      - Compare/contrast Planetopia plants with an Earth plant of choice
        - » Plant parts
        - » Survival needs
        - » Adaptations
        - » Reproduction
    - Have students learn about plants in general





      - Plant parts
      - Parts of a flower
      - Parts of a fruit
      - Photosynthesis
      - Plant & animal cell diagrams
      - Compare/contrast plant & animal cells
      - Plant Inquiry
    - Watch videos related to extension activity topics.
      - Cell Structure
        - » The Cell Song (Animal & Plant Cells) ~3 min. (3rd – 5th)
        - » Plant Cells and Organelle Descriptions ~8 min. (5th – 8th)
        - » Virtual Plant Cell ~5 min. (5th – 8th)
        - » Plant Cells ~10 min. (7th – 12th)

Note:
The teacher should always preview videos prior to showing them in class.

Note: One slide per video/website is included in the student slides with its link, so you can easily assign to students.

- **Post-Design Options**
  - Extension activities
    - Watch videos related to extension activity topics (continued):
      - Photosynthesis
        - » Why Leaves Change Color ~3 min. (2nd – 4th)
        - » Vegetation Transformation ~3 min. (4th – 6th)
        - » Simple Photosynthesis ~4 min. (4th – 6th)
        - » Photosynthesis Visualized ~4 min. (6th – 8th)
        - » The Calvin Cycle ~6 min. (6th – 8th)
        - » Photosynthesis ~13 min. (7th – 12th)
      - Plant Adaptations & Unusual Plants
        - » Excellent Evergreens ~5 min. (2nd – 4th)
        - » Desert Life ~5 min. (2nd – 4th)
        - » Meat-Eating Plants 1 ~3 min. (2nd – 4th)
        - » Meat-Eating Plants 2 ~4 min. (4th – 8th)
        - » Planetary Plants ~5 min. (5th – 6th)
        - » Do Plants Think? ~6 min. (5th – 8th)
        - » Can Plants Talk? ~5 min. (5th – 8th)
        - » How Plants Tell Time ~4 min. (5th – 8th)
        - » Amazing Plant Defense ~6 min. (4th – 8th)
      - Growth, Reproduction & Genetics
        - » How Seeds Become Plants ~4 min. (2nd – 4th)
        - » Got Seeds? ~4 min. (3rd – 8th)
        - » Fruit & Bees ~4 min. (2nd – 4th)
        - » The World's Smelliest Flower (Pollination) ~4 min. (2nd – 4th)
        - » Inventing with Plants (Spreading Seeds) ~4 min. (2nd – 4th)
        - » How Bees Help Plants Have Sex ~5 min. (7th – 8th)
        - » Mendel's Pea Plants ~3 min. (4th – 8th)
      - Miscellaneous
        - » The Lowest Level: Dead Stuff ~4 min. (3rd – 8th)
        - » Robo-Bees ~3 min. (4th – 8th)
        - » Robo-Bees ~2 min. (4th – 8th)

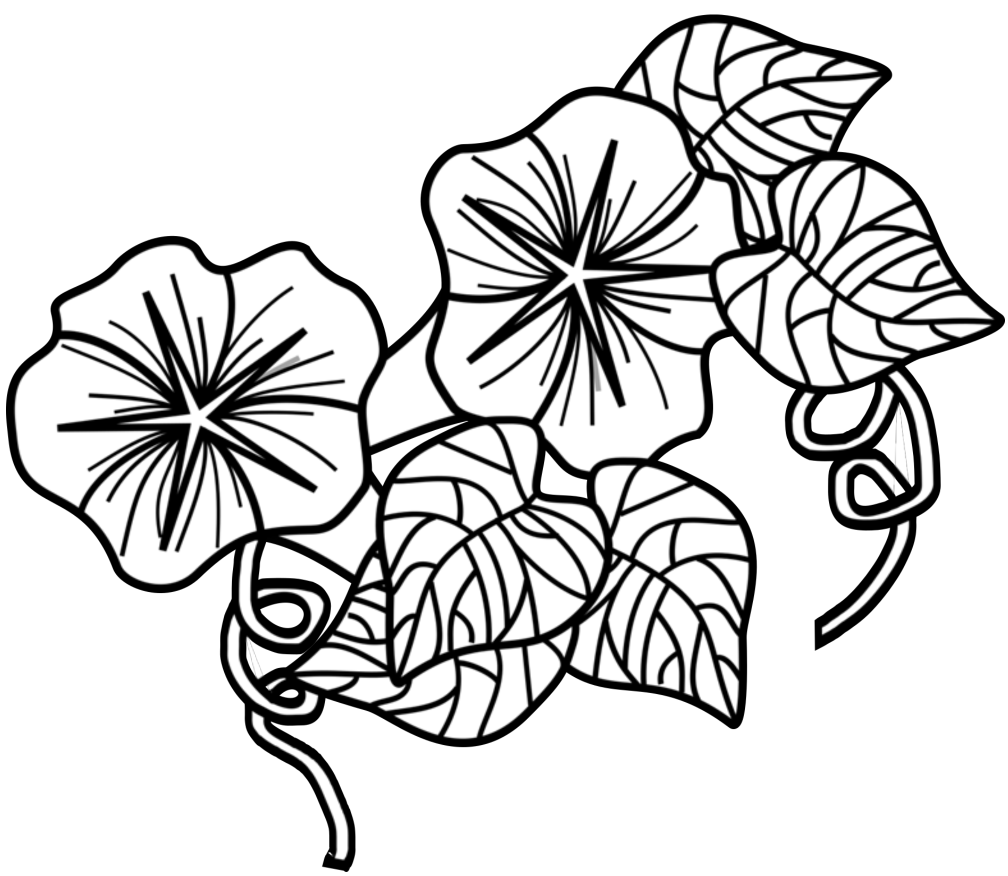
Note:
The teacher should always preview videos prior to showing them in class.

Note: One slide per video/website is included in the student slides with its link, so you can easily assign to students.

- **Post-Design Options**
  - Extension activities (continued)
    - Websites & Close Reads
      - The Great Plant Escape
      - Learn about robotic bees
        - Robo-Bees Article 1
        - Robo-Bees Article 2
    - Writing & Art
      - Plant Walk
        - Take a walk to observe, sketch, and/or photograph plants. Have students do one or more of the following:
          - Create field notes, including descriptive details and properties observed.
          - Create plant poetry. This blog post describes a "Poe-tree" lesson.
          - Create drawings or paintings.
            - Consider working in the style of Warhol or another artist of student choice.
          - Write narratives or descriptive paragraphs about their plants. Encourage students to use strong descriptive language.
    - Hands-on experiments & Activities
      - Look Inside a Flower ~4 min. (2nd – 4th)
      - Build a Terrarium ~5 min. (2nd – 5th)
      - Celery / Transport ~4 min. (2nd – 5th)
      - Grow Your Own Plants, pt 1 ~6 min. (2nd – 5th)
        - Part 2 ~4 min. (2nd – 5th)
      - Metaphorical Cells (FREEBIE)
      - Flower Frenzy STEM Challenge ($)
      - Hands-On Photosynthesis ($)
      - Characteristics of Living Things ($)

Note: One slide per video/website is included in the student slides with its link, so you can easily assign to students.

- **Post-Design Options**
  - Extension activities
    - Students create a process flow map for how to make their plant designs. They trade process maps and try to build the other's design (process flow map handout included).
    - Students create and solve math problems related to designs (handout included).
      - E.g. In a field of 45 plants. How many leaves, thorns, flowers, etc. are present? How many more leaves than flowers are there?
    - Have students graph class data:
      - Number of plants with:
        - » Similar adaptations (thorns, poison, drought-resistance, etc.)
        - » Similar parts: flowers, leaves, thorns, stems, roots, lasers, etc.
        - » Colors, sizes, similar reproduction methods, etc.



Universal STEM Challenge Notes & How to Use the Design Analysis Slides

STEM Challenge Cycle (overview video of the STEM Challenge steps)

Planning

- Try giving students experience with different planning styles on different challenges, so they can begin to understand their own preferences. Several approaches are listed below:
  - Students begin to manipulate materials immediately
  - Students sketch ideas prior to building
  - Students discuss ideas with teammates prior to building
  - Have students jot notes for their plan prior to building
  - Students have 3 – 5 minutes of silence to think about what they will do prior to building (follow with another approach, or go straight into building)
  - Walk & talk: Introduce the challenge, then have students go on a short walk to discuss ideas with teammates prior to building
  - Free choice or mix/combine approaches

Post-Design – Design Analysis Slides

- Multiple iterations are always recommended to allow students an opportunity to apply learning, try new ideas, and to be in keeping with the engineering process. While you might not be able to do so with every challenge, try to do it whenever you can. Never conducting a second or third iteration is akin to never asking students to tell you how they *could* improve their writing, but never actually having them revise it; the execution of ideas is crucial in developing skills!
  - For each new iteration, make a new copy of the design analysis slides.
  - The following analysis question can be used in different ways: "Which was your more/most effective design? What do you think it was about the design that made it superior to the other(s)?":
    - **Option 1:** Have students consider the evolution of their design within the current iteration of the challenge. Frequently, students change aspects of the design right up until time is called. Their final version is not necessarily the best version. If they insist they stuck with one idea throughout and have nothing to compare, select option 2 or 3 below.
    - **Option 2:** Students can select what they think was the most effective design in the class, not necessarily their own.
    - **Option 3:** If you will conduct multiple iterations, students can wait to answer this question until after the final iteration, and answer it only once on the final set of handouts (or use options 1 or 2 to answer the question prior to the last handout set).

Next Generation Science Standards (NGSS)

A Note RE: NGSS Science & Engineering Practices

This STEM Challenge has the potential to hit upon all NGSS ETS standards depending on the depth and number of iterations you choose to implement in your classroom. Take a moment to review the Performance Expectations as well as the Disciplinary Core Ideas (DCIs) included here prior to inform your decisions and approach.

K-2 NGSS
Science & Engineering Practices: Performance Expectations

K-2 Science & Engineering Practices

Students who demonstrate understanding can:

- **K-2-ETS1-1.Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.**

- **K-2-ETS1-2.Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.**

- **K-2-ETS1-3.Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.**

K-2 NGSS Disciplinary Core Ideas (DCIs)

- **ETS 1.A: Defining and Delimiting Engineering Problems**
  - A situation that people want to change can be approached as a problem to be solved through engineering. (K-2-ETS1-1).
  - Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1).
  - Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)
- **ETS 1.B: Developing Possible Solutions**
  - Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2).
- **ETS 1.C: Optimizing the Design Solution**
  - Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3).

3-5 NGSS
Science & Engineering Practices: Performance Expectations

3-5 Science & Engineering Practices

Students who demonstrate understanding can:

- **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.**

3-5 NGSS Disciplinary Core Ideas (DCIs)

- **ETS 1.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). Difference 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).
- **ETS 1.B: Developing Possible Solutions**
  - Research on a problem should be carried out before before beginning to design a solution. 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).
- **ETS 1.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).

Teacher-Author note: I philosophically disagree with DCI 3-5-ETS1-2. With an iterative design approach, one often produces more innovative designs by *not* researching first. Design first also motivates students to have a reason to research between iterations. It's nice to have the baseline of design results before and after research as well. This challenge reflects my approach.

Middle School NGSS
Science & Engineering Practices: Performance Expectations

MS Science & Engineering Practices

Students who demonstrate understanding can:

- **MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**

- **MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**

- **MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**

- **MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

Middle School NGSS Disciplinary Core Ideas (DCIs)

- **ETS 1.A: Defining and Delimiting Engineering Problems**
  - The more precisely a design task's criteria and constraints can be defined, the more likely is is that the designed solution will be successful. Specification of constraints includes consideration of specific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1).
- **ETS 1.B: Developing Possible Solutions**
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4).
  - There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3).
  - Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3).
  - Models of all kinds are important for testing solutions. (MS-ETS1-4).
- **ETS 1.C: Optimizing the Design Solution**
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process – that is, some of those characteristics may be incorporated in the new design (MS-ETS1-3).
  - The iterative process of testing the most promising solutions and modifying what is proposed on the basis of test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4).

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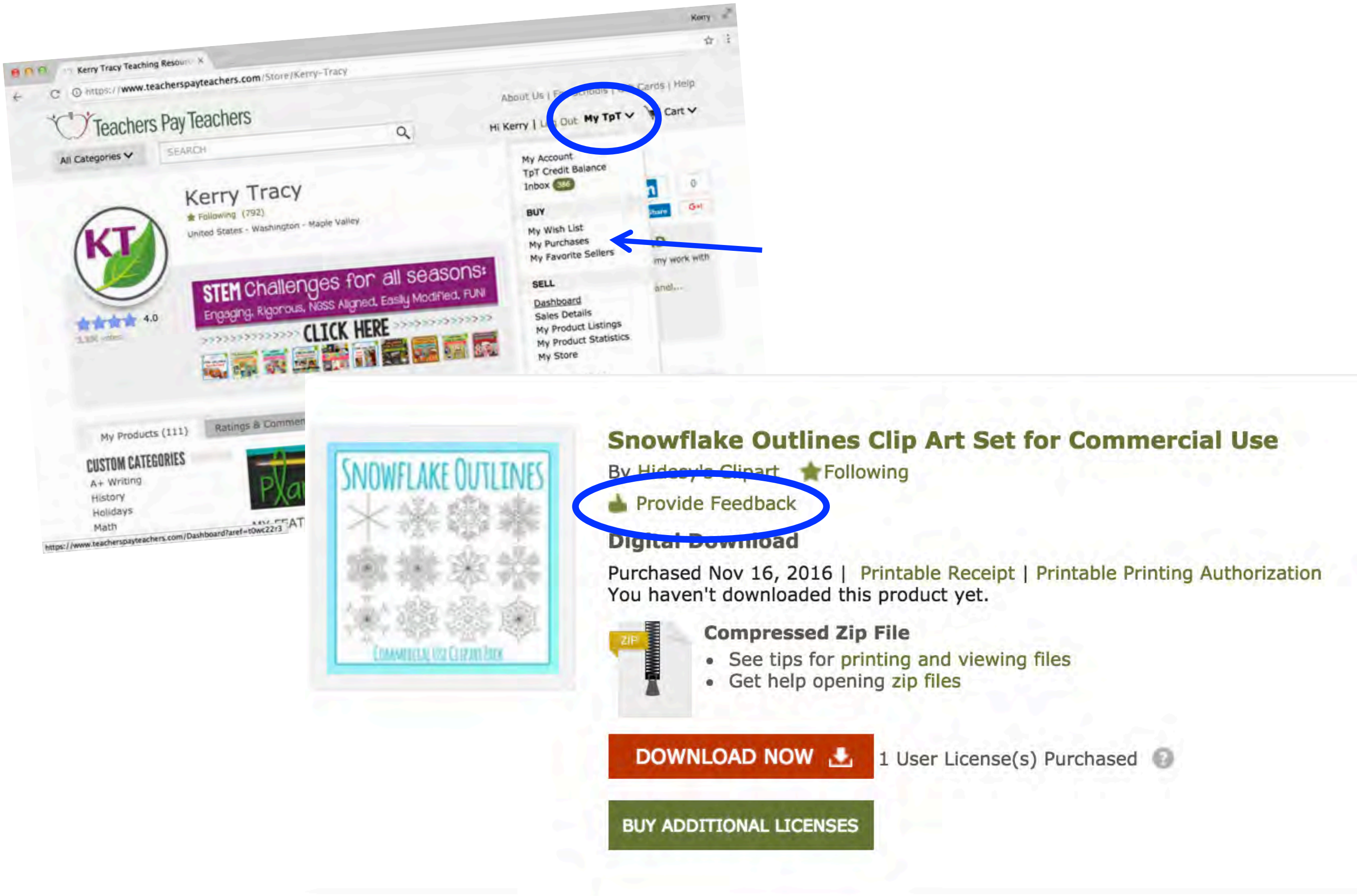

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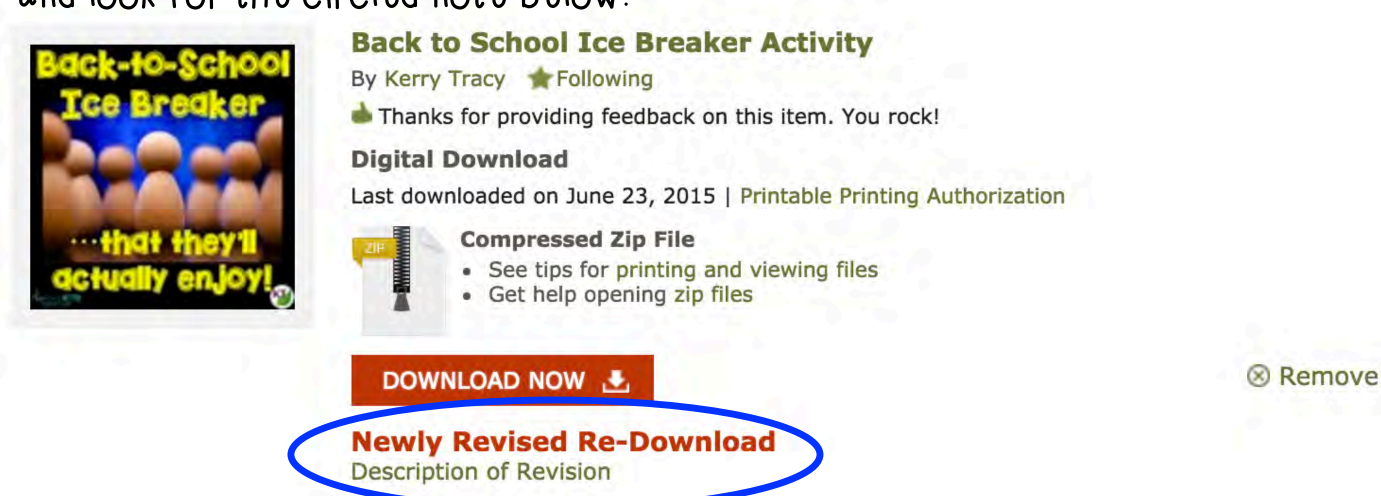

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