SUMMER STEM CHALLENGE

2nd – 8th
NGSS Aligned

Keep it Cool / Make it Melt

DIGITAL/PAPERLESS VERSION

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Thanks & happy teaching!

~ Kerry

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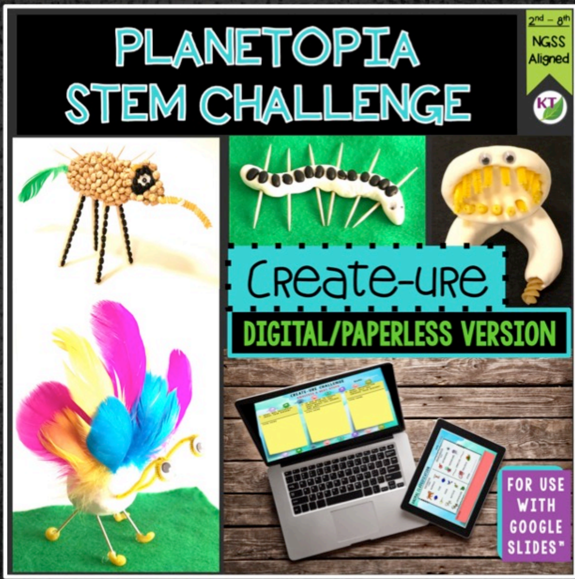

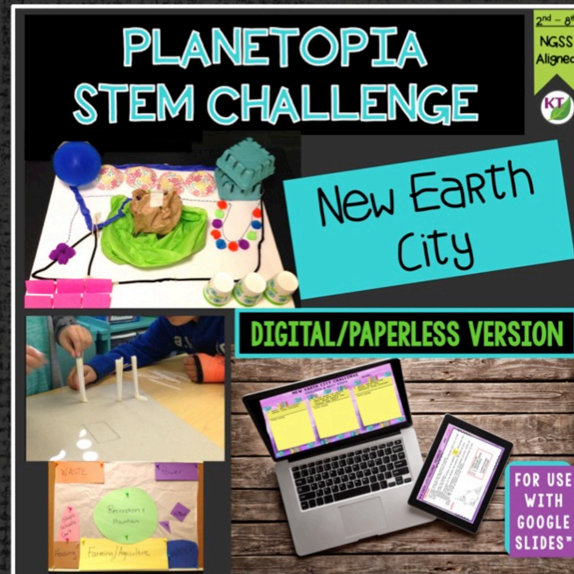

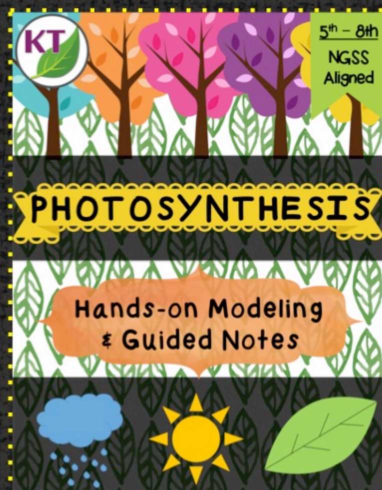

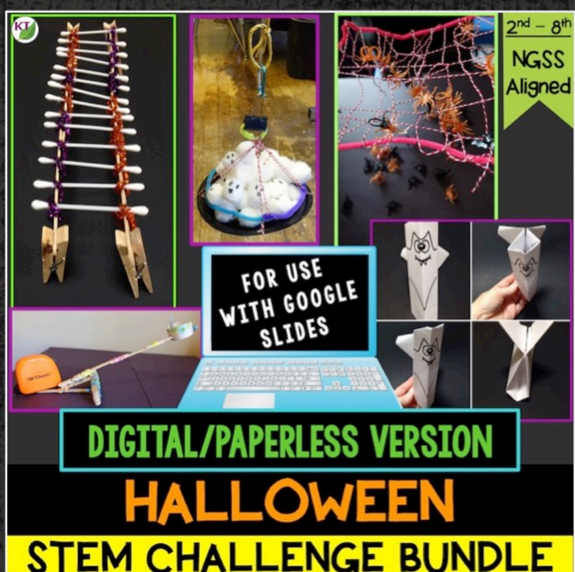

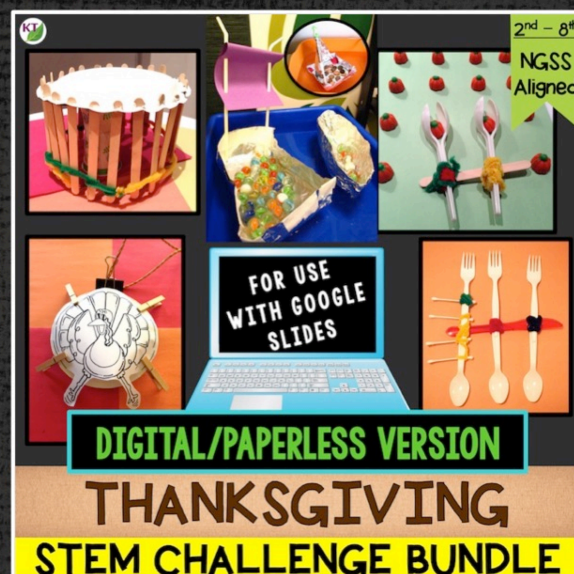

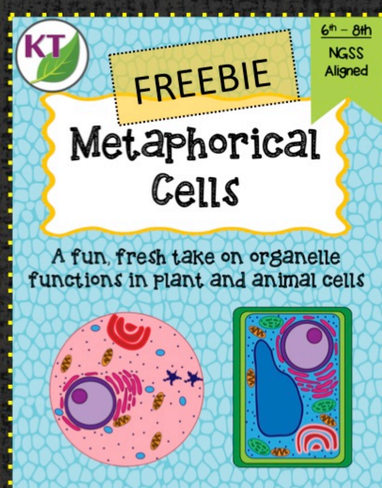

Summer STEM Challenge:

Keep it Cool – Make it Melt

TABLE OF CONTENTS

Click on any entry below to navigate through the document.

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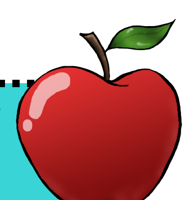


GETTING STARTED

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.

Keep it Cool / Make it Melt 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.

- **For each student or group:**
  - Hershey bars (give each group three rectangles - ¼ of the bar - for testing)
    - Hershey bars are ideal because it is easy to observe changes as the chocolate becomes shiny, the lettering fades, and lines become wavy.
    - Ice cubes can be substituted, but try to ensure they are equal in size.
  - Small cups (1-2)
  - Foil (~ 12 in.^{2})
  - Plastic baggies or plastic wrap (1 – 2)
  - Pipe cleaners (4 – 6)
  - String/yarn (12 – 24 in.)
  - Cardboard scraps
  - Cotton balls (3 – 6)
    - Tissue, paper towels, or toilet paper can be substituted
  - Scissors
  - Tape (12 – 24 In.)
  - **Optional**
    - Thermometers
    - Markers & Construction paper
    - Rubber bands
    - Clothespins
    - Stopwatches
    - Cameras to capture changes over time

Video Walk-Through

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

For more Summer STEM Challenge Videos,
check out this playlist.

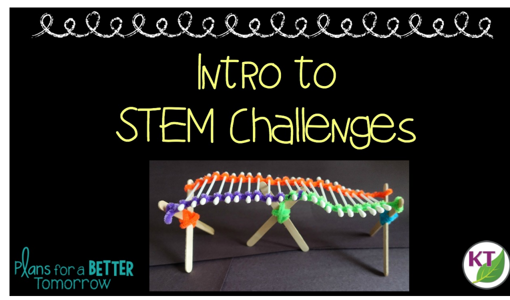
Note to Teachers

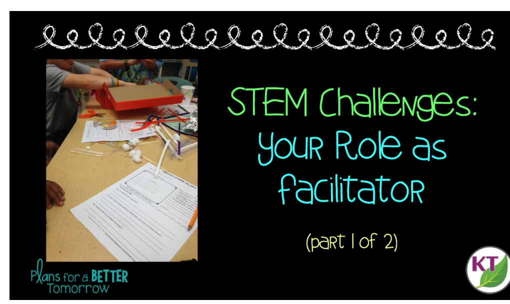
The beauty of STEM Challenges is that they are open-ended and require critical thinking and problem-solving. This is why we don't give students directions to build a specific design. In keeping with the engineering design process, a criteria & constraints list is provided to give students a framework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

- **Premise**
  - In partners or groups, students will design and build two devices: one to slow the melting process (Keep it Cool) and one to speed it up (Make it Melt).
  - Plan to give students approximately 30 – 40 min. to design, 30 – 45 min.* to measure and share results, and 10 – 30 to complete design analysis slides. Additional time will be needed if you are assigning extension activities.
    - *The time required for observing changes varies based on weather. These estimates were taken on an 81°F sunny day.

- **Set up**
  - Watch the challenge walk-through video. If you are new to STEM Challenges, you may also want to view one or more of the how-to videos on the prior page.
  - This challenge will take ~ 90 minutes to complete. Assuming you do not have a 90-minute block to devote, the recommended approach is to have teams build both the Keep it Cool & Make it Melt designs on day one and test the designs against a control in day two, along with completing design analysis slides. You might have time in day two to include some extension options (Teacher Tips, page 3).
    - For the control, simply set one piece of chocolate on a plate, or paper towel straight on the ground. Note: occasionally the heat from the ground will cause the control to perform better than student designs in Make it Melt, which frequently include a buffer between the chocolate and ground. It is recommended not to point this out ahead of time, but help students analyze results and draw this conclusion on their own if this happens to them. They can then use this result to inform their re-designs.
  - Select an area for students to set up both designs and their control in direct sunlight where they won't be disturbed. Also, be prepared for wind. You may need to bring extra tape or weights to secure designs during testing.
  - Decide on observation intervals. Five or ten minutes usually works well, though you want to err toward shorter intervals when the weather is very warm and sunny. You will also need to decide if you will announce every interval to make observations or provide students with stopwatches to track the intervals on their own.
  - There will be some down time in between recording observations. Below, find recommendations for making good use of this time:
    - There are two sets of design analysis slides: one set for Keep it Cool and a second for Make it Melt. Have students begin the portions of the slides they are able to (sketch/photograph designs, construction/materials notes, etc.).
    - If you have purchased the States of Matter Mini-Unit, this is a great time to play the included game because it can be played in very short sets.
    - If you have purchased Drippin' Dash, the observation lulls are a perfect time to conduct a first or second iteration of design or to run the relay race.

- **Set up (continued)**
  - Optional: If you have a reliable set of thermometers, have students take the temperature next to each piece of chocolate as part of their interval observations.
  - Optional: You might want to allow students to use cameras to capture changes at different intervals.

5 min.

45 min.

25 min.

Note: If you elect to have students take pictures, ask them to include the control at all intervals.

- **Criteria/Constraints**
  - An editable version of the Criteria & Constraints List slide is provided.
  - Increase or decrease the time as needed.
  - Ideas to increase the difficulty of the challenge:
    - Add a constraint that if a material is used in one design, it must be utilized in the other (i.e. if foil is used in Make it Melt, it must also be used in Keep it Cool).
    - Add criterion that the Keep it Cool design must be open-air on at least one side.
    - Add a criterion that the two devices be created within one, unified design (i.e., one compartment keeps it cool, the other melts, and these compartments are connected on one side.)

- **Measuring Results**
  - Students should verify they have met all listed criteria/constraints.
  - Students record whether their designs out-performed the control as well as the time elapsed at the first observable change. For Make it Melt, less time elapsed is the goal. For Keep it Cool, more time elapsed is the goal.

- **Post-Design Options**
  - Design analysis (slides included)
  - Discussion questions (slides included)
  - Re-design and re-test (consider incorporating new, student-suggested materials).
  - Extension activities
    - Introduce or review states of matter, and what causes matter to change state (adding or removing heat energy).
      - Solid, Liquid, Gas Song ~3 min. (2nd – 3rd)
      - Solids, Liquids, Gases, & Oobleck ~5 min. (2nd – 3rd)
      - What's Matter? ~4 min. (3rd – 5th)
      - Matter & Particles ~4 min. (3rd – 5th)
      - Oobleck & Non-Newtonian Fluids ~4 min. (4th – 6th)
      - Solid, Liquid, Gas, and Plasma ~4 min. (6th – 8th)
      - The Invisible Motion of Still Objects ~5 min. (6th – 8th)
      - Plasma: The Most Common Phase of Matter ~4 min. (6th – 8th)
      - Solids ~9 min. (8th+)
      - Liquids ~11 min. (8th+)
      - The Ideal Gas Law ~9 min. (8th+)
      - Van Der Waals Equation Gases ~12 min. (8th+)
    - Related online articles for close reads and research.
      - » What's the Matter ?
        - Under the video, expand the background essay to print and read. There is also an activity described for K-2 students.
      - » States of Matter 1
      - » States of Matter 2
      - » Five States of Matter
        - Properties of Solids
        - Properties of Liquids
        - Properties of Gases
        - Properties of Plasmas
        - Properties of Bose-Einstein Condensates

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)
    - Identify physical properties of the design challenge materials. Have students conduct research on the impact of conductors/insulators as well as color on heat absorption. Students should then use their research to re-design and justify their changes.
      - Save the Snowman ~4 min. (2nd – 3rd)
      - Heat & Light Time Lapse ~2 min. (2nd – 3rd)
      - Wood, Water, and Properties ~4 min. (4th – 6th)
      - Student Experiment on Color & Heat Absorption ~3 min. (5th – 8th)
    - Introduce or review physical changes in matter.
      - Does Hot Water Freeze Faster Than Cold Water? ~3 min. (5th – 8th)
      - Hunt for Highest Melting Point ~5 min. (6th – 8th)
      - Physical Change ~5 min. (4th – 6th)
      - Physical vs. Chemical Change ~8 min. (6th – 8th)
    - Research how the greenhouse effect helps keep Earth warm and how greenhouse gases impact global climate change.
    - Have students use the knowledge gained in the first iteration of the challenge and/or research to create a new design and participate in a "Melt-off" contest. The first team to completely melt a piece of chocolate wins.
    - Use personification to vividly describe the Make-it-Melt challenge from start to finish from the point of view of the melting chocolate.
      - After the longer-form descriptions, have students create haiku or other poetry from the chocolate's point of view. If time allows, students should read aloud their poems in ultra-dramatic form.
    - In teams, students generate two lists: the first should be synonyms/metaphors/similes for "cold" and the second, for "hot". This can be just for fun, a contest, or post the lists and have students use them to revise their melting chocolate descriptive writing and poems.
    - Frosty the Snowman is desperate to take a summer vacation in San Diego. Write a narrative about his adventure and/or a list of tips & rules to beat the heat.
    - Students create a process flow map for how to make their Keep it Cool and/or Make it Melt designs. They trade process maps and try to build the other's design (slide included).
    - Students create and solve math problems related to designs (slides included).

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

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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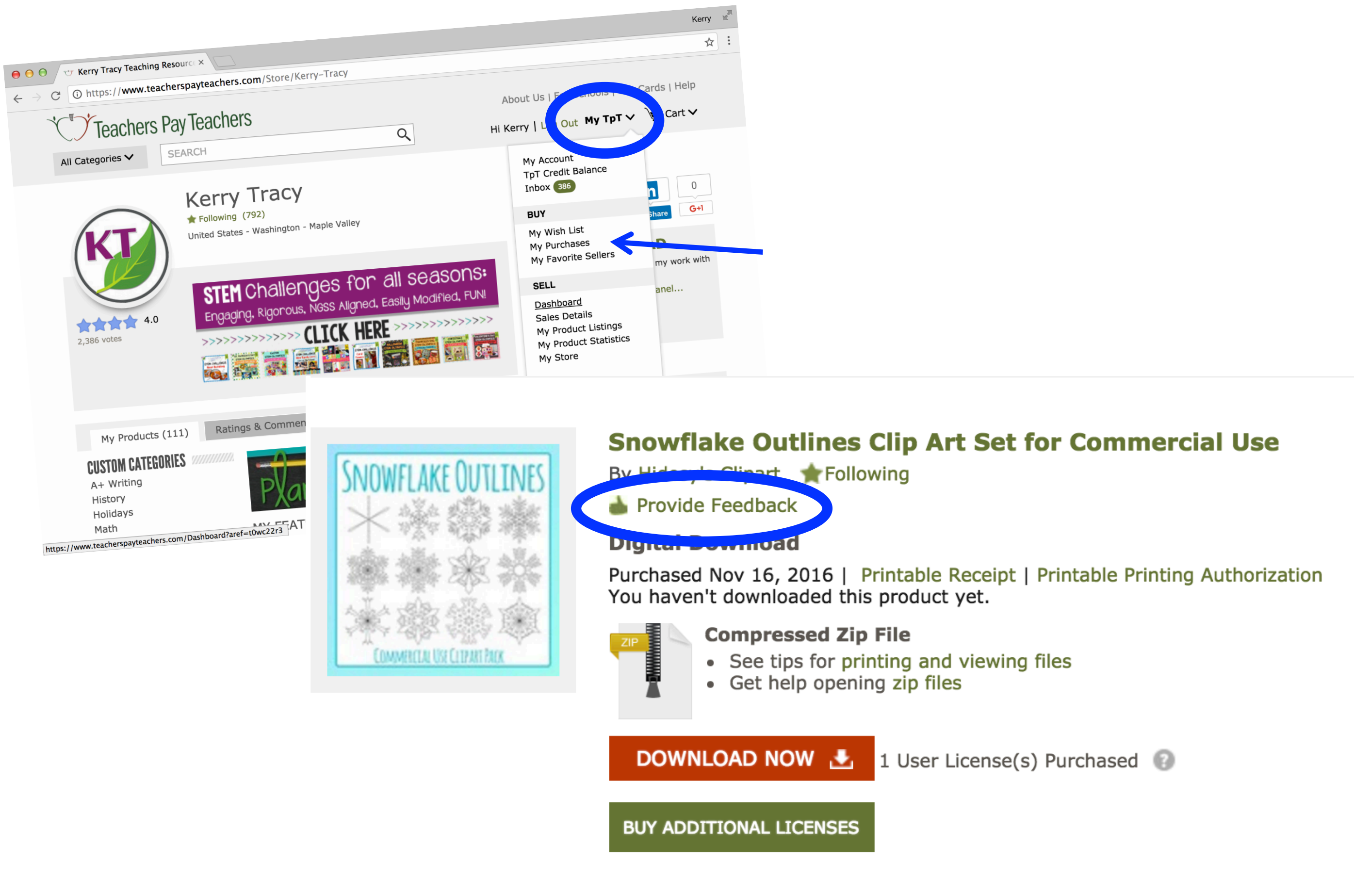

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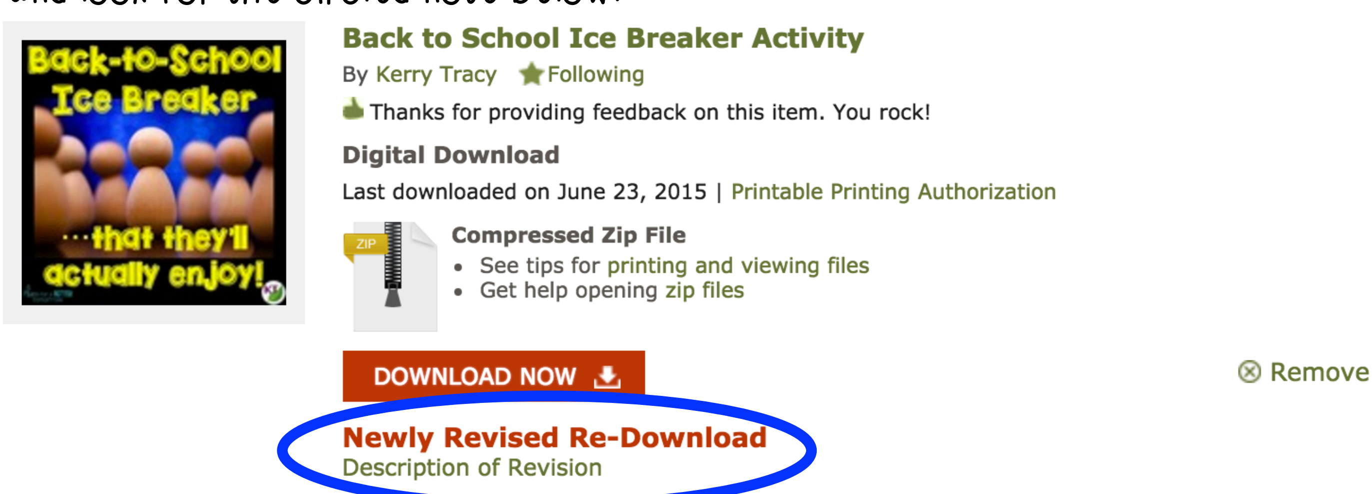

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