



STEM

Challenge


Tennis Ball
Tower



- ~ Easy Prep
- ~ Engaging Design and Construction
- ~ Lab Sheet or Interactive Notebook Graphic Organizer

Teachers Are Terrific!

Teacher Background



This Tennis Ball Tower Challenge is more challenging than it appears to be! There are not very many materials and the quantity of each is also a problem to solve. How will students use the materials to support the ball and how will they use ALL of the materials?

This challenge is to build a tower that will hold a tennis ball aloft. The ball must be off the table top a specific height and all the supplies must be used. The supplies include items that are not easily attached together and a tennis ball is heavier than you expect. Students will test and improve constantly to try to get their tower to stand. The towers are precarious! In addition, the requirement of using all the supplies will present new problems to solve. How clever can your students be in decorating the tower with supplies not needed in the structure?

An alternative version of this tower is also included. The rules of the alternative have students using all of the materials but they must be used in a functional way. This adds a new dilemma for the students!

Students will follow the steps of the Engineering Design Process for this challenge. Procedures for the teacher are marked with the steps of the process as well as the student lab sheet. The teacher directions include hints in **shaded boxes** and photos of the project or student lab sheets. This resource includes a lab sheet and an interactive notebook folding graphic organizer in case you prefer that method of data keeping.

This package will give you a list of materials, preparation ideas, and then step-by-step procedures to make this a successful event. Change the procedures and events in any way you need to in order to suit your age level and student population. These towers are ranked high on our list of favorite challenges! Enjoy yours!

This challenge is provided in two files. **File 1** includes the teacher directions, tips, photos, lab sheets, scoring rubric, and more! **File 2** contains all forms in an editable format.

Materials and Prep

MATERIALS

You will need:

- Tennis Balls
- Craft sticks
- Straws
- String
- Masking Tape
- Coffee stir sticks
- Containers for group supplies- The container can be anything- a brown paper sack, plastic shoebox, large zip lock bag, or just a tray. This container is optional.

NOTE: You can opt to use only straws instead of the coffee stir sticks (which are tiny straws).

Please Note: Teacher Procedures are provided with Hints throughout this package. Hints are my experiences with this kid-tested challenge. Your experiences will differ.

PREPARATION

BEFORE CLASS:

- Prepare supplies. The easiest way to present these is to gather everything in a plastic shoe box or a brown paper bag.

Each group needs the following:

- 1 tennis ball
- 4 coffee stir sticks
- 8 craft sticks
- 3 feet of tape
- 4 straws
- 2 feet of string

Hint for Tape: Pull a three foot length from the roll of masking tape and tape it to the edge of work tables.

- Decide which version of this challenge you will use. Pages 4- 11 are the easier version. An alternative and more challenging version starts on page 20.
- Decide how you will introduce this challenge or use the plan we followed.
- Copy the lab sheet provided or create your own record keeping for this challenge. A lab sheet is provided and a folding graphic organizer. Each of these is also in the editable file.
- Decide how you will display the constraints for this challenge. I have provided two different ways. One is a full sheet that you can display with your projector or copy for each group. The second is a set of small cards that you can copy and laminate. I use these and place them in the student supply boxes. (A small card set without background color is included to help with printing costs! And these are also in the editable file.) The alternative version has its own set of criteria cards.
- Decide how you will divide your students into groups. I usually have groups of 3-4 students. Allow 1 class period to complete this challenge. We completed this challenge in a one hour class time.

Teacher Directions

ASK

Discuss the problem to be solved in this challenge. A stated problem is already listed on the top of the lab sheet.

How can you use the given supplies to design and build a tower that will support a tennis ball?

The ASK step is the beginning of the Engineering Design Process. We always start with a question or problem to set a purpose for the task.

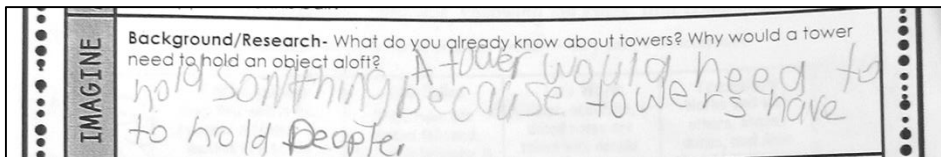
BACKGROUND

Begin with a discussion of towers. What do towers resemble? How are towers supported? What is the purpose of a tower? Have students ever seen a tower that held an object aloft (like a water tower)?

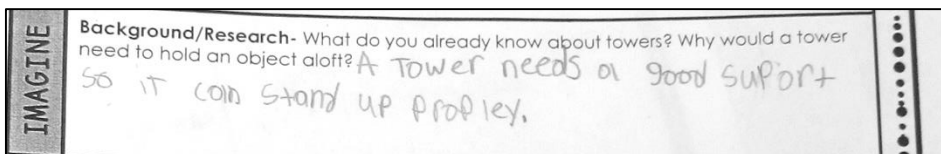
BACKGROUND: I have tried an introduction that involved a lot of preliminary talk and I have tried just giving students the supply boxes and the rules. Both set-ups work great! It really depends on how much time you have to complete this challenge. I have also left this challenge with substitutes that briefly discussed towers with the students, but let them get to work fairly quickly.

Following this discussion students will complete some writing about towers on the lab sheets.

NOTE: Students should be divided into groups by this point.



"A tower would need to hold something because towers have to hold people."



"A tower needs a good support so it can stand up properly."

WRITING: Writing as a scientist/engineer is important. I tell my students that writing is tracking their thinking and often writing something down will help "cement" the learning. It may help them remember later that a tower must have a strong base if they have talked about it and written about it.

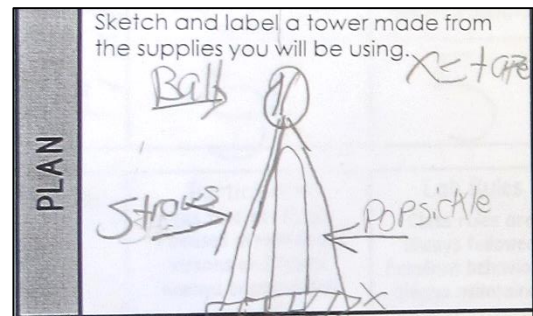
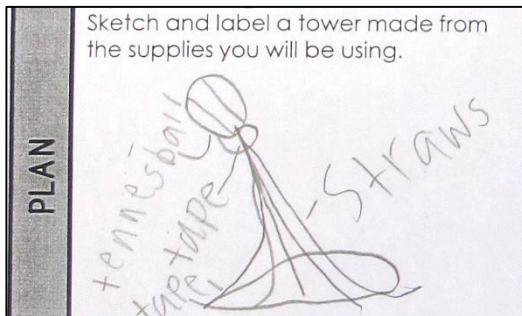
ANSWERS: Samples from actual student lab sheets are included instead of an answer key at the end. Your answers are going to differ, of course!

Teacher Directions

IMAGINE

Discuss the task with students and share the constraints. If you are using the small constraints cards have each group look at this as you go over the rules to this task. Students will also need knowledge of the materials in order to begin planning. Students may have questions and the ones my students asked are listed below. After a questioning time students need to draw and label their own personal idea for the tower.

SKETCHING: You are likely to find that students want to examine the supplies and even lay them out to view them while sketching and planning. I allow this, but I also caution students about waiting until **after** every group member has had a chance to share his/her drawing and talk about the ideas *before* beginning the structure. The final idea decided upon by the group is one they can agree on and may have parts of everyone's personal idea. (More about planning on the next page!)



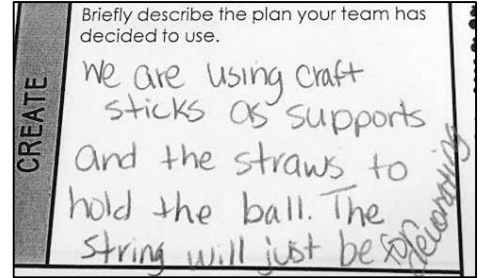
QUESTIONS STUDENTS HAD: My students are really good at trying to “skirt” the rules of tasks! Here's a list of things they asked me about this challenge:

1. Can we tape the tower to the table? YES! The rules do not restrict this. (You may certainly change this rule to make this task even more difficult.)
2. Can we poke supplies into the tennis ball? NO! Absolutely not! It is hard to pierce a tennis ball and anything they use for this is a safety concern for the students. I allowed the tennis ball to be taped or tied with the string, but not punctured.
3. Does it have to resemble a tower? That is tricky! It shouldn't be just a pile of sticks and straws, but have a definite shape. Will it look like any tower we have ever seen? It might! It might also end up looking very artistic and resemble a sculpture.
4. Do we have to use every supply in a working way? NO! The supplies do not have to be functional, but all must be used. However, being wasteful is not part of this task. Use decorative touches with intent! (Example: cutting straws into tiny pieces to use as grass is decorative, but wasteful. Your option, of course!)
5. Is it the top of the ball that has to be 10cm off the table? No, it's the bottom of the ball and it can be off the table more than 10 cm.
6. Are we trying to make the tallest possible tower? No, your goal is to have the tennis ball held aloft. The tower itself does not have a height requirement.

Teacher Directions

PLAN

After completing the sketches the teams need to share ideas! This is a crucial step in the design process when working with groups. After each team member shares his or her idea the team needs to decide how to begin. They may choose one idea or combine them. After the decision is made students will sketch and write about the idea chosen.



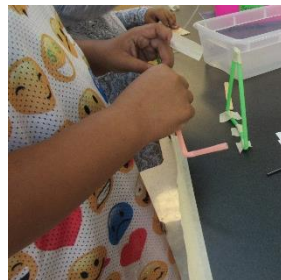
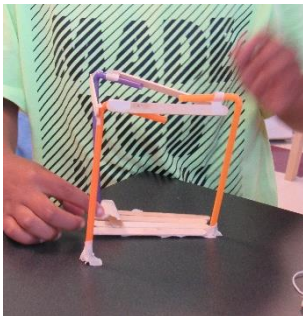
"We are using craft sticks as supports and the straws to hold the ball. The string will be for decorating."

PLANNING: I have learned after many challenges that this part is important. Although some students will want to get started without a real plan I insist that each team member has a sketched and/or written plan and then each team **must** talk. This helps every team member feel a part of the group and each has a voice in the design. We also spend a lot of time talking about not always having ideas used. A good team member supports the team decision and works on the idea- even if they think their own idea is better. Do what is good for the team! It is also very likely that the first idea will need modification, in which case another idea is tried! This is a learning process!

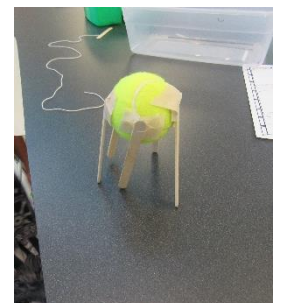
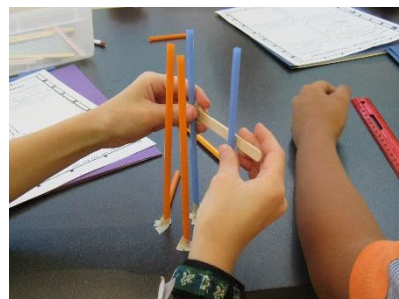
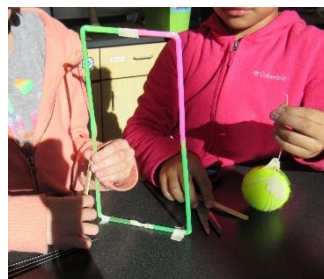
CREATE

When teams are ready let them begin. You may still have questions to answer as they begin to use supplies- especially if their plans are not working.

Photos of Beginning Towers



It is quite normal for kids to abandon the original plan when they begin to use the supplies. They will discover things don't fit together as expected and they quickly try something else.

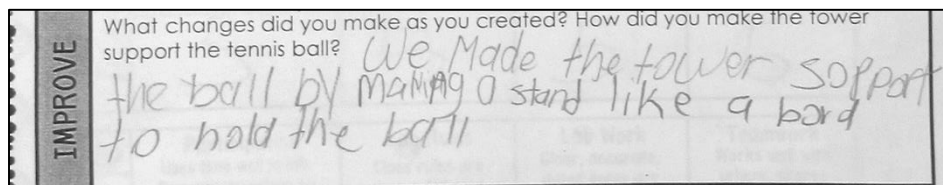


Teacher Directions

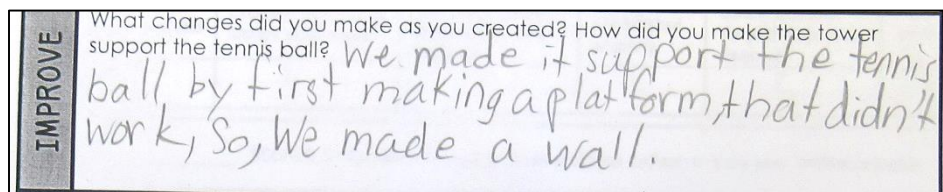
IMPROVE

As groups are working in this stage of the design process they will encounter problems to solve. It is an intriguing aspect of STEM Challenges and one we use for the benefit of every group. After 10-15 minutes stop for a Brain Break (or whatever you wish to call this). Have each group talk within their team about problems they are having and how these are being solved. Then have every team report one problem and solution to the whole class. The lab sheet has a place to record this information.

PROBLEMS/SOLUTIONS: I find this little Brain Break to be an essential part of my STEM Classes. You may opt not to do this. The benefit I see is how it helps everyone. When a group begins to share how something will not fit together the way they wanted and then tells us how they fixed the problem, another group can use this information! Often, I will have a group telling about a problem and have another offer to come and show them what they might try! It is fantastic collaboration!

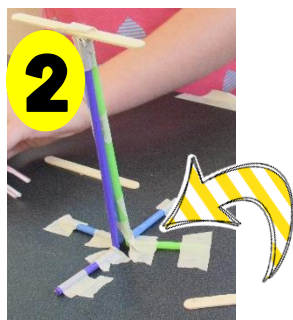
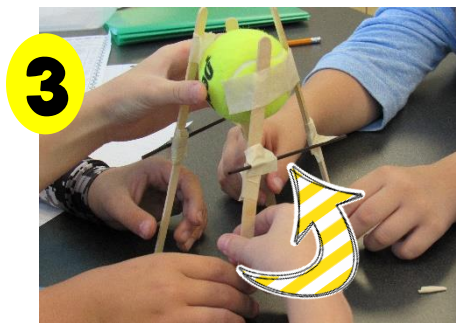
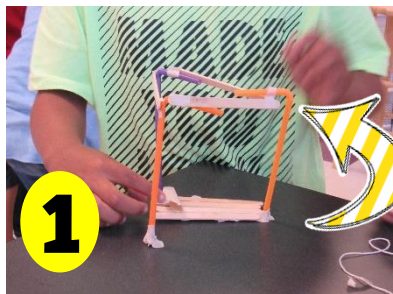


"We made the tower support the ball by making a stand like a board to hold the ball."



"We made it support the tennis ball by first making a platform. That didn't work, so we made a wall."

PROBLEMS/SOLUTIONS



Photos 1 and 2 are showing clever uses of the bendy part of the straw. Photo 3 is a team making cross bars to help with support. Photo 4 is pointing to the coffee stir sticks that are just propped under a part of the tower that was toppling.



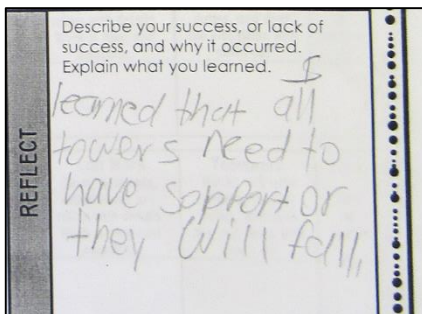
Teacher Directions

TEST

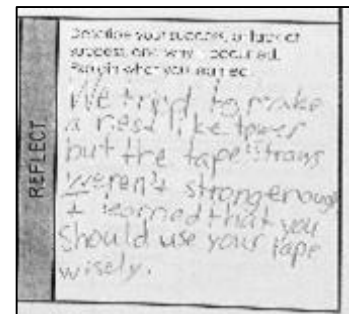
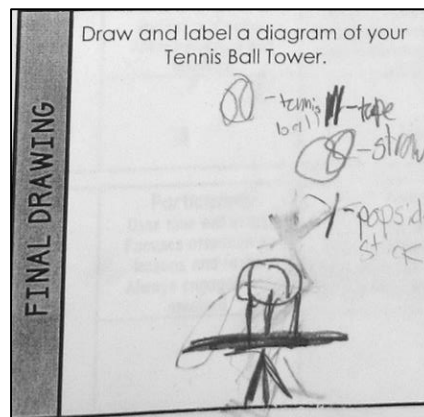
As a group finishes you will need to check the structure to see if it follows the constraints. This will include measuring the height of the tennis ball and seeing if all supplies were used.

TESTING: I did find groups that had great structures, but the tennis ball was not off the table enough. Some of these groups were able to alter their structure enough to still have a successful design. I did try to diligently check for the height requirement as students worked! Students also had rulers to check the height themselves. It was also really fun to see how the supplies were used creatively!

After the tower is completed and checked, students need to sketch and label a final drawing. They also have space on the lab sheet for writing about their success and what they learned.



"I learned that all towers need to have support or they will fall."



"We tried to make a nest like tower, but the tape and straws weren't strong enough. I learned that you should use your tape wisely."

PRESENT

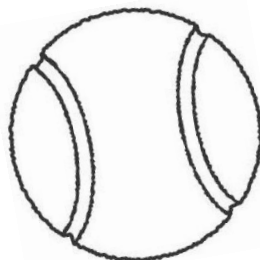
When your time allotment is up, have each group share their tower and talk about the building and improving that took place. This is an important discussion as all groups will have something to say! Kids love to share, even if the tower was unsuccessful.

SHARING: The talk at the end of a STEM challenge is one of my favorite parts. Kids want to let everyone know about their frustrations and successes. They especially love to show clever ways they solved problems. I find that groups that are unsuccessful are very willing to talk about why. We often use this time to make suggestions about team dynamics and what worked in job sharing. It's a great way to end class!

Clean up is easy- Recycle parts of towers that were not cut or bent. Let the standing towers remain on display for a few days!

Constraints of the Tennis Ball Tower Challenge

1. You may only use the given supplies.
You may also use scissors and rulers.
2. You must use ALL of the supplies in
some way. They do not have to be
functional.
3. The tower can be any height.
4. The tennis ball must be held aloft and
the bottom of the ball must be at least
10cm from the table.
5. You may not pierce the tennis ball.
6. The tower can be attached to the
tabletop.
7. All data must be recorded!



Design a tennis Ball tower

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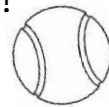
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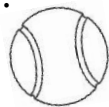
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TENNIS BALL TOWERS

NAME

ASK

ASK / PROBLEM: How can you use the given supplies to design and build a tower that will support a tennis ball?

IMAGINE

Background/Research- What do you already know about towers? Why would a tower need to hold an object aloft?

PLAN

Sketch and label a tower made from the supplies you will be using.

CREATE

Briefly describe the plan your team has decided to use.

IMPROVE

What changes did you make as you created? How did you make the tower support the tennis ball?

FINAL DRAWING

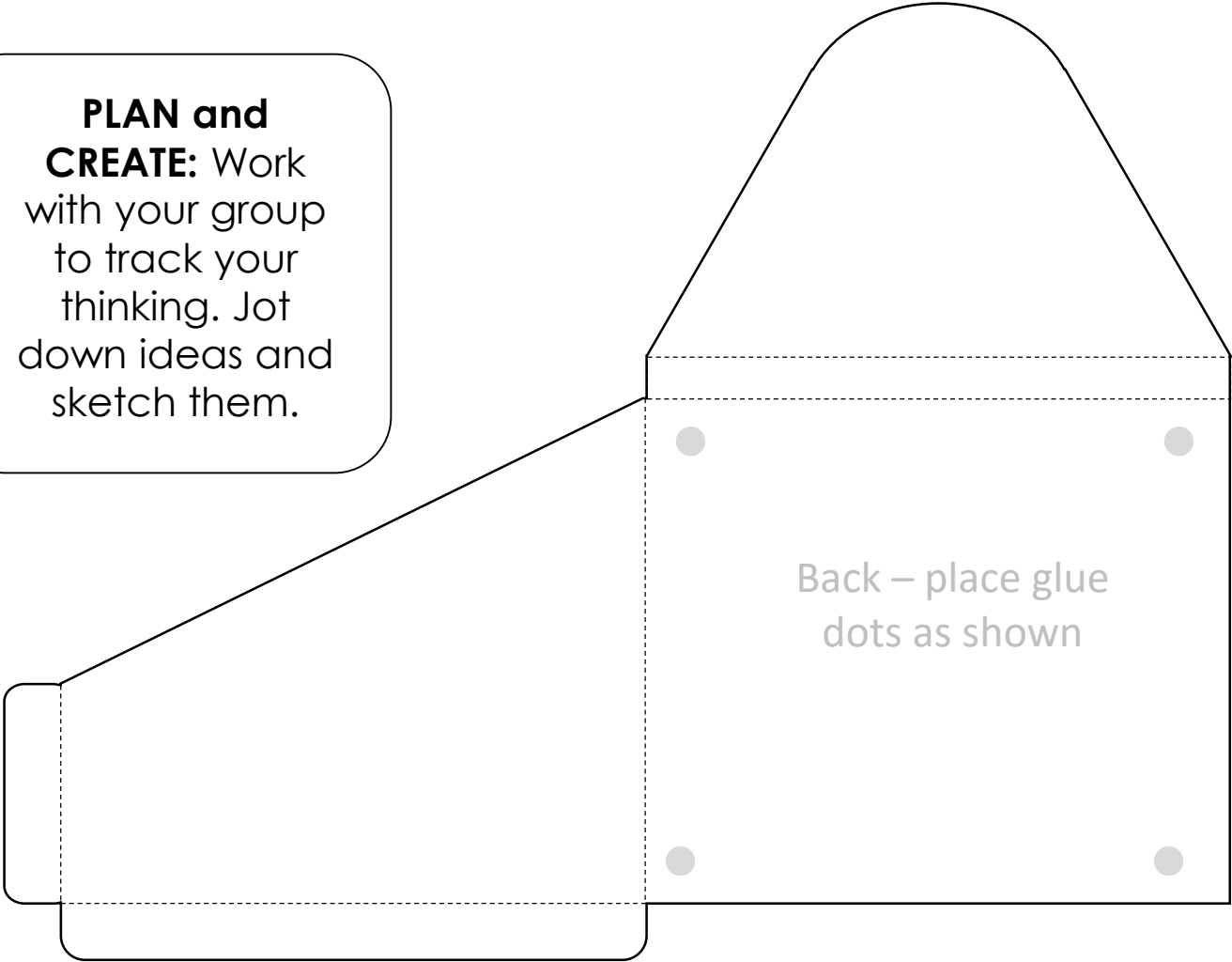
Draw and label a diagram of your Tennis Ball Tower.

REFLECT

Describe your success, or lack of success, and why it occurred. Explain what you learned.

TENNIS BALL TOWERS

PLAN and CREATE: Work with your group to track your thinking. Jot down ideas and sketch them.



IMPROVE: What changes did you make as you created? How did you make the tower support the tennis ball?

CONCLUSION: Draw and label a diagram of final tower.

REFLECTION: Describe your success and what you learned.

Photos



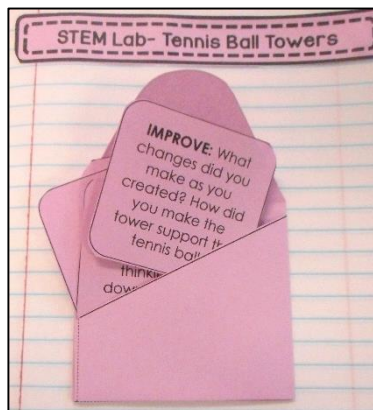
Fold flaps to the inside of the pocket after cutting out.



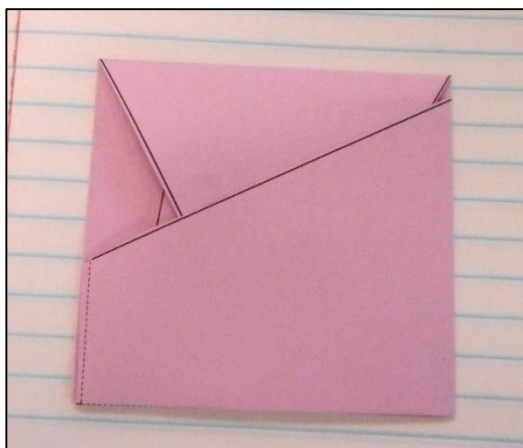
Place glue dots on the back as shown.



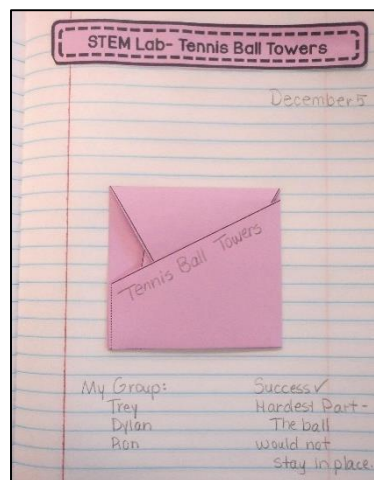
Place into INB. Then add glue dots to the flaps as shown. Fold the flap over onto the back of the envelope to create the pocket.



Each answer card will then slide into the pocket. Students use the back of the answer card for their work.

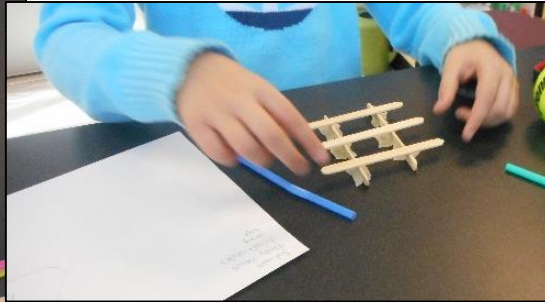
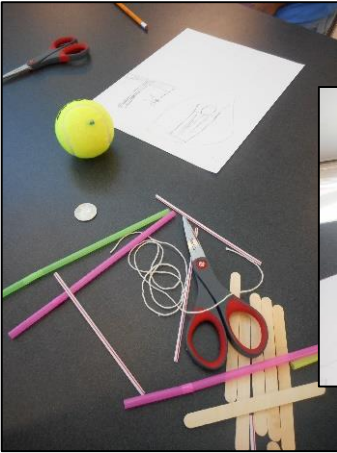


The top flap will fold and tuck into the pocket to close it!

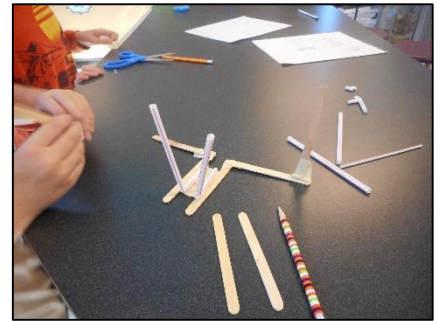
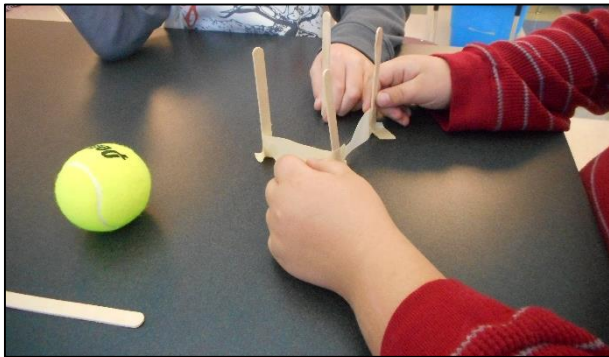


This organizer leaves space for more writing on the page.

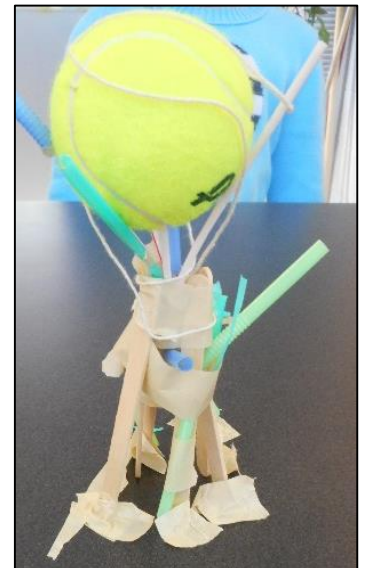
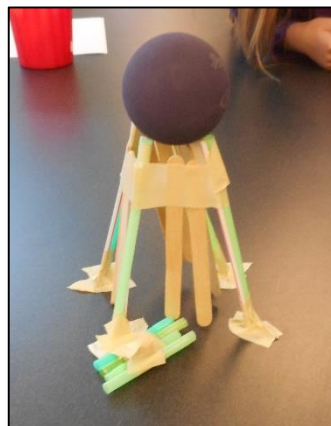
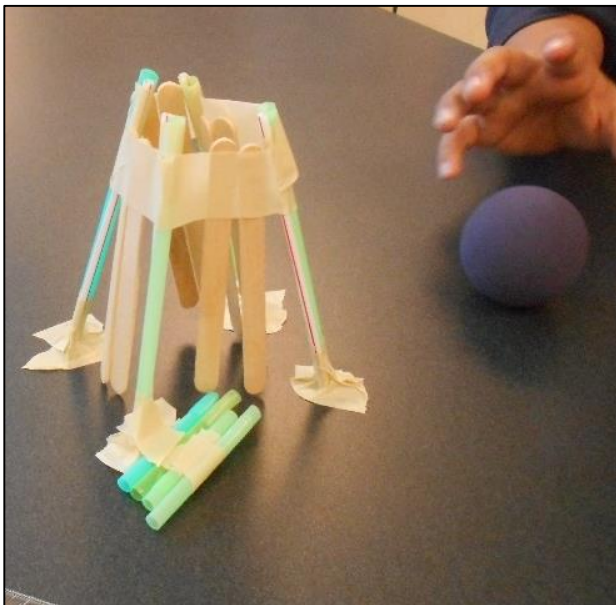
Photos



This challenge was more difficult than students expected! Joining craft sticks and straws with only tape proved to be challenging. Some tried a platform, but could not elevate the ball enough.



The tepee shape was the one I saw the most. This one looks finished, but the group still had pieces left that were not used. (They were elevating a racquet ball since I didn't have enough tennis balls.)

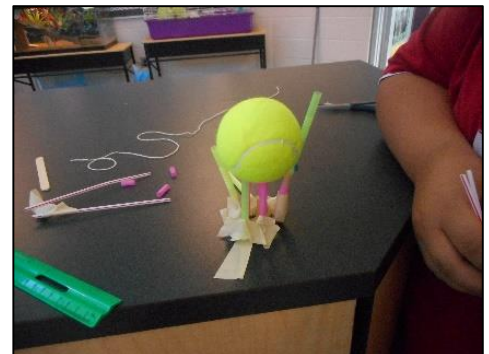
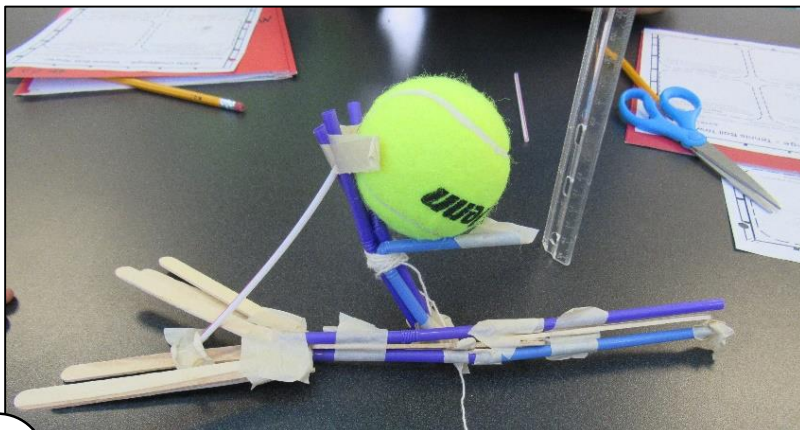
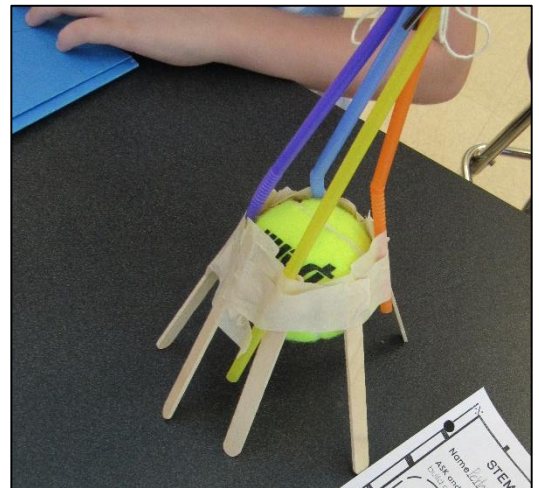
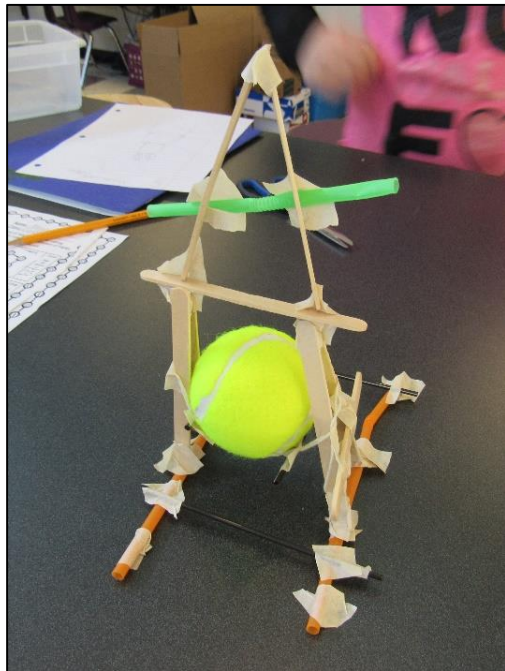
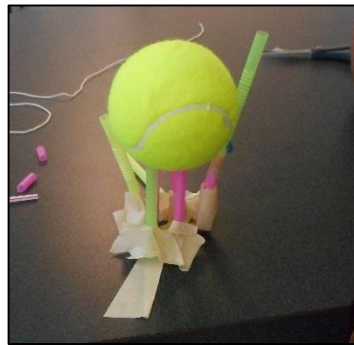
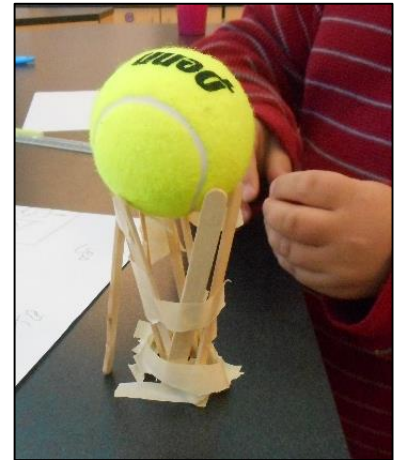


Photos

Great ideas- but not tall enough!

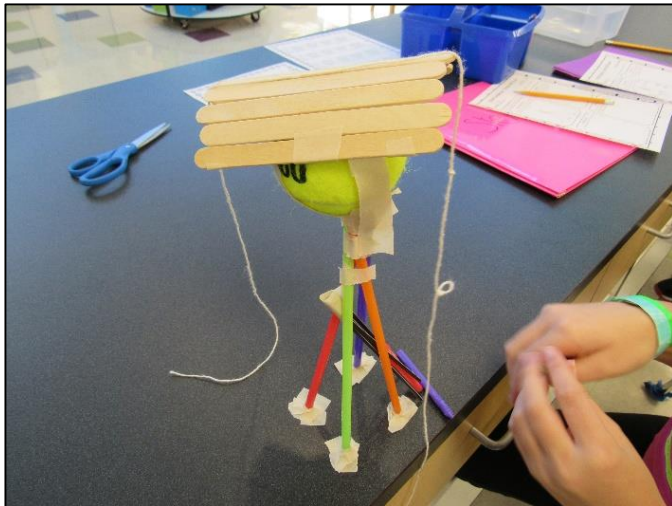
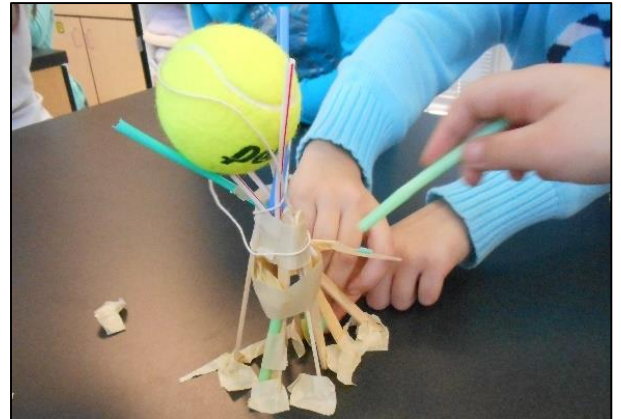
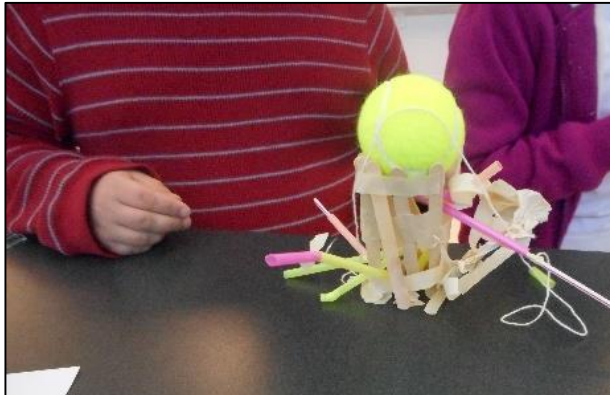
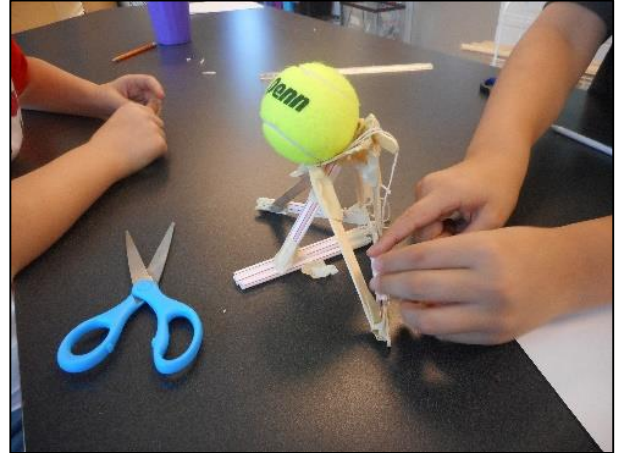
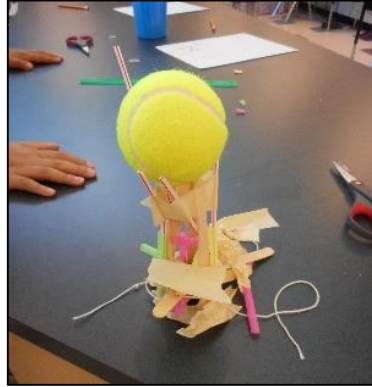
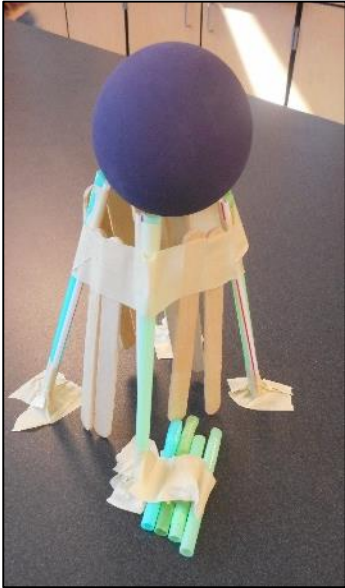


The height requirement was an issue with some groups because they were measuring to the top of the tennis ball instead of the bottom.

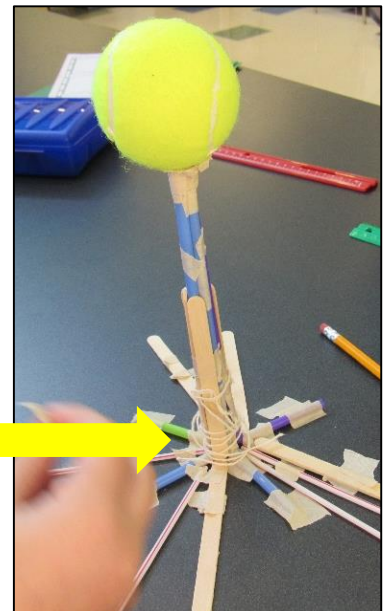


Photos

Requiring the tower to use all the supplies was interesting. Kids came up with some very clever ways to use the leftovers as décor. The tower to the left has the string wrapped up in a ball of tape. The finished towers were a little messy, but the goal was to elevate the tennis ball- and they did!

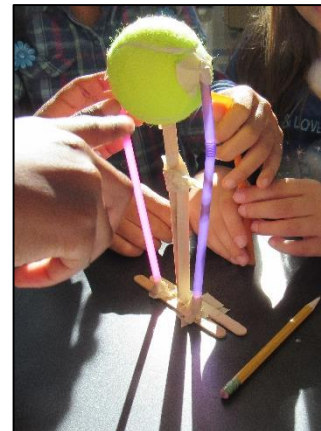
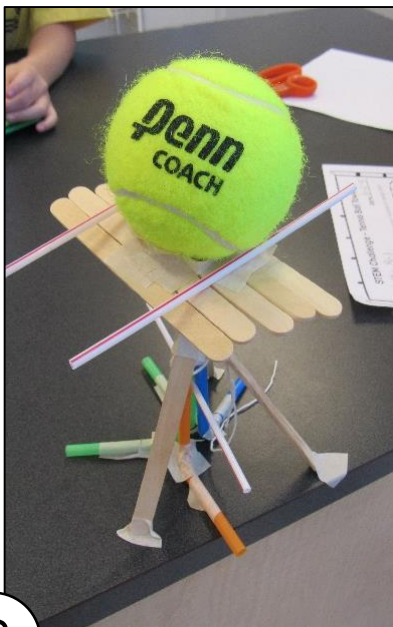
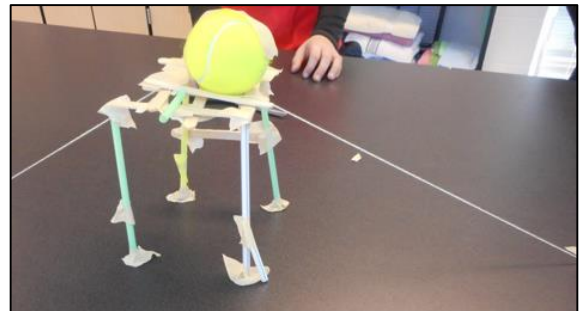
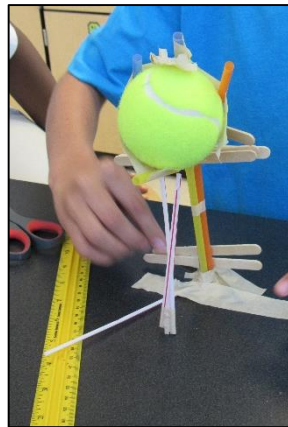
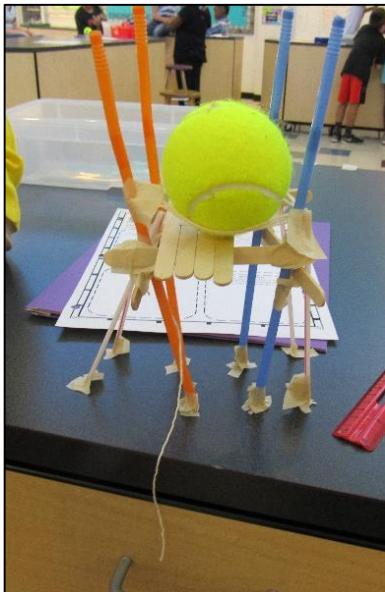
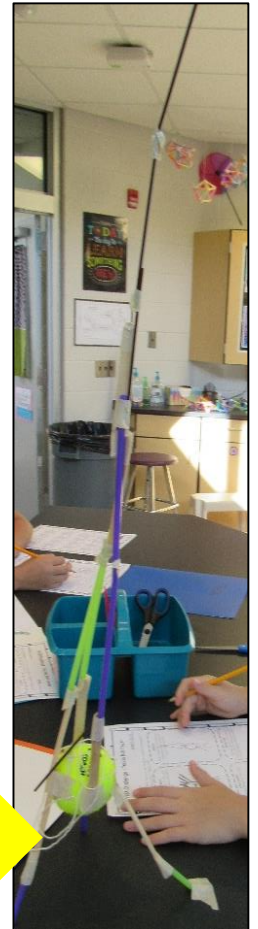
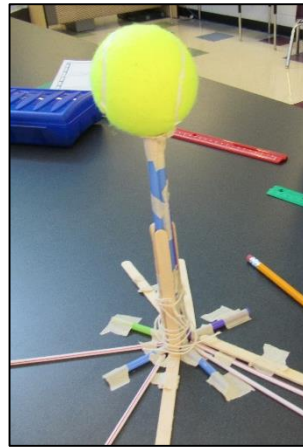
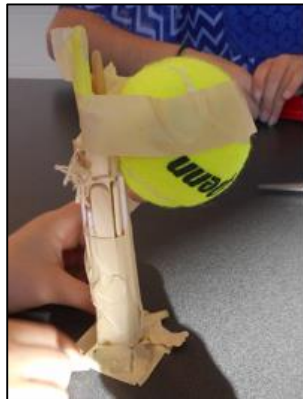
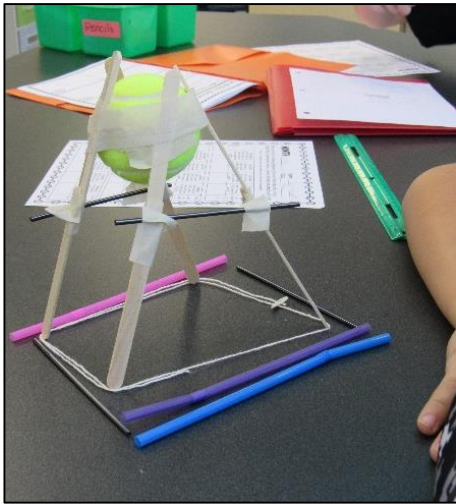


String wrapped around the structure!



The team in the picture above told me that the wooden platform did not work as expected and it turned out they didn't need it. So, they just draped it on top!

Photos All Finished!



This one followed all the rules and somehow remained standing despite being about 80cm tall!

Tennis Ball Tower Scoring

For each statement list a score for your effort.

1= Unsatisfactory 2= Needs to Improve 3= Good Effort 4= Outstanding Effort

Personal Description	Score
I sketched a plan for the tower and shared it with my team. I listened while other team members shared.	
I helped as we started building the tower. My job was _____.	
I helped with ideas for improving the tower and for using all of the materials in some way.	
I completed my lab sheet with thorough and detailed answers.	

Team Description	Score
We talked through all of the team member's ideas. We listened to everyone before making decisions.	
We started building after making sure that everyone had a job in the group. We worked diligently.	
We improved the tower as we ran into problems. We found creative ways to use all of the materials.	
Our Tennis Ball Tower was very successful. It was the right height and held the ball aloft well. We shared with the whole class.	

COMMENTS:

ALTERNATIVE TOWER

The original Tennis Ball Tower can be quite challenging. The decisions about using the small amount of materials are critical to having a standing tower at the end of the creation time. I have discovered that my older students, especially late in the school year, need this challenge to be even more challenging! So, this version has a rule change that makes them really think!

All of the materials must still be used, but all of them must be a functional part of the tower. There can be no straws just laying at the bottom or draping the string around the tennis ball.

This proved to be an additional rule that made my fifth graders think differently about solving this challenge.

I have included a set of criteria cards that reflects that rule change. The lab sheet and rubric for the original version work for this version, too.

PREPARATION

BEFORE CLASS:

- Prepare supplies. The easiest way to present these is to gather everything in a plastic shoe box or a brown paper bag.

Each group needs the following:

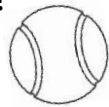
- 1 tennis ball
- 8 craft sticks
- 4 straws
- 4 coffee stir sticks
- 3 feet of tape
- 2 feet of string

- You will use the same set of steps on pages 4-8. Just be sure to emphasize that the materials must be used in a functional way. As students are working you will need to check on their structures in order to advise them about materials that don't seem to be part of the structure. The photo pages have some examples.
- Decide how you will introduce this challenge or use the plan we followed.
- Copy the lab sheet provided or create your own record keeping for this challenge.
- Copy the criteria cards for this version or post these with your projector.
- Decide how you will divide your students into groups. I usually have groups of 3-4 students.
- Allow 1 class period to complete this challenge. We completed this challenge in a one hour class time.

REPLENISHING MATERIALS: I did note that with this more challenging version students ran out of tape. I DID NOT give them more. **You can opt to give each team another foot of tape if you like.** With my groups I didn't give extra tape and they worked hard to change their designs or pull up tape to tear it in half.

Design a Tennis Ball Tower

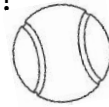
1. You may only use the given supplies. You may also use scissors and rulers.
2. You must use ALL of the supplies in some way. **Each** material must be used in a **functional** way.
3. The tower can be any height.
4. The tennis ball must be held aloft and the bottom of the ball must be at least 10cm from the table.
5. You may not pierce the tennis ball.
6. The tower can be attached to the tabletop.
7. All data must be recorded!



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Design a Tennis Ball Tower

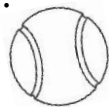
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Design a Tennis Ball Tower

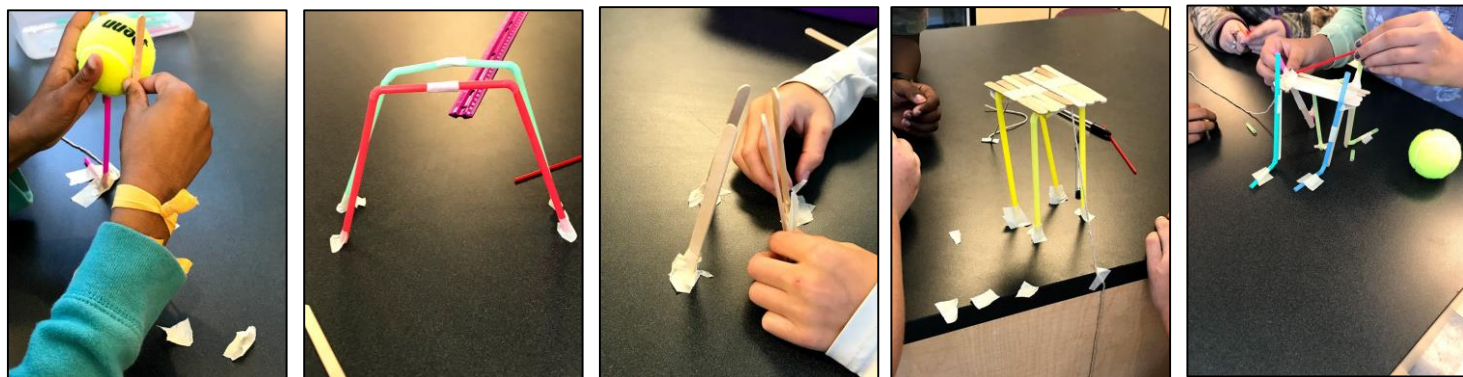
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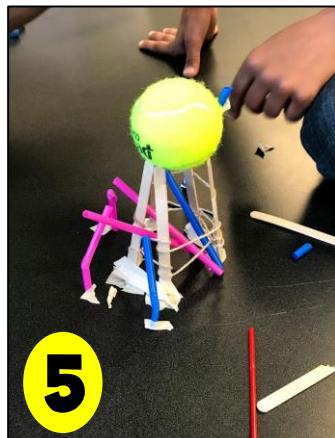
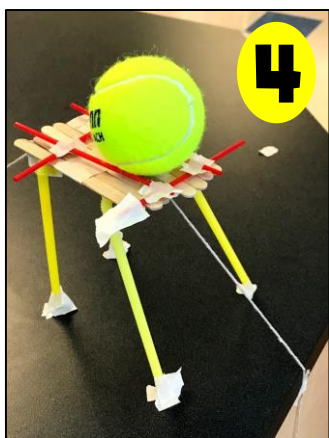
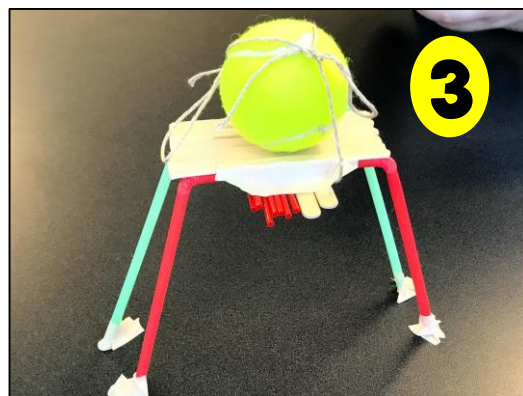
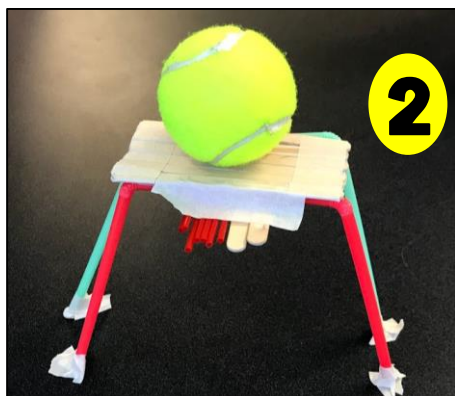
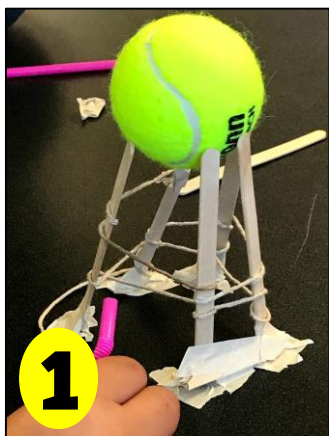
NOTE: Our "coffee stir sticks" were tiny red straws.

Photos



There are many ways to get started building this structure. Straws are usually used as the tower legs because of their flexibility. Most teams saved the craft sticks to make a platform for the tennis ball.

"Skirting the Rules"?



Did these towers follow the rules of the task? At first glance they appear to, but look closely.

Photo 1- Is the string holding the structure together? It might be, but there are also straws missing.

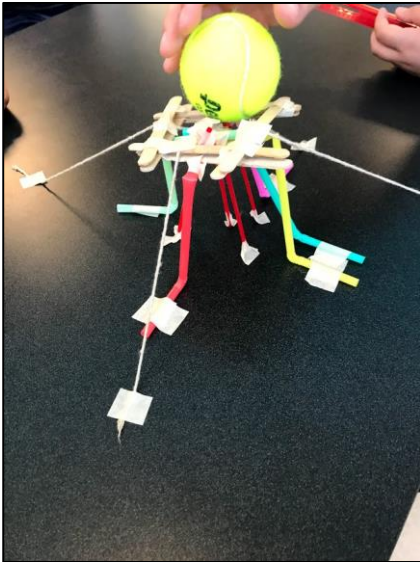
Photo 2- The string is missing, so now check photo 3. The team added the string by tying it around the ball. I pointed out that the string is not holding the ball on the platform, because photo 2 proves it is not needed.

Photo 4- The string is taped to the side of the table. The rule says it can be taped to the tabletop!

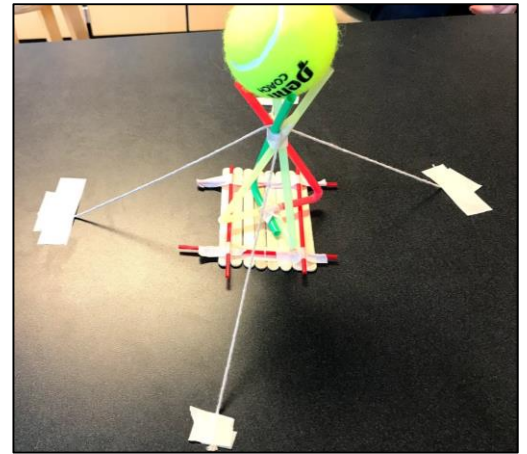
Photo 5 - The pink and blue straws are taped to the table and standing up but they are not attached to anything.

Photos

FINISHED

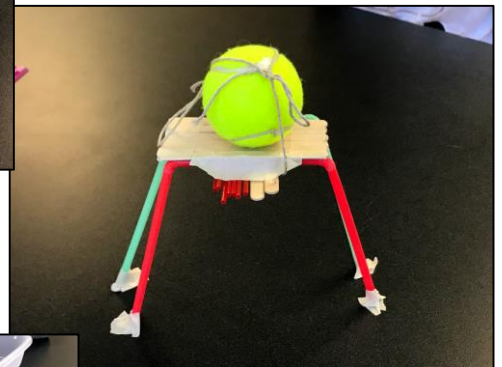
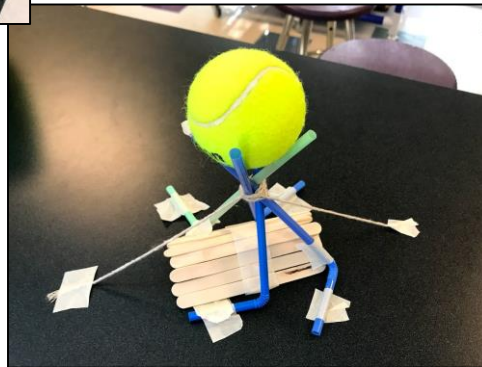


To the left- This one is a mess, but it works and all of the materials are used and visible! The craft sticks made a frame for the tennis ball to sit in.

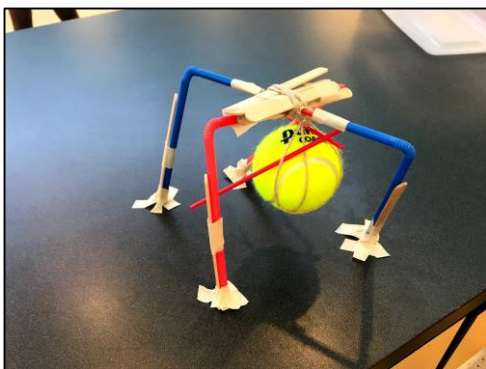


Above- This one is very symmetrical and held the ball in place perfectly. The strings used as guide wires is a key part of this challenge!

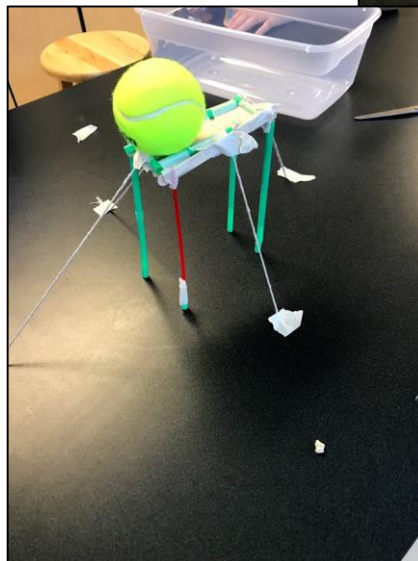
To the right – The blue straws are taped to the craft stick base and the red straws are inside the blue ones for extra support!



Above- I would still say this one is not using the string for anything, but students assured us the ball would roll off the top if they released the string.



Above -The craft sticks are used as supports for the straws and it worked. However, the tennis ball is too low. Before the tower started leaning the ball was at the right height.



To the left- some of the small red straws are inside the green straws to provide extra support.



If you have any questions or concerns, please email me at teachersareterrific@gmail.com.

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