

Teacher Background

One of our favorite tower challenges is one that uses only index cards as the building material. Another favorite is to build towers with only cups. After repeating variations of these recently I thought about trying to combine those two materials in a new tower building event. Then we ran out of index cards.....so we substituted with large craft sticks! What a simple idea for a great building event!

In this challenge students will have only two materials and the task of building the tallest tower possible. What makes this a little bit challenging are the constraints of the task. This involves what can and cannot touch on the tower. With very little instruction kids will get right to work trying to determine a way to follow the task rules and create the tallest structure. **In addition**, this was tested with three grade levels and 3 sets of constraints. Constraints cards for all three versions are included so that you can choose which will work best for you! The constraints cards are all on page 5- two sets of each version.

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 photographs. A sample student answer sheet is also provided.

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 materials to suit your needs and student population. This is a shortened version of STEM Challenges you can find at *Teachers are Terrific* with only 3 pages of teacher directions and 2 pages of photos. Look for longer and more detailed instructions with the gigantic selection of challenges in my store!

MATERIALS

You will need:

- Craft sticks
- Cups
- Copies of student lab sheet



Each group needs:

- 50 craft sticks
- 50 cups



HINTS about SUPPLIES:

CRAFT STICKS: We used the wider craft sticks. If you want to make this even more challenging try the narrow sticks! A box of 300 can be found at Wal Mart or Hobby Lobby for about \$5. Also, consider asking parents to donate.

CUPS: I used a 5 ounce paper cup. Three ounce cups, plastic or paper, will also work, but I did find the challenge to be even a little harder with the smaller cups. Styrofoam cups might be less expensive, however, you are likely to discover that Styrofoam will have a static problem. The cups will move away from one another or towards one another as kids move them around.

MORE SUPPLY HINTS:

- Toss materials into a plastic shoebox for an easy way to hand out to groups.
- I did not count the craft sticks- I just grabbed a handful and threw them into the bins. I had the students count them and then added or took away until they had 50.
- I counted one tower of 50 and then just leveled the other towers and gave each group a set.
- The craft sticks will not be harmed during this challenge so the large amount being used is completely reusable. The cups should also be reusable, although a few may be crushed.

PREPARATION

BEFORE CLASS:

- Prepare supplies. I just gave each group a tower of cups and a handful of craft sticks. They counted the sticks and we evened the numbers to 50.
- Copy the Challenge Constraint card of your choice. There are three versions of the constraints. You can also display the constraints with your projector/document camera instead of copying the cards.
- Decide how you will introduce this challenge. You can use the plan we used or create your own.
- Determine a way to divide your class into teams. For this challenge we had teams of 3. Teams of 2 will also work great.
- Allow 1 class period to complete this challenge.

BACKGROUND

Introduce this challenge by just talking about towers and any you have previously built in STEM class. Discuss the need for a sturdy base, talk about balance and counterbalancing, and set up the event with a scenario of your choosing. Or, just get busy with the task!

OUR SCENARIO: This tower challenge is one we completed purely for fun, so I did not spend a lot of time setting up a scenario. You can add more to the introduction if you like. This challenge is also a fantastic one to use as a reward for your class, a sub day, a fun Friday afternoon, STEM night at your school, Grandparent's Day, a holiday celebration using cups decorated for the holiday, and so much more.

Teacher Directions

ASK

The lab sheet begins with a question to set a purpose for this task.

How can you use the two materials and build the tallest tower possible?

This is the beginning of the Engineering Design Process. The Ask step is the place to address the task and/or problem that will be solved. This question or stated problem will set a purpose for the task, just like the question that begins the scientific method.

IMAGINE

Explain to students that they will be building the tallest tower possible using only two materials and they must follow a set of rules. Give each group the materials and then read through the constraints you have chosen.

As soon as the teams know what is being built each student needs to respond to the first section on the lab sheet. This is the Imagine section and asks them to write about their knowledge of building towers and what might be needed for the towers to be successful.

Teacher Directions

IMAGINE - cont.

Allow students 5 minutes to experiment with the craft sticks and cups and learn how these might be used together. Each group should have enough cups and sticks for each student to build a small tower. This will help them make planning and then building decisions. The lab sheet has space for writing about this experimenting time.

PLAN

Planning for the tower is going to entirely depend on which set of constraints you are using. (More about this below.)

THE CONSTRAINTS AND PLANNING: The constraints cards are numbered 1-2-3. Number 1 is the easiest version. With this one students may arrange the cups and sticks any way they like as long as the cups do not touch. The planning discussion is likely to take only a short time. For constraints card 2, the middle level of difficulty, students may need to talk more in order to determine which rows follow an arrangement that is the same. You will also have to make sure those using #2 know what the word *adjacent* means. For constraints 3, the hardest version, students will really have to work together to make sure every row of sticks or cups is different in some way. This may take longer to plan. Students completing #3 will also have to stop building occasionally to make sure they have no repeats in their structures.

Students will now independently sketch an idea for the structure. You can choose to have the group talk about it and make decisions without independent sketches. Hints below explain why we do independent drawings first.

PLANNING: We follow a procedure for planning. Each student writes and/or sketches about the structure. Students are asked to label their sketches by identifying the materials. After each team member has a drawing, then each one stands before the others and shares their drawing and explains it. The group talks about the best parts of each plan and decides what to do. This procedure allows every student to be part of the decision making for the structure being built. Having a voice right from the beginning helps all students- especially the quiet, shy ones.

The lab sheet has space for sketching and labeling ideas.

CREATE & IMPROVE

As soon as groups have a plan they will start building the tower. They will make constant improvements as these precarious towers will sway and fall easily. You might consider having students build on the floor rather than an easily shaken tabletop.

As soon as a team has a tower at a height they wish to be measured, be ready to do this. Record those numbers and then the team can try to make the tower event taller. This will happen especially as other teams get higher measurements.

Teacher Directions

CREATE & IMPROVE- cont.

IMPROVING: You will find students naturally begin to revise their thinking and then the towers as they discover something doesn't work. With this tower I had groups that exhausted one or both of their materials and told me they could not get it any higher. But, they can! The top layers or rows can get increasingly smaller and end up being single cups to create the tallest tower. Our tallest was 127 cm.

Since these towers fall easily students may have to completely start over- which also gives them an opportunity to try something else.

Remind students to record heights on their lab sheets and also record some of the changes that had to be made as they worked.

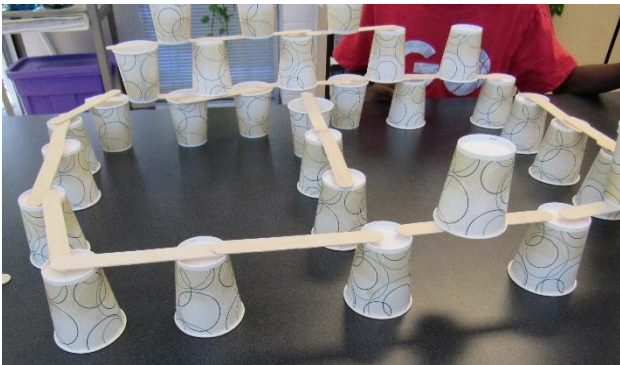
PRESENT

Normally, you will have a sharing time at the end of class and allow each group to talk about and present their project. With this tower you may find this is not possible as they fall so easily. Rather, you can get the class to observe as you measure completed towers and then get back to work on their own.

REFLECT

The challenge ends with a reflecting time. Have a class discussion about what did or did not work? What was the tallest tower? Why was the tallest able to stand? What were some of the frustrations? How were these frustrations handled? What were the hardest or easiest parts? Finally, have students complete the lab sheet.

Clean up is easy! Just restack the cups and place craft sticks in a bin for use on another project.



DIFFERENCES IN CONSTRAINTS: I tried this challenge with second-fifth graders and all of them completed it differently. Their thinking about the task was as different as their constraints! The photo to the left is from a third grade class. The constraints were basically that they could build in any arrangement and they took that very literally! The second grade towers were very much the same! The older students were much more likely to start small and try to get very tall quickly, with some exceptions. The photo pages will show you more!

Constraints for Craft Stick Towers 1

- The cups cannot touch each other.
- Rows of cups and sticks **can** look the same.

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Constraints for Craft Stick Towers 2

- The cups cannot touch each other.
- Adjacent rows of cups and sticks **cannot** look the same.

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Constraints for Craft Stick Towers 2

- The cups cannot touch each other.
- Adjacent rows of cups and sticks **cannot** look the same.

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Constraints for Craft Stick Towers 3

- The cups cannot touch each other.
- Rows of cups and sticks **must all look different.**

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Constraints for Craft Stick Towers 3

- The cups cannot touch each other.
- Rows of cups and sticks **must all look different.**

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NAME _____

Towers with Cups and Craft Sticks

ASK

How can you use the two materials and build the tallest tower possible?

IMAGINE

What are some things you will need to remember about building towers?

IMAGINE & PLAN

Describe the experimenting that your team did as part of the planning step.

PLAN

Sketch and label your idea for structure.

CREATE

Describe one way you worked together to build the tower.

Record any height measurements of your tower.

IMPROVE

What changes did you have to make in order to build the tower?

REFLECT

Describe this building experience. What was the hardest part? What was your favorite part?

Towers with Cups and Craft Sticks

ASK

How can you use the two materials and build the tallest tower possible?

IMAGINE

What are some things you will need to remember about building towers?

A tower has to have a good base and you have to be careful to make everything balanced. Sometimes the top can be really skinny, but not the bottom.

IMAGINE & PLAN

Describe the experimenting that your team did as part of the planning step.

We tried just stacking whatever way we were thinking would be best. Then we started noticing things that didn't work and we talked about it. That helped us plan later. Lots of people were making pyramids, but we didn't think those could get as tall as straight up towers.

PLAN

Sketch and label your idea for structure.

CREATE

Describe one way you worked together to build the tower.

We had one person that could stack cause I was too nervous. So, I just handed the cups to her. Then we needed someone to catch the tower when it would start to fall to try to keep it from totally crashing.

Record any height measurements of your tower.

49cm

67 cm

IMPROVE

What changes did you have to make in order to build the tower?

First, we had to stop stacking in rows because it wouldn't stay up anyway and it was wasting cups. Then we had to figure out how to use the craft sticks so the cups could stay level. At the end we took sticks off the bottom like Jenga so we could use them on the top.

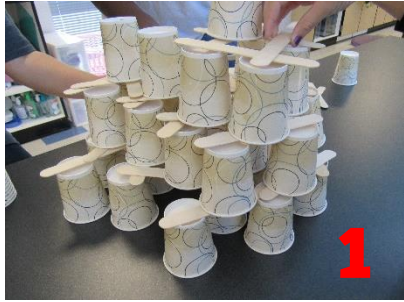
REFLECT

Describe this building experience. What was the hardest part? What was your favorite part?

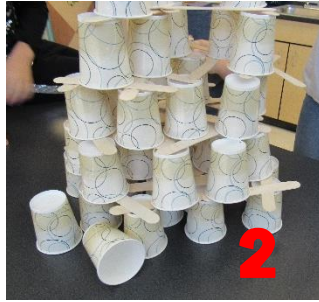
This was harder than I thought it would be. It crashed a bunch of times. The hardest part was when it got really tall and our hands were shaking and you could not breathe on it. My favorite part was when the towers got tall and everybody cheered.

Photographs

Third grade – with Constraints 1



1



2



3



4



5



6



7

Photos 1 and 2 show some cups just in piles with little thought to making the tower tall and some misuse of the craft sticks (using too many). It didn't take long for the kids (all age groups) to learn that wider towers or large arrangements limited the height. They also learned to be more frugal with the sticks. In photo 3 the group has started using single sticks between rows of cups. Photo 4 has a tower that worked by having a great base and then getting more narrow. Photos 5 and 6 are similar, but notice the craft sticks all in a row in photo 6! Photo 7 is the tallest tower of the third graders at 127 cm.

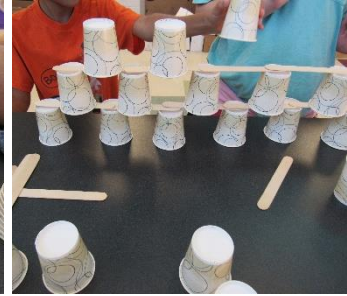
Fourth grade – with Constraints 2



The 4th graders used the constraint that allowed for rows to be the same, but not adjacent rows. They very quickly caught on to making the square or triangular base arrangement and then going up with cups either facing up or down and just repeating this. More 4th grade photos on the next page.

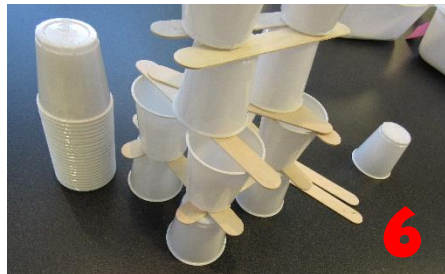
Photographs

Fourth grade – with Constraints 2



Some unusual arrangements were tried! Should you advise kids that something is not going to work? I don't! They learn by seeing it collapse and then trying something else!

Fifth grade – with Constraints 3



Fifth grade constraints were that every row had to be different in some way. We either made the cups or the sticks different. All of the above are following the rules. Photo 1- the bottom row is double cups (which limits the height). Photo 2- the three bottom rows have cups facing up and down in different ways and then rows of three cups doing the same. Photos 3 and 4 have elaborate systems of cups facing up and down and in different locations. They actually were listing these on paper to make sure they didn't repeat. Photo 5 has sticks arranged differently. Photo 6 is from a team that wanted to try the smaller cups. These were harder to work with! Photo 7 is the tallest fifth grade tower – at 127 cm.





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