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Engineering CUP: Paper Bridge Construction

Teaching and Learning LAP 3: Classify Different Bridge Materials and Folding Techniques by Strengths and Weaknesses

I. Content: Describe *what* it is you will teach. What is the content?

- This lesson is two exploration lessons meant to expand students' choices around improvements for when they redesign their bridges and we have our final tests. Students will have the chance to explore different types of materials for constructing their bridges as well as introduce them to different ways to fold their paper (or other material should they choose) to make a stronger bridge. In the first lesson, they will be shown each material and get an opportunity to test them out. Each group will test all of their materials. They will record the quality of the material and if it is suitable for this project. In the second lesson, students will engage with a video which I will project on the Elmo two times. Then they will break into their partner groups and get 4 pieces of construction paper, one for each folding technique. Then they will get to test their designs and will be expected to record their results in their packets like in the first lesson. This will feed into their improvements for the final designs, models, and testing.

II. Learning Goal(s): Describe what specifically students will *know* and *be able to do* after the experience of this class.

- SWBAT identify potential materials used for building bridges.
- SWBAT identify at least four different ways to fold paper to build a bridge.
- SWBAT work with their partner to construct models for each material and four different models for each folding style.
- SWBAT demonstrate respect and collaboration skills when testing bridges and seeking materials around the room.
- SWBAT record results in a chart.
- SWBAT explain their reasoning for why one material/folding technique is better for this project than another and justify their answers.

III. Rationale: Explain how the content and learning goal(s) relate to your Curriculum Unit Plan learning goals.

- The above learning goals relate to my CUP because students are continuing their work as collaborative engineers through exploration of materials and folding styles. Students will have a chance to explore different materials in which they might reconsider their previously issued material, construction paper, for a different one such as cardstock. They will also test out tin foil and wax paper to identify qualities which are not suitable for bridges. Students will also get to test out folds resembling tubes, crinkled with triangular patterns, and flat with edges. They will get to make decisions around which of these models helps and which ones hinder their success in holding many pennies. Students in this lesson will further develop their ideas and abilities to work together towards a common goal by focusing on not only the structure of the material they are using but the way it functions also. This also connects directly to the Project Lead the Way work my mentor teacher is doing with them on days I leave for classes at the same time.

IV. Assessment: Describe **how** you and your students will know they have reached your learning goals.

- I will know my students have reached their learning goals by if they can explain their thinking around which material they will use and which way they will choose to fold their final bridge and why. My students will be able to use their metacognition and explain their process of testing folds and how they knew which ones work better than others. Their completion of the chart and their ability to produce testing models with different materials and with different folds will be the main forms of assessment. This will show me how well they were able to work together to produce models and how well they can record and explain the information they get from their tests.

V. Personalization and equity: Describe how you will provide for individual student strengths and needs. How will you and your lesson consider the needs of each student and scaffold learning? How specifically will ELL students and students with learning disabilities gain access and be supported?

- ELL students are supported in this lesson through continuous vocabulary support. The hands-on exploration approach continues in this lesson as well as the previous one. This helps all students because it allows them to build concepts in STEM and engineering without burdening them with lengthy writing tasks or complicated vocabulary. In addition to the lesson structure and having carefully planned partnerships, I have also included colored images of the folds in the packet. This will hopefully help them understand what I am expecting from their models. ELLs, along with all of my students, will also get to watch the explanation video not once, but twice, because it is brief but does show the expectations for this lesson well. By visually seeing and hearing the lesson, seeing it and reading it, working with their partners, and support from me, every student should be able to access the expectations and contribute to their understanding around how to improve their bridges in this project.

VI. Activity description and agenda

a. Describe the activities that will help your students understand the content of your class lesson by creating an agenda with time frames for your class. Be prepared to explain why you think each activity will help students on the path toward understanding.

Day 1 Schedule:

Time	Students	Teacher	Materials
2:40-2:45	<ul style="list-style-type: none"> • Think About Anchor Chart and EDP 	<ul style="list-style-type: none"> • Go Over EDP and Introduce Project 	<ul style="list-style-type: none"> • Anchor Chart
2:45-3:10	<ul style="list-style-type: none"> • Break into partners • Receive one piece of each materials • Make models using each material • Test Periodically • Record Results 	<ul style="list-style-type: none"> • Pass Out Tin Foil, Cardstock, Construction Paper, and Wax Paper and Tape • Pass Out Packets • Set Up Dictionaries and Pennies for Testing Station • Support students as needed 	<ul style="list-style-type: none"> • Dictionaries • Construction Paper • Cardstock • Tin Foil • Wax Paper • Pennies • Tape

3:10-3:15	<ul style="list-style-type: none"> ● Fill in the top chart of the Different Materials and Folds page 	<ul style="list-style-type: none"> ● Support with Vocabulary and Sentence Stems on Board as needed 	<ul style="list-style-type: none"> ● Packets ● Expo Marker
3:15-3:20	<ul style="list-style-type: none"> ● Share Out Ideas 	<ul style="list-style-type: none"> ● Call on Children to Share ● Communicate how to choose a strong material suited for this purpose 	<ul style="list-style-type: none"> ● Completed Packets

Day 2 Schedule:

Time	Students	Teacher	Materials
2:40-2:45	<ul style="list-style-type: none"> ● Think About Anchor Chart and EDP 	<ul style="list-style-type: none"> ● Go Over EDP and Introduce Project 	<ul style="list-style-type: none"> ● Anchor Chart
2:45-2:50	<ul style="list-style-type: none"> ● Watch Video 	<ul style="list-style-type: none"> ● Play Video https://youtu.be/CqYGVW2Eu6Y 	<ul style="list-style-type: none"> ● Computer ● Elmo ● Video
2:55-3:00	<ul style="list-style-type: none"> ● Break into partners ● Receive materials ● Make models reflecting each fold style ● Test Periodically ● Record Results 	<ul style="list-style-type: none"> ● Pass Out Papers and Tape ● Pass Out Packets ● Set Up Dictionaries and Pennies for Testing Station ● Support students as needed 	<ul style="list-style-type: none"> ● Dictionaries ● Construction Paper ● Pennies ● Tape ●
3:00-3:15	<ul style="list-style-type: none"> ● Fill in the bottom chart of the Different Materials and Folds page 	<ul style="list-style-type: none"> ● Support with Vocabulary and Sentence Stems on Board as needed 	<ul style="list-style-type: none"> ● Packets ● Expo Marker
3:15-3:20	<ul style="list-style-type: none"> ● Share Out Ideas 	<ul style="list-style-type: none"> ● Call on Children to Share ● Communicate how to make improvements regarding folding style for final designs and final tests 	<ul style="list-style-type: none"> ● Completed Packets

- b. What particular challenges, in terms of student learning or implementing planned activity, do you anticipate and how will you address them?
- I anticipate my directions and clarity around expectations to be difficult. That is why I have incorporated that into my Rounds questions for the second day. I want to find ways to communicate my expectations clearly so that the learning environment is safe and productive. I want my students to be successful in this lesson because they have followed my expectations thus far but lack diversity in folding styles resulting in weak models. Many still just fold a piece of material in half once or twice and then tape the ends. Some have begun to try new ways of folding expressed wanting to try new materials. This lesson could be very helpful for them as far as making improvements to their own bridges if they can be successful at it.

So much of that success depends on my instruction and set up of the lesson. I have carefully planned out spacing around the room as well as partners and their orientation around the room. I anticipate many students to deviate from the expectations and try their own designs which is not an issue for exploration but is an issue in my teaching practice. I hope that my abilities help my students be successful in their exploration and that this lesson supports their curiosity to try new ways to fold their paper materials into strong bridges.

VII. List the Massachusetts Learning Standards this lesson addresses.

- Grade 2 Common Core standards
 - **2.K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same design problem to compare the strengths and weaknesses of how each object performs.
 - Data can include observations and be either qualitative or quantitative.
 - **2.W.7.** Participate in shared research and writing projects (e.g. read a number of books on a single topic to produce a report; record science observations).
 - **2.W.8.** Recall information from experiences or gather information from provided sources to answer a question.
 - **2.W.10.** Write routinely for a range of tasks, purposes, and audiences.
 - **2.SL.1.** Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.
 - a. Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion).
 - b. Build on others' talk in conversations by linking their comments to the remarks of others.
 - c. Ask for clarification and further explanation as needed about the topics and texts under discussion.
 - **2.SL.4.** Tell a story, recount an experience, or explain how to solve a mathematical problem with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences and using appropriate vocabulary.
 - **2.SL.6.** Produce complete sentences when appropriate to task and situation in order to provide requested detail or clarification.
 - **2.L.1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking; retain and further develop language skills learned in previous grades.
 - **2.L.2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
 - **2.L.3.** Use knowledge of language and its conventions when writing, speaking, reading, or listening.
 - **2.L.6.** Use words and phrases acquired through conversations, activities in the grade 2 curriculum, reading and being read to, and responding to texts, including using adjectives and adverbs to describe.
 - **2.MD.9.** Generate measurement data by measuring lengths of several objects to the nearest whole unit, or by making repeated measurements of the same object. Organize and record the data on a line plot (dot plot) where the horizontal scale is marked off in whole-number units.

- **2.MD.10.** Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems, using information presented in a bar graph.

I. Rounds Reflection

- a. In light of all areas of planning, but especially in terms of your stated purpose and learning goals, in what ways was the activity(ies) successful? How do you know? In what ways was it not successful? How might the activity be planned differently another time?

- After reviewing student work as well as the videos taken from both lessons, I noticed some obvious areas of great learning happening and some areas to change the next time I teach this lesson. By discussing my Rounds questions with my peers and mentors, I could really focus on my own teaching and facilitation of this style of lesson. This unit requires me to have a hands-off approach and allow students' to participate in the productive struggle of uncovering their own conclusions around the selection of materials, folds, and techniques for collaborating to build a successful bridge model.

I was very interested to see if there was evidence of students using prior knowledge about the Engineering Design Process to guide their thinking while exploring the materials and folds. In both lessons, I wanted to know if my students could hold thoughts about the next steps and final tests while also actively engaging in the classification of the materials and folds. After review and discussion, I know that some students were able to think ahead and back around which step in the EDP we were currently in, where we were, and where we are going next. This shows me that if I want students to get better at holding multiple thoughts in their minds, I need to scaffold and model what that looks like as well as provide charts or accessible information to help them articulate those thoughts.

In general, these lessons are the lessons in the unit which most relate to the only Engineering-specific standard. The standard is based around having students be able to analyze data from two different objects intended to solve the same design problem and compare the strengths and weaknesses of how each object performs. This is exactly the skill I wanted my students to practice in these two lessons. Not only did I want them to diversify their thinking around what a bridge's design can be and get more creative with their models, I wanted to be intentional about how I introduced those concepts.

My students showed a large improvement in their collaboration skills in these lessons. I was very pleased with their ability to split up the work of writing, designing, recording, and testing. I saw some groups struggle but also persevere through their struggle. Students were able to be successful in their models and most could articulate why a material or folding style would be good or bad for their bridge designs. They understood which materials were more effective and which designs ended up being more effective even if they had a different hypothesis at the beginning of each lesson. Students' abilities to change their minds and update thinking to solve problems shone through in these two lessons regarding choice of materials and folds.

Something I noticed after the first lesson that did not change in the second was that despite my students being able to verbally or physically explain their thinking around their reasoning why a material or fold would be good or bad for bridge-building, they were not successful in recording those thoughts in the chart in writing. Most students left the "why" section of the chart blank as you can observe in the Student Work Appendix below. This concerned me because I was not sure why they were not able to write those

ideas done onto their assessment but could explain their thinking when prompted verbally.

b. What did you learn from the experience of this lesson that will inform your next LAP?

- In my post-Round discussion we spoke about ways I could have improved this lesson and my instruction to make space for even more success for my students. Like I had mentioned, I was not sure why they had so much success in collaborating and explaining their thinking to me and each other but unable to produce quality written work to reflect that thinking. One suggestion that really stuck out to me which I knew I had skipped over was providing vocabulary and visuals for my students. I needed to show them the words I needed them to use and we needed to define those words. My students were not writing what I expected because I had not provided the right scaffolds necessary for them to use and take ownership over the language they needed to be successful at that aspect of the lessons. This is a concept in which I will be drafting my next lesson completely around.

It is extremely important that my students understand the “Improve” section of their EDP for this project because as I had mentioned before, the only engineering standard they have to accomplish in second grade is around being able to compare similar models designed for the same purpose and their effectiveness. I knew my students could do this work because I had heard their thinking aloud. I need to do an intervention and explicitly model and scaffold what I was expecting them to get out of these two lessons.

This intervention lesson would have visuals of the materials and folding techniques for students to see. We would collectively define each one and identify its strengths and weaknesses regarding this project and the use we need from it. Then, students will work independently to reflect on these lessons and begin to make improvements to their designs to be retested in the final design.

Another suggestion made to me in the post-Round discussion which I had not considered was the color or paper I chose. In the video we watched, and in the screen capture I included in their packets for them, there are four different colored papers to represent the different folding techniques. I only provided orange paper because I assumed it would not make a significant difference. In the film and from my peers comments, I realized that most pairs got confused slightly around which models they had made and tested and which ones were left to do. Some students made duplicates and omitted types of folds which could have also contributed to them having difficulty completing the chart.


Moving forward, I need to reevaluate the ending to this unit and design a new lesson to help solidify the learning goals from these lessons in order to ensure my students can make well-thought out and informed decisions regarding how to improve their designs and models to make the strongest bridges possible. After that intervention, we will make our final designs and conduct a final test. It is crucial they understand why they improve and how to make rational choices for improvements.

Student Work on Next Pages

A. Students' Charts

Picking Different Materials and Folds


Material:	Good or Bad for Bridges?	Why?
Tin Foil	Good	we read it is strong
Wax Paper	bad	is not strong
Construction Paper	Good	And it's strong
Cardstock	good	is strong



Kinds of Bridges:	Good or Bad for Bridges?	Why?
Folded like Yellow	No	because it is not strong
Folded like Red	Yes	is so strong
Folded like Green	No	it's good and we can't bend
Folded like Blue	Yes	it had curves

Picking Different Materials and Folds


Material:	Good or Bad for Bridges?	Why?
Tin Foil	Good	
Wax Paper	bad	
Construction Paper	bad	
Cardstock	Good	



Kinds of Bridges:	Good or Bad for Bridges?	Why?
Folded like Yellow	bad	
Folded like Red	good	
Folded like Green	Good	
Folded like Blue	Good	

Picking Different Materials and Folds


Material:	Good or Bad for Bridges?	Why?
Tin Foil	good	strong
Wax Paper	Bad	not strong
Construction Paper	good	strong
Cardstock	good	strong



Kinds of Bridges:	Good or Bad for Bridges?	Why?
Folded like Yellow	No	
Folded like Red		
Folded like Green	kind of	if fell
Folded like Blue	super great	strong

Picking Different Materials and Folds


Material:	Good or Bad for Bridges?	Why?
Tin Foil	the best	
Wax Paper	Bad	
Construction Paper	good	
Cardstock	the best	



Kinds of Bridges:	Good or Bad for Bridges?	Why?
Folded like Yellow		the worst it is like a spring
Folded like Red		it was in the bad it had it all over
Folded like Green		
Folded like Blue		

Picking Different Materials and Folds


Material:	Good or Bad for Bridges?	Why?
Tin Foil	Good	strong
Wax Paper	bad	weak
Construction Paper	Good	
Cardstock	Good	



Kinds of Bridges:	Good or Bad for Bridges?	Why?
Folded like Yellow	bad	the coins fall
Folded like Red	bad	it slipped off
Folded like Green	kinda	weak
Folded like Blue	supr good	we fold it alot

Picking Different Materials and Folds


Material:	Good or Bad for Bridges?	Why?
Tin Foil	It is good	It hold's strong
Wax Paper	good	it
Construction Paper	good	It didn't hold good
Cardstock	amazing	



Kinds of Bridges:	Good or Bad for Bridges?	Why?
Folded like Yellow	Bad	The pennys fall
Folded like Red	bad	it didn't ever hold
Folded like Green	good	
Folded like Blue	good	it could hold

Picking Different Materials and Folds


Material:	Good or Bad for Bridges?	Why?
Tin Foil	its good	it holds strong
Wax Paper	bad	
Construction Paper	Bad	it didn't hold strong
Cardstock	amazing	



Kinds of Bridges:	Good or Bad for Bridges?	Why?
Folded like Yellow	Bad	the pennys fall
Folded like Red	Bad	it didn't even hold
Folded like Green	good	they held alot
Folded like Blue	good	that held alot

Picking Different Materials and Folds

Material:	Good or Bad for Bridges?	Why?
Tin Foil	Bad	
Wax Paper	good	
Construction Paper	good	
Cardstock	great!	



Kinds of Bridges:	Good or Bad for Bridges?	Why?
Folded like Yellow	Bad	
Folded like Red	Great	
Folded like Green	good	
Folded like Blue	Great	