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| Title | Building Pasta Bridges to understand structural engineering |
| Introduction | I will be creating a virtual expedition throughout the unit with a focus of learning various fields of engineering and implementing STEM applications in the classroom. Students will be traveling to Medieval Times and focusing on the creation of draw bridges used in castles from that time period. Each group of students will have to create a bridge made of only various types of pasta and tape. I will be focusing on addressing number and operations, measurement, geometry, and data analysis math goals.  |
| Learning Outcomes | Students will apply the engineering design process.Students will analyze a particular problem (creation of a draw bridge) and work as a team to build a bridge from various forms of pasta.Students will understand the use of Microsoft Excel as a tool for collecting data and applications to create formulas to solve math problems.Students will learn how to determine the weight on an object in standard measurement and convert it to the metric system. |
| Curriculum Alignment | 5th grade Math NCSCOS Goal #1 Number and Operations1.02a Develop and analyze strategies for adding and subtracting numbers1.03 Develop flexibility in solving problems by selecting strategies and using calculators, mental computation, and paper and pencilGoal #2 Measurement2.01 Estimate the measure of an object in one system given the measure of that object in another systemGoal #3 Geometry3.01 Identify, define, describe, and accurately represent triangles, quadrilaterals, and other polygonsGoal #4 Data Analysis 4.01 Collect, organize, analyze, and display data to solve problemsScience NCSCOSScience Goal 4:The learner will conduct investigations and use appropriate technologies to build an understanding of forces and motion in technological designs.4.07 Determine how people use simple machines to solve problems.Framework for 21st Century Learning components1.Core subjects3. Learning and Innovation Skills5. Life and Career Skills6. 21st Century Support Systems |
| Classroom Time Needed | 4-5 class periods Each period 45 minutes to 1 hour each |
| Materials Needed | Pasta used: lasagna, rigatoni, rotini, spaghetti, elbowsMasking and scotch tapeRulers and meter sticksGraph paper for drawings of their bridgeWeight scale for determining weight of bridge Textbooks to be used as the weights for breaking the bridges (anything really can be used to break the bridges as long as it is uniform)Laptops for using Microsoft Excel, if not able to use laptops, students could create budgets on paper and pencil method of collectionSMART Board used in lesson, but if your do not have one, could use 1. PowerPoint presentation for lesson overview2. Chart paper and markers for data table 3. Timer, watch, or clock for a timer |
| Technology Resources | SMART Board used throughout the lesson. Intro and analysis of bridges to describing engineering design process to data collection.Could be replaced with:1. PowerPoint could be used for intro of lesson and analysis of various bridges
2. Chart Paper and markers for data collection

Laptops for using Microsoft Excel: could be replaced with paper and pencil collection of expenses |
| Pre-Activities | Prior to this lesson, I have introduced the engineering design process as the students made towers from pipe cleaners. With the pipe cleaner towers, students were also introduced to structural engineering. If this is the first lesson being done with students, Understand the engineering design process found at Boston Museum of Science / Engineering is Elementary website (<http://www.mos.org/eie/engineering_design.php>).Preparation for lesson before starting:Determine costs and label the pasta (for example: Lasagna $2.75 each, Rigatoni $1.75 for 10, Rotini $1.50 for 15, Elbows $1.00 for 20, Spaghetti $1.25 for 5, Masking Tape $1.75 per foot, Scotch/Clear Tape $.75 per foot)Microsoft Excel application: understand how to make formulas in worksheets to teach students  |
| Activities | Day #11. Discuss with students that the pipe cleaner challenge was the first stop on their virtual expedition they will be taking with focusing on engineering
2. They will be traveling next to Medieval Times, create a discussion with the students with their background knowledge of Medieval Times. This discussion should involve two major elements, first that this time period took place in Western Europe (mainly England and Spain) and second being the use of castles
3. Introduce the problem (motivational piece), a group of medieval engineers built a castle, but built themselves inside. A moat that measures 20 feet long and 20 feet deep surrounds the castle. They do not have the ability to swim or walk across the moat. They have to design something that incorporates one simple machine that will allow them to get out of the castle.
4. Reintroduce the engineering design process, because the process if circular and not linear, create a discussion to which of the five steps of the process the students should start at. The students should understand that they should start on the ‘ask’ or ‘imagine’ phase because the ‘improve’ phase would be started if there was a bridge that already existed, ‘plan’ phase would be started if we brainstormed or already knew the task, and ‘create’ would be started on if the task was already mapped out.
5. In this case, I chose to start on the ‘ask’ phase and addressed the building challenge. Tell the students “Your task will be to create a bridge that can span a 20 inch gap (I use 20 inches because it is creating scale representation that is addressed in the Landforms science unit taught in fifth grade). They also have to incorporate one simple machine with their design.
6. Moving to the ‘imagine’ step, have the students brainstorm different bridges they have seen before and ask what type they thought they used in medieval times. Brainstorm different simple machines that exist (inclined plane, level, pulley, wheel and axel) and which they could incorporate with their bridges. Bring the discussion to focus on draw bridges and how they implement the use of a pulley.
7. Final part of day #1, ‘plan’ step. Students have to create a scale drawing of the bridge they are going to create. Describe to students that a scale drawing is one that drawn to accurately represent their creation. It will actually show the length of certain pieces included. When completed correctly, anyone can take their drawing and recreate the bridge they create without seeing their original. This is directly related to blueprints used.
8. Students are given a sample of the different pastas to measure and have the ability to accurately draw them in their plan. Students work together to create a plan for the bridge they are going to create.

Day #21. Discuss the previous day’s activities to address the challenge already covered.
2. Tell the students they will be assessed in 4 different components for their bridge. The four parts are: 1. Creativity of bridge designed, 2. Budget for building the bridge (this is two-fold, one part is creating and maintaining a budget correctly using Microsoft Excel, and second part is keeping their costs low which will be assessed by comparing the spending of the other groups in class), 3. Their ability to work in teams, 4. Effectiveness of their bridge which will be measured by how many textbooks it can hold
3. Introduction and application of using Microsoft Excel spreadsheets to keep track of their budget.
4. Each group will be given a laptop and I will model the use of Excel and how to implement formulas in the cells to make their math easier. If you do not know or understand Excel refer to program handbook directions found on software.
5. Remind students that this is one of the four major components they will be assessed on.
6. I am using Blackboard software with students, which allows students to submit me their spreadsheets via internet to eliminate the need for paper to be used.

If you do not have the ability of using laptops or computers with Excel on them, budgets can be created and tracked using paper and pencils method.Day #31. Students have to submit a proper plan before they can build their bridge.
2. Students start buying materials for their bridge and start building their bridge.
3. You can limit the number of lasagna if you wish to make this task a bit harder for students, depending on level of learners in your room
4. Building for entire class period

Day #41. Introduce to the students that we will be using a textbook to measure effectiveness of the bridge for weight.
2. Give them a weight scale and let them know they cannot just put the textbook on the scale to determine the weight of it. Their task as a class is to find a way to find the accurate measure of the textbook. This inquiry task should guide the students to a potential solution of first weighing a student in class (multiple times) then weighing him with the textbook in their hand. They can subtract the two weights to determine the weight of the textbook in pounds. Then have them covert the pounds to its weight in the metric system.
3. Have students submit their budgets for their purchases, and grade themselves on the teamwork used during the challenge.
4. Have students grade each others bridges on a scale from 1-4 for the creativity used in their design
5. Using a 20 inch gap between tables or desks has the students view the testing of each bridges strength. Add textbooks until the bridge breaks. When each group witnesses their breaking, have them insert their scores for the 4 different categories of assessment on the chart found on the SMART Board.
6. Continue until all groups are completed and have inserted their data on the SMART Board.

Day #51. Have each student group create a video science journal entry using the webcam on a computer. Each group has to answer 4 questions for their entry. 1. What was your challenge and how did your group go about solving the challenge? 2. What was the most difficult part of your challenge? 3. What is your view of completing engineering tasks in class? 4. What would you do differently if you had to do this challenge again?
2. Students need complete the notebook entry on the computer (discussion questions found in assessment section). This could be done in paper copies of notebooks.
3. Discussion of the ‘improve’ step of the design process. Create a discussion with the data table created and completed surrounded around the question of how you would improve if you would do this challenge again.
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| Assessment | 1. First form of assessment will be analyzed throughout the discussion based on the data with the students. Identify if they are using the data from the table to support the logic in their thinking.
2. Second form of assessment will be their responses given in their STEM notebook discussion questions.

Discussion questions to be answered1. If you compare your effectiveness of your bridge and how much you spent, do you think your team did a quality job? How did your costs and effectiveness compare with other groups in the class?
2. What geometric shapes should be used to give more strength to a structure?
3. How is Microsoft Excel used as a tool?
4. The last assessment will be analyzing the different video submissions of each group. While listening to them, analyze the student responses in relationship with the standards being addressed in this challenge.
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| Modifications | 1. This task is meant for any style of learner. The SMART Board template or PowerPoint of same material supports learners with ELL, LD restrictions because it provides visual representation of material being covered.
2. Working in teams, allows for different levels of learners to share and understand together. With grouping students, make sure to create heterogeneous groupings to allow for students to help teach and learn from each other.
3. Using different ways of responding to the discussions questions is a modification to be used to meet various IEP or ELL needs. If students struggle with written responses, use a version of the webcam or oral discussion of answers to questions.
4. Depending on students strengths and weaknesses, make the prices for the pasta simpler or more difficult to manipulate.
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| Alternative Assessments | See modifications #3 |
| Supplemental Information | 1. NC State University Engineering website “The Engineering Place” <http://www.engr.ncsu.edu/theengineeringplace/educators/index.php>
2. Boston Museum of Science EiE website <http://www.mos.org/eie/index.php>
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| Critical Vocabulary | Engineering design processStructural engineeringMicrosoft Excel vocabulary used: formula, cell, row, columnSimple Machines: level, pulley, inclined plan, wheel and axelScale drawing3 view drawing (front, top, and side view) |
| Websites | 1. NC State University Engineering website “The Engineering Place” <http://www.engr.ncsu.edu/theengineeringplace/educators/index.php>
2. Boston Museum of Science EiE website <http://www.mos.org/eie/index.php>
3. Teach Engineering multiple excellent resources <http://teachengineering.org/>
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| Comments | 1. This is a lesson that I learned at NC State’s Engineering Camp held for students in grades 3-5. The initial use of this was a simple building activity. I created a unit that digs deeper into the budget, determining weight, changing the expectations, adding multiple forms of pasta, including multiple pieces to make it a complete STEM activity, adding the idea of a virtual expedition.
2. This is completed after the pipe cleaner towers because it digs deeper into the idea of structural engineering (pipe cleaner challenge found on engineering place website : <http://www.engr.ncsu.edu/theengineeringplace/educators/index.php>
3. When doing this with my class, I found it easier to spread the days out to five because of the time allotted for students to dig deeper into the learning. The weighing of the textbooks seems trivial, but has produced numerous rich conversations between students trying to troubleshoot through the process of determining weight of an object.
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