STEMJOBS℠
DO WHAT YOU LOVE.

5-E Classroom STEM Activity:
Building Bridges

Dr. Alexandra Owens

From the Ground Up

Building a STEM Career in Construction

By Dorothy Crouch

Building impressive structures— and a sense of pride—are all in a day's work for project engineers in construction fields.

Entering a construction career was a decision that stemmed from fond family memories for project manager Cherdine Lewis. Sometimes also known as a project engineer, Cherdine remembers going to work with her father who was a computer analyst for an alumina mining and production company.

"Being able to see the process of creating a finished product formed the foundation of my pursuit of a career in construction," explains Cherdine.

From her summer job as a kid to her current project engineer role, Cherdine believes every professional experience has been valuable. Along her career path, Cherdine has learned STEM skills that have prepared her for success in her current job, such as working with contracts; planning; communication; owner relations; cost management; submittals and shop drawings review; and safety, quality, and project closeout management.

In her career, Cherdine has focused heavily on STEM, but she also knows the importance of communication skills.

"Some of the integral skills required for my job are problem solving, teamwork, cost management, conflict resolution, strategic planning, and project management," says Cherdine.

This understanding of a perfect formula made by blending a strong understanding of STEM concepts with solid communication has brought Cherdine a long way during her career.

"One of my accomplishments is being the assistant project manager of a project that received the People's Choice Award in the 2016 America's Transportation Competition," she says. For Cherdine, the sky is the limit as she works on one awesome project after another. "I am currently the project engineer on a $409 million project for the I-64 High Rise Bridge in Chesapeake, Virginia."

As the construction industry grows through advances in

Photo: Vichien Petchmai / Getty Images

CHERDINE LEWIS, P.E.
PROJECT MANAGER III
DEGREE: BACHELOR'S IN CIVIL ENGINEERING
YEARS IN THE INDUSTRY: 14
STEM TYPE: MAKER

technology, Cherdine believes students will see more opportunities in this field.

"The construction industry is constantly evolving," explains Cherdine. "With the progress of new technology being incorporated into heavy civil construction projects, roads and bridges will become safer, greener, and more efficient."

For students who are interested in construction, Cherdine reveals that many different jobs exist to fit a variety of personalities. In her field, she feels that each day provides new experiences and fresh challenges that allow students to feel the satisfaction of seeing their work in a finished structure.

"This industry enables you to see the full gamut of infrastructure being built from start to completion," says Cherdine. "I would sometimes drive by a bridge and say, 'I was part of the team that built that!' It is an exciting and humbling accomplishment when you can look at a completed project."

I am currently the project engineer on a ***$409 million*** *project for the I-64 High Rise Bridge in Chesapeake, Virginia.*

STEMJOBS℠
DO WHAT YOU LOVE.

5-E Classroom STEM Activity: Building Bridges

Here are some ideas for how middle school teachers could use this story as a launching point for integrated STEM learning. Our activities follow the 5-E Learning Cycle Model.

Part 1: Engage

1. Ask students to describe the job of a civil engineer. How is it similar to or different from other engineering fields?
2. Have students read the article "From the Ground Up" in *STEM Jobs*℠ magazine. Discuss the following questions:
   a. What types of things does Cherdine design and build?
   b. What skills are important for this field?
   c. How will advances in technology change the field?
3. Hold a class discussion about various bridges in your community. If your community does not have many, show various photographs from your region.
   a. What do they look like?
   b. How do their designs make them strong?
   c. What similarities exist between their designs?
   d. What are their differences and why may they exist?
4. Show the video "12 Most Amazing Bridges Ever Built" found at edu.STEMjobs.com/teacher-resources to illustrate different bridge designs.

Part 2: Explore

1. Break students into groups of three or four.
2. Allow students to select a bridge design of interest, or assign a bridge design to each group. Ensure that no two groups are researching the same design. Bridge designs include:
   a. Truss
   b. Beam
   c. Suspension
   d. Cable-stayed
   e. Arch
   f. Tied Arch
   g. Cantilever
3. Using their research, have groups create a presentation to teach the class about their bridge design. The presentation should include a description of the design, why it is used, strengths, weaknesses, and famous examples.
4. Hint to students that their research and presentations will assist them in an engineering challenge later in the lesson.

Part 3: Explain

1. Groups will present their bridge design research to the class. Students should share their research using presentation software such as PowerPoint or Google Slides. Students should explain their bridge design, its strengths, its weaknesses, and examples of it in the real world.
2. Allow students to ask questions following each presentation.

Part 4: Elaborate

1. Present the engineering challenge to students: Create a bridge using only spaghetti and glue. The bridge must be able to cross a 1 meter space between 2 tables of the same height, have a roadbed at least 5 cm wide, and be able to hold weight suspended from its center. Bridges cannot be attached in any way to the table or floor. Bridges will be scored based on the mass held divided by its total mass. The best score wins! (You may provide more detailed constraints for additional challenge.)
2. Provide time for students to brainstorm and build their spaghetti bridge.
3. When students are ready, hold a class competition. If available, invite school administrators and local civil engineers to help judge the event.
4. Measure the mass of each bridge prior to testing. Allow students to observe other groups' creations in a gallery walk.
5. To perform weight testing, use magnets, nylon strap, rope, or other means of hanging a series of weights from the center of the bridge. Score each design by dividing the mass successfully held by the mass of the bridge itself to determine the strongest bridge.
6. Consider allowing students to vote on designs in categories such as most creative design, most visually appealing design, and best craftsmanship.

Part 5: Evaluate

Students will be evaluated for their presentation and spaghetti bridge using the following rubric.
Provide the rubric at the beginning of the lesson to clarify expectations and objectives.
Each group will be graded, therefore all students in the group will receive the same score.

Scoring Rubric

____ **/20 Presentation**
- Was research on the design completed?
- Was the information accurate?
- Were the bridge design's strengths and weaknesses described?
- Was the presentation clean and easy to understand?

____ **/20 Bridge**
- Does the bridge span at least 1 meter?
- Was the roadbed at least 5 cm?
- Was the bridge only made of spaghetti and glue?
- Was the information from the presentations considered in design?

____ **/10 Participation**
- Did each student contribute to the overall project?
- Did each student assist in creating the presentation and bridge?

____ **/50 Total**

Standards Addressed:

Common Core State Standards - Math

CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.
CCSS.MATH.PRACTICE.MP4 Model with mathematics.
CCSS.MATH.CONTENT.6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
CCSS.MATH.CONTENT.7.RP.A.3 Use proportional relationships to solve multistep ratio and percent problems.

Common Core State Standards - ELA

CCSS.ELA-LITERACY.RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
CCSS.ELA-LITERACY.W.6.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.W.6.7 Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.
CCSS.ELA-LITERACY.W.6.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
CCSS.ELA-LITERACY.W.6.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
CCSS.ELA-LITERACY.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.
CCSS.ELA-LITERACY.SL.6.5 Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.
CCSS.ELA-LITERACY.W.7.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.W.7.7 Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation.
CCSS.ELA-LITERACY.W.7.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
CCSS.ELA-LITERACY.W.7.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
CCSS.ELA-LITERACY.SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.
CCSS.ELA-LITERACY.SL.7.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
CCSS.ELA-LITERACY.W.8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.W.8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
CCSS.ELA-LITERACY.W.8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
CCSS.ELA-LITERACY.W.8.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
CCSS.ELA-LITERACY.SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
CCSS.ELA-LITERACY.SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

Standards Addressed (Cont.):

Next Generation Science Standards

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.
Science and Engineering Practices
Asking Questions and Defining Problems. Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
Disciplinary Core Ideas
ETS1.A: Defining and Delimiting Engineering Problems
The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
Crosscutting Concepts
Influence of Science, Engineering, and Technology on Society and the Natural World. The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
Science and Engineering Practices
Engaging in Argument from Evidence. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.
Disciplinary Core Ideas
ETS1.B: Developing Possible Solutions
There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a 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.
Science and Engineering Practices
Analyzing and Interpreting Data. Analyze and interpret data to determine similarities and differences in findings.
Disciplinary Core Ideas
ETS1.B: Developing Possible Solutions
There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
ETS1.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 into the new design.

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.
Science and Engineering Practices
Developing and Using Models. Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.
Disciplinary Core Ideas
ETS1.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.
Models of all kinds are important for testing solutions.
ETS1.C: Optimizing the Design Solution
The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

ISTE Standards for Students

4c Students develop, test and refine prototypes as part of a cyclical design process.
6a Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.
6b Students create original works or responsibly repurpose or remix digital resources into new creations.
6d Students publish or present content that customizes the message and medium for their intended audiences.

Texas Essential Knowledge and Skills- Math

6-8.1.A apply mathematics to problems arising in everyday life, society, and the workplace.
6-8.1.B use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution.
6-8.1.D communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.
6-8.1.E create and use representations to organize, record, and communicate mathematical ideas.
6.4.B apply qualitative and quantitative reasoning to solve prediction and comparison of real-world problems involving ratios and rates
6.4.E represent ratios and percents with concrete models, fractions, and decimals
7.4.D solve problems involving ratios, rates, and percents, including multi-step problems involving percent increase and percent decrease, and financial literacy problems

Standards Addressed (Cont.):

Texas Essential Knowledge and Skills- Science

6-8.1.B practice appropriate use and conservation of resources, including disposal, reuse, or recycling of materials
6-8.2.A plan and implement comparative and descriptive investigations by making observations, asking well defined questions, and using appropriate equipment and technology
6-8.3.A analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student
6-8.3.C identify advantages and limitations of models such as size, scale, properties, and materials
6.11.B understand that gravity is the force that governs the motion of our solar system