5-E Classroom STEM Activity: Building Bridges

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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

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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.*

5-E Classroom STEM Activity: Building Bridges

Here are some ideas for how high 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*[SM] 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.

Common Core State Standards - ELA

CCSS.ELA-LITERACY.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
CCSS.ELA-LITERACY.RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
CCSS.ELA-LITERACY.RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
CCSS.ELA-LITERACY.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. quantitative data, video, multimedia) in order to address a question or solve a problem.
CCSS.ELA-LITERACY.RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
CCSS.ELA-LITERACY.SL.9-10/11-12.1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10/11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
CCSS.ELA-LITERACY.SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
CCSS.ELA-LITERACY.WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
CCSS.ELA-LITERACY.WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Next Generation Science Standards

ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
Science and Engineering Practices
Constructing Explanations and Designing Solutions. Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Disciplinary Core Ideas
ETS1.C: Optimizing the Design Solution
Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
Science and Engineering Practices
Constructing Explanations and Designing Solutions. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Disciplinary Core Ideas
ETS1.B: Developing Possible Solutions
When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

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

A.1.A apply mathematics to problems arising in everyday life, society, and the workplace.
A.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.
A.1.D communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.
A.1.E create and use representations to organize, record, and communicate mathematical ideas.

Texas Essential Knowledge and Skills- Science

P.3 The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom.
P.4 The student knows and applies the laws governing motion in a variety of situations.