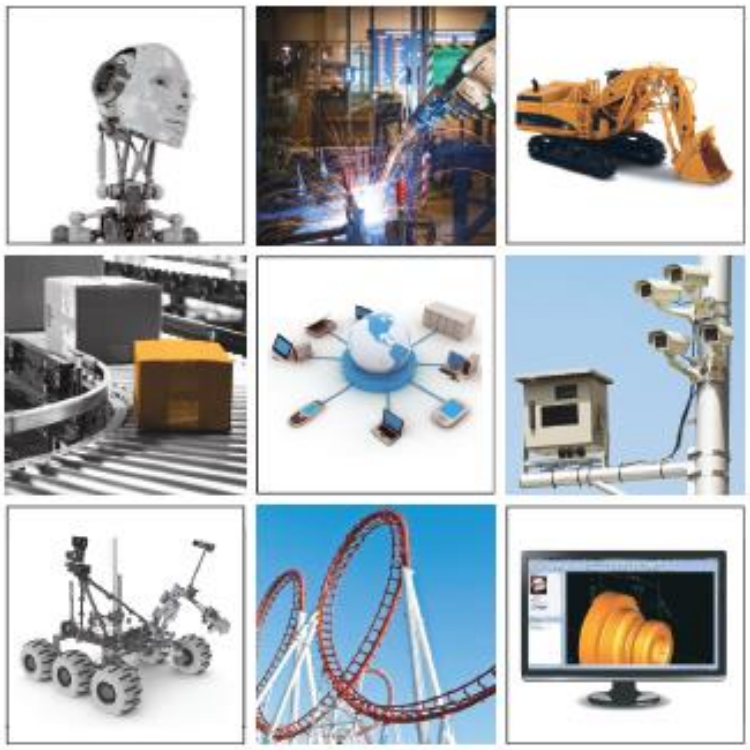
SREB | High Schools That Work

Advanced Career

Middle Grades STEM Curricula



College or Career?...Why Not Both?

Middle School STEM Projects

Project Title	Summary	Career Pathways
1. **Bridging The Gap** (Engineering)	Teams design, build and test a model Balsa wood bridge.	Architecture & Construction
2. **Reducing Waste, One Package at a Time** (Materials Science)	Teams reverse engineer a product package and redesign it so that it maintains form and function but contains at least 20 percent less material.	Engineering & Technology
3. **3-D Imaging** (Manufacturing)	Teams design a coin using Solid Edge for the design process and a 3-D printer to produce the prototype. The prototype must have at least 25% less surface area than a quarter.	Design/Pre-Construction
4. **Coding for Fun** (Computer Science)	Teams design, develop and test a computer game for middle grades students.	Programming & Software Development
5. **Harnessing the Wind** (Renewable Energy)	Teams design, build and test a blade for a wind turbine.	Power, Structural & Technical Systems
6. **Sound the Alarm** (Logistics)	Teams design and evaluate a disaster preparedness plan for their community.	Health, Safety & Environmental Management
7. **Take a Tour** (Informatics)	Teams design, develop and evaluate an on-line story map of places in their community that might be of interest to tourists.	Information Technology
8. **Product Creation** (Food Science)	Teams develop a process for converting a fruit or vegetable to a nutritious chip. Teams also develop a method for evaluating their chip and their process.	Food Products & Processing Systems
9. **Outbreak** (Health Sciences)	Teams design, develop and evaluate a containment procedure for an outbreak in a rural community.	Health Sciences/Support Services
10. **Growing a Better Plant** (Biotechnology)	The title and focuSs of this project changed. It now involves teams developing and evaluating a more vigorous mustard plant.	Plant Systems
11. **Eye in the Sky** (Aerospace Engineering)	Students develop a process for using a GPS camera equipped drone to tag photographs of crops in order to assist farmers with the identification of problem areas.	Science & Mathematics
12. **Generating Electricity from the Sun** (Energy and Power)	Teams now design, build and test and model house equipped with photovoltaics that can be used to demonstrate the benefits of photovoltaics to potential customers.	Power, Structural & Technical Systems

EXCERPTS FROM MS STEM PROJECT
PROJECT 1 - BRIDGING THE GAP

ACKNOWLEDGEMENTS

This Middle School (MS) STEM project was developed as part of the MSSTEM Curriculum Development Initiative, a partnership with the West Virginia State Department of Education and the Southern Regional Education. The goal is to prepare more students for rigorous career-technical and academic studies at the high school level so that they graduate both college- and career-ready and fully prepared to pursue an array of postsecondary options. Thanks to the Middle School STEM teachers and administrators, industry partners, and academic leaders involved in the planning, development, and field-testing and of this program of studies.

PURPOSE OF THE PROJECT

According to Infrastructure Report Card (http://www.infrastructurereportcard.org/), over 200 million trips are taken daily across deficient bridges in the nation's 102 largest metropolitan regions. The average age of America's 607,380 bridges is 42 years. The Federal Highway Administration (FHWA) estimates that to eliminate the bridge deficient backlog by 2028, 20.5 billion dollars need to be invested annually, compared to the 12.8 billion currently spent. This includes the repair of current bridges and the construction of new bridges. Clearly, the need to design efficient bridges, that can last a long time and remain stable for longer periods of time, is critical.

Federal and state laws restrict the weight of vehicles that pass across bridges. Moreover, federal and state budgets often constrain the amount of construction that can occur. Therefore, sound decisions must be made by bridge designers to get the most effective bridge at the lowest possible cost. Therefore, students will learn how to build a bridge of a prescribed size to withstand a certain amount of force within a given budget.

The purpose of this project is for students to design, build, and test a bridge prototype. The prototype's specifications are 12" x 2." The goal is to build a bridge with a high supported weight to bridge weight ratio.

Teams are provided with a materials cost list and a budget. After researching bridge design, students decide upon the best design for their bridge. However, each team must then decide which materials are affordable within their budget and decide about any compromises in their bridge structure that may result. Teams must also budget for any improvements needed if the testing data indicates a problem.

PROJECT DESCRIPTION

Your team is part of a civil engineering group. A new bike path is being constructed and needs a bridge to cross a stream. The bridge will span a distance of sixty feet and needs a deck that is 10 feet wide to accommodate two bicycle lanes as well as access for emergency vehicles. The bridge must support the weight of the emergency vehicle.

Your team will research bridge types and discuss the loading the bridge will support. The team will create a design for the bridge and construct a scale model. The object is to design a bridge with the largest strength to weight ratio keeping the use of materials to a minimum. Your team will submit a budget with the design for the bridge prototype. The table below represents the scaled costs for materials which your team will use to create the bill of materials. Additional materials beyond those submitted on the bill of materials may be purchased during construction for twice the original price.

Quantity	Material	Price per Unit
1	File folder or other think paper	$200
1	Inch of Masking Tape	$400
1	1 Lineal Inch of 1/8" x 1/8" Balsa Wood (Structure)	$1,000
1	1 Lineal Inch of 3" x 1/8" Balsa Wood (Road Decking)	$8,000
1	1 lineal inch of string	$100
1	.5 OZ white glue	$7,500

As you watch videos and read informational texts on the principles of bridge design, you will begin an Engineering Notebook. You will participate in enabling learning activities to assist you in designing, building, and testing a bridge prototype. You will be introduced to a Design Brief and Engineering Report, the documents used by engineers. Your team will discuss and document the design and structure of your bridge prototype and evaluate it in terms of load supported. Support your discussion with evidence from the texts, and prepare a presentation of your work for the class and guests from the engineering community.

Middle School STEM Projects
Engineering Design Process (EDP) and Sample Project Overview
(Based on Project 1 - Bridging the Gap)

EDP STAGE 1: ASK/INQUIRE (Blocks 1 – 5)

Deliverables: List of criteria/constraints and a refined problem statement.

Key Questions:
- *What is our project about?*
- *How will we manage our project?*
- *What type of help/assistance can we expect during the project?*
- *What baseline information do we need to begin our project?*
- *What are our limitations and how do we know when we are successful?*
- *How do we define the problem we are solving?*

Overview:
Students begin by watching bridge collapse videos and then review the project documentation. Teams read articles relating to the project and begin their independent research and vocabulary documentation. This stage closes with the refinement of the problem statement, and the Engineering Notebook is introduced.

EDP STAGE 2: IMAGINE (Blocks 6 – 14)

Deliverables: List of criteria/constraints, a refined problem statement and a communication plan

Key Questions:
- *What additional information do we need?*
- *How can we use the concepts of ratio and proportion to develop scale drawings?*
- *What are some potential solutions to our problem?*
- *Is our planned approach acceptable to our customer?*

Overview:
Teams begin to develop a comprehensive project management plan, conduct research, participate in two enabling learning activities – forces and ratio/proportion (mathematics lesson) and brainstorming possible solutions to the problem. The Design Brief is introduced.

EDP STAGE 3: PLAN (Blocks 15 - 19)

Deliverables: Testing protocol and decision matrix

Key Questions:
- *How good are our brainstormed solutions?*
- *How will we test our solution to determine if it accomplishes what we want?*
- *How will we select the best solution?*

Overview:
Teams conduct research to determine the viability of their solution; identify alternatives; and record research and reflections in their Engineering Notebooks. Teams design a testing protocol/method to determine the quality of their solution and develop a decision matrix to select a solution/design.

EDP STAGE 4: CREATE (Blocks 20 - 24)

Deliverable: Prototype

Key Questions:
- *How do we document our design?*
- *How do we create our prototype?*

Overview:
Teams have determined their solution/design and now begin to develop, refine, and document their selected solution. Teams focus on creating plans for their prototype with sketches, renderings, working drawings, charts, bill of materials, etc. Teams should create a list of materials in alignment with the proposed budget. Teams should also order materials. Finally, teams complete their prototype.

EDP STAGE 5: EXPERIMENT/EVALUATE (Blocks 25 - 26)

Deliverable: Analysis of the prototype

Key Questions:
- *How do we employ our testing protocol to test our prototype?*
- *What does the data tell us about our design?*

Overview:
Teams use their testing protocol to test their bridge and collect and analyze pertinent data. Students continue to add information to their Engineering Notebooks and make adjustments to their Design Brief.

EDP STAGE 6: IMPROVE (Blocks 27 - 29)

Deliverable: Final documentation

Key Questions:
- *How do we finalize our documentation?*
- *How do we analyze our final results? What knowledge did we gain? How do we make sure that our final documentation fits our final design?*

Overview:
Teams use the test data acquired to improve their designs as needed and to further develop understandings. Teams finalize and formalize the communication about their documentation and capture all the analysis. The Engineering Report is introduced.

EDP STAGE 7: COMMUNICATE (Blocks 30 - 35)

Deliverables: Presentation and reflection.

Key Questions:
- *How well did our communication plan work?*
- *How will we write our Engineering Report?*
- *How will we prepare our final presentation to an authentic audience?*
- *How will our group present our bridge design to an authentic audience?*
- *What have I learned while completing this project*?

Overview:
Teams will review their communication plan, make adjustments as needed, and prepare their final presentation. They present to the authentic audience, and the project closes with the project reflection and End-of-Project Assessment.