Zome System

Builds Genius!

Bridge Building Project

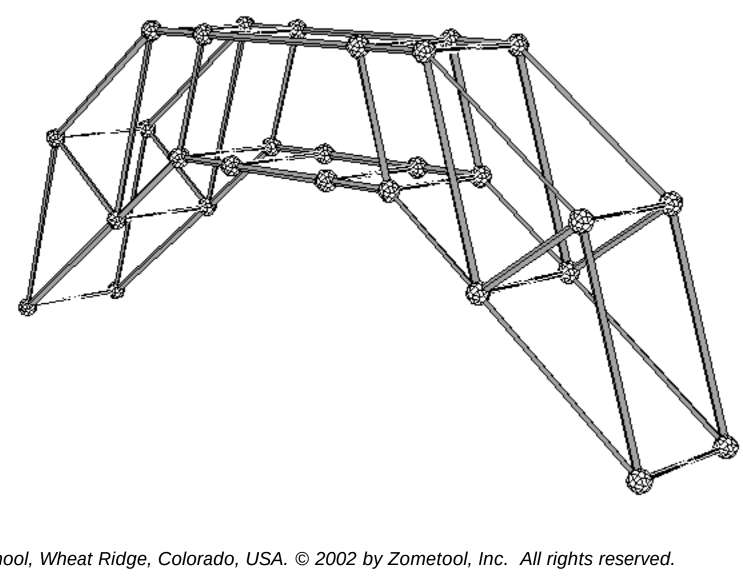
Integrated Unit
Intermediate Concept

Unit Objective:
In this unit students will design and build models of a bridge intended for a local creek or river. They will learn how to develop plans and descriptions of the bridge, calculate a budget covering all project costs, and build scale models with Zome System elements. They will also make written and oral presentations of their designs. During the project students will address numerous concepts including measurement (metric and British/US standard,) basic geometric concepts such as lines, rays, angles; shapes, perimeter, area, scale, and decimals, budgeting and accounting, technical writing, presentation skills, and science concepts including stress and gravity.

Prerequisite Skills:
Students must know basic geometric shapes ("Geometric Shapes"). They should also be able to use a protractor (Attention Angles!," and "Trying the Triangle").

Time Needed:
The unit may take between 6 and 9 weeks if your students work on it for 45 minutes per day. The exact time will depend on how deeply you concentrate on each component.

Materials Needed:
- Two Zome System Creator Kits for 20-24 students
- Building project plans and blueprints of different types: bridge plans, house plans etc. Can be obtained at the library, through architects and building companies, and at some local hardware stores. Some schools may have plans made by students in earlier years.
- any good books on bridges, buildings, and structures
- protractors
- cardboard
- meter stick, yard stick, rulers
- three old telephone books (metric and British/US standard)
- masking tape
- graph paper
- tape measure



Unit by Susie Van Scoyk, Pennington Elementary School, Wheat Ridge, Colorado, USA.

Procedure:

The unit contains 20 components, each teaching different concepts. The four components listed first use Zome System, and are described in detail. The later 16 components are outlined briefly below, and should be planned using other resources. In many cases it is appropriate to run several component simultaneous. Each group of students can work on a component until they have completed all its tasks. As your students complete the self-directed assignments they can rotate to the next station.

graphic of bridge built with Zome System

Explain to your class that they are about to start a project that will take them several months to complete. They will be divided into teams of 3-4 students for the duration of the project. Each team will form a small construction company that is competing with other companies to build a bridge over a local creek or river. The County Commission (substitute applicable governmental entity) will choose which company will win the bid. The bidding process will include the tasks listed below. You may want to post the task descriptions in a prominent location in your class room.

• giving the Commissioners plans and descriptions of the bridge
• presenting the Commissioners with a Zome System model of the bridge that follows the building code.
• presenting an itemized budget of all costs, including construction materials, salaries, and land.

1. Metric Measurement. A math station intended to prepare the students for the bridge building unit. Students should read and follow the directions on the attached instruction sheet. The instruction sheet, which should be photocopied for each student, also serves as an evaluation form for the teacher.

2. Making Plans. A math station to prepare the students for the bridge building unit. Students should read and follow the directions on the attached instruction sheet. The instruction sheet, which should be photocopied for each student, also serves as an evaluation form for the teacher.

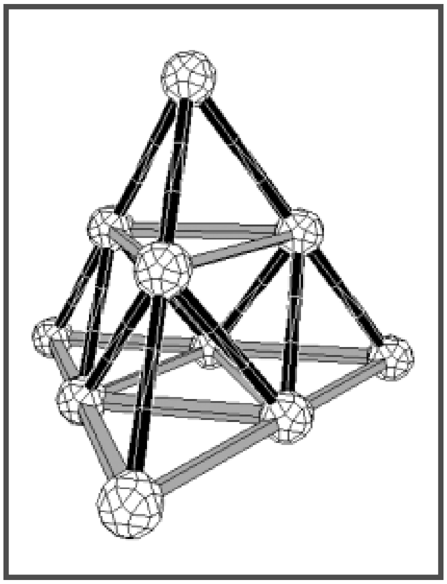
3. Construction Crew Wanted. A math and construction station providing a shorter practice project to prepare the students for the bridge building unit. Students should read and follow the directions on the attached instruction sheet. The separate evaluation sheet should be photocopied for each student.

4. Building to Scale. A math station providing the students with a greater knowledge of the concept of scale. Students should read and follow the directions on the attached instruction sheet. The instruction sheet, which should be photocopied for each student, also serves as an evaluation form for the teacher.

5. Create a Tile. This component is needed to review the basic concepts of symmetry and shapes.

Zome System lesson plans on tiling and tessellation are recommended ("Trying Tessellation," Plane Patterns," "Triangle Tiles," and "Translational Symmetries in Tilings").

6. Angles. You need to provide one component addressing the measurement of angles. Students need to know how to differentiate between and build right, obtuse, and acute angles. Zome System lesson plans on angles are recommended ("Attention Angles!").



7. Mighty Triangle. One station should be devoted to experiments with weight and rigidity. One goal for these directed experiments should be to show the students that they need to incorporate triangular trusses in their bridges. The trusses can of course be built with Zome System (3-D Triangle Tiles).

8. Feel Like a Building. Students need a general section dealing with different architectural features. You should expose them to both engineering elements such as trusses, and to design consideration and architectural styles. Most libraries have resources to address this component.

9. History of Bridges. This component should focus on the historical development of bridge design and construction. Your students can gain this historical perspective through books, videos, and museum visits. Their research will help them make to connections to history, culture, and art.

10. Bridge Design. A more specific component examining different types of bridge design and their purposes. Use Zome System to build the various bridge features.

11. Soil Samples. Studies of soil and geology will help your students adapt their bridge design to suit their chosen location. This learning can be achieved with site visits, lab work and text books.

12. Hydrology. Theoretical hydrology is important when deciding how a bridge may be affected by erosion of the river's banks and its bottom. There are several good books and videos in the market that deal with this topic.

13. Build a River. A lab component demonstrating water flow and erosion. Many children's museums have displays of this type, and a classroom version can be made with a trough, a garden hose, and sand and gravel.

14. Field Trip. A visit to the creek will prompt discussion of the environmental effects of construction projects. Your students can also document terrain features that they will have to take into account when designing their bridge.

15. Newspaper Articles. Ask your students to read about high school model bridge building contests and related topics.

16. Speakers. Attempt to bring in parents or other people from the community who work in professions that can be related to the bridge unit. Examples include civil engineers (builds structures), geologists (soil samples), construction foremen (working from building plans), naturalists (environmental impacts), etc.

17. School to Work. It is helpful to use one section for a discussion of occupations and skills that are required in the type of construction projects the students are modeling.

18. Budgets. Students will need a comprehensive session on the concept of projected cost in order to make their projects realistic. In addition to traditional text books, it is possible to obtain materials on budgeting and economics from various business organizations.

19. Reflective Essay. Student essays should contain rationale for their site selection, bridge design, and other concepts they have learned from the unit.

20. Project Presentation. In this final component the students will make an oral presentation of their proposed bridge to a panel of "commissioners" (can be parents, teachers, or other students). The presentation should address the selected site, design of the bridge, and their budget. Other features that can be required include a display of detailed building plan on graph paper, and graphic representation of the budget.

<u>Assessment</u>:
Assessment will involve continuos student observation, individual and group questioning, and review of their presentations, essays, and the notes taken during each component. Achievements required to meet and exceed the standards will vary with each component.

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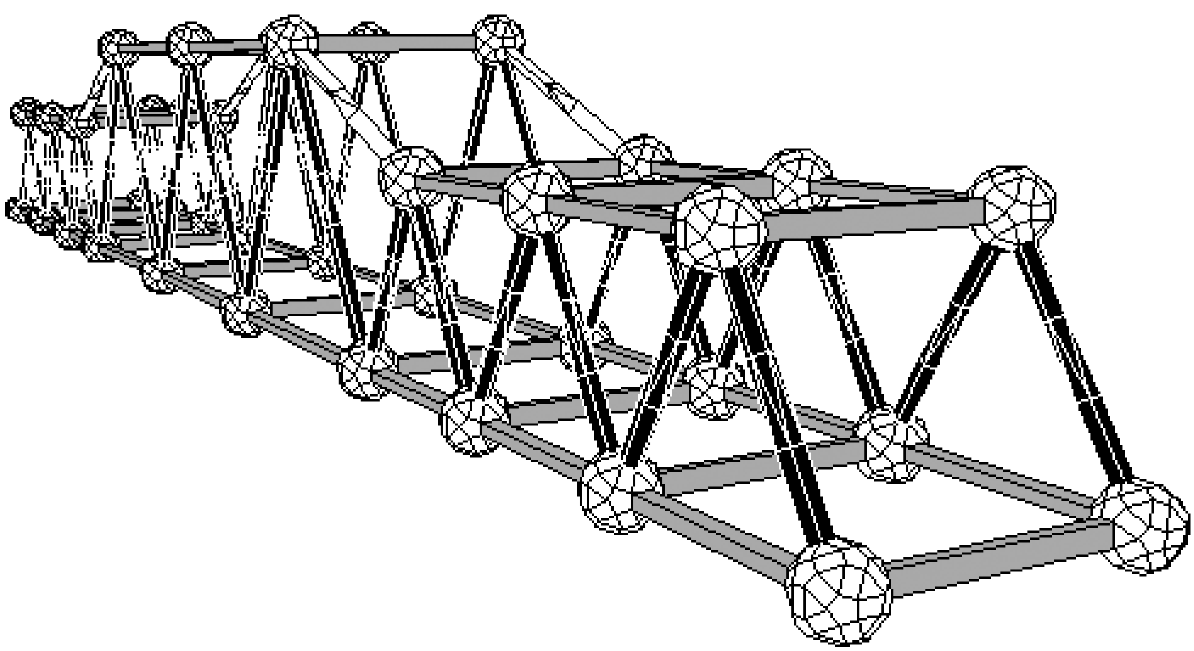
Standards Addressed:
* Mathematics standards addressing mathematical problem solving as a method of inquiry and application (NCTM Standard 1).
* Mathematics standards addressing investigation of mathematical connections (NCTM Standard 4).
* Mathematics standards addressing the study of the geometry of one, two, and three dimensions in a variety of situations (NCTM Standard 12).
* Mathematics standards addressing extensive concrete experiences using measurement (NCTM Standard 13).
* Language Arts standards requiring students to write and speak for a variety of purposes.
* Language Arts standards requiring students to apply thinking skills to their reading, writing, speaking, listening, and viewing.
* Physical Science standards requiring students to know and understand common properties, forms, and changes in matter and energy.

Transfer Possibilities:
The unit provides numerous connections to other subjects. Examples include architectural design and other forms of applied arts, city planning policy ("The Livable City"), more advanced work on budgeting and business finance, etc.



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Making Plans

Materials needed: 10-20 of each Zome System element. Protractors, rulers, graph paper. Building plans provided by your teacher.

Name:____ Date:________________

Step I
Select one set of plans. Measure the angles using a protractor and write them down. Did all members of your group get the same results?

Step II
Build a simple three-dimensional Zome System structure.

Step III
Make plans of your structure on graph paper. You must include the angle dimensions. Remember you must have your name on the plans.

Step IV Bonus
Make your plans in more than one color.

Metric Measurement

Materials needed: math textbook or dictionary, meter stick, yard stick, rulers (standard and metric), 10 of each Zome System strut.

Name:____ Date:________________

Step I

Look up the word metric in your math book, write the definition:

Look up the word meter, write the definition:

Look up the word centimeter, write the definition:

Examine the meter stick. How many centimeters are there in a meter?

Which is longer the yard stick or the meter stick?

Why?

Measure the Zome System struts in centimeters (cm) then in inches (in.).

	Centimeters (cm)	Inches (in.)
1. short red		
2. short blue		
3. short yellow		
4. medium red		
5. medium blue		
6. medium yellow		

	Centimeters (cm)	Inches (in.)
7. long red		
8. long blue		

9. long yellow

How are <u>centimeters</u> and <u>inches</u> similar to each other?

How are they different?

Look at your ruler again, the smallest unit of measurement on the centimeter side is a millimeter (mm). How many millimeters in a centimeter? In a meter? Measure the Zome System struts in millimeters and place this column next to the inches column above. Which measurement system do you like best? Why?

Step II

Construct three two-dimensional (flat) Zome System shapes. Using your measurement chart add up the centimeter measurement of each strut for each shape. Draw your shape and then write the totals below.

Shape 1 Shape 2 Shape 3

_____cm _____cm _____cm

Look up the word <u>perimeter</u> in your math book, write the definition:

What would be the <u>perimeter</u> of each shape in inches?

Shape 1_______________ in. Shape 2_______________in. Shape 3______________in.

Construction Crew Wanted

Materials needed: half set of Zome System, three old phone books

Each crew will:
- create the tallest possible structure that will support three phone books
- stay within a budget of $2,400,000
- keep complete, accurate records of all your experiments
- complete the evaluation form

Each crew must purchase their supplies from Zome System Building Supplies.

Building materials	Cost
Nodes	$1,000 each
short:	
red struts	$500 each
blue struts	$525 each
yellow struts	$550 each
medium:	
red struts	$1,500 each
blue struts	$2,000 each
yellow struts	$2,500 each
long:	
red struts	$3,000 each
blue struts	$3,500 each
yellow struts	$4,000 each

Evaluation Sheet for Construction Crew Wanted

(to be done individually)

Name:____ Date:________________

1. What did you learn about structures when doing this station?

2. What did you learn about budgets by doing this station?

3. How is this budget the similar to those you have done in other classes.

4. How is this budget different than those you have done in other classes?

5. If you could repeat this task what would you do differently?

6. If you could repeat this task what would you do the same?

7. On a scale of 1- 5, 5 being excellent, how did your group work together?

8. Why did you give your group that rating?

Building to Scale

Materials needed: 10-20 of each of the blue struts, 40-60 nodes, making tape, tape measure

Name:____ Date:________________

Step 1
Measure all of the blue struts using the inches side of your ruler.

Short blue strut ____________________in. Medium blue strut _________________in.

Long blue strut ____________________in.

Step 2
Convert the inches to feet. The scale is 1" = 1 ft.

Short blue strut __________________ft. Medium blue strut __________________ft.

Long blue strut __________________ft.

Step 3
Using a tape measure, measure the scale footage. Take masking tape and mark the scale footage on the floor. Lay the Zome System on the floor next to the tape.

What do you observe?

What's the same in both?

What's different?

Step IV Bonus
Build a simple structure using the blue struts. Draw your structure on graph paper labeling the measurements in both inches and feet.

Zome System Warehouse Price list

<u>Materials</u>	
Land (cardboard)	$500,000
Building Materials (all colors)	
Short struts	$10,000 per 5
Medium struts	$15,000 per 3
Long struts	$25,000 per 3
Welding material (nodes)	$250 each
Building plan paper (4 sheets graph paper)	$25,000
Extra sheets of graph paper	$10,000 per sheet
<u>Services:</u>	
Audit Service	$2,000
Conflict Management	$5,000

<u>Fines</u>

Your company may be fined for any of the following infractions:

• disturbing other companies	$400
• leaving messy construction sites	$550
• handling bridges that are under construction by other companies	$1,000