

**Lesson Objective:**

Two-dimensional shapes can define planes of space within a three-dimensional structure. Students will learn how a two-dimensional shape becomes a three-dimensional object.

**Lesson Description:**

Students will draw the two-dimensional shapes observed in three-dimensional forms and then manipulate these two-dimensional shapes to create planes of space in a different three-dimensional form.

**Lesson Goals & Assessment Criteria:**

**Target:** Students represent the planes of space of a 3-D form.

**Criteria:** Students sketch the 2-D shapes observed from different viewpoints of a 3-D form.

**Target:** Students transfer sketches of 2-D shapes onto poster board paper.

**Criteria:** Students use measuring tools to approximate geometric shapes.

**Target:** Students create 3-D form from 2-D planes of space

**Criteria:** Students attach paper shapes, using only cut notches, for height, width and depth.

**Target:** Students manipulate paper in at least two different ways.

**Criteria:** Students fold, twist, curl, crumble, notch, score, and/or cut-out etc. paper shapes.

**Target:** Students create a self-standing form.

**Criteria:** Students form a stable base.



Source: [www.community.webshots.com](http://www.community.webshots.com)

**Integrated Subjects:**

Math

Visual Arts

**Suggested Grade Levels:**

2nd-5th

(See Lesson Adaptations section for use with upper and lower grades)

**Essential Academic Learning Requirements (EALRS):**

Arts 1.1

Arts 1.2

Arts 2.1

Math 1.2

Math 1.3

**Lesson Duration:**

Up to four one-hour class periods

**MATERIALS:**

- Geometric 3-dimensional forms
  - cubes
  - spheres
  - cylinders
  - cones, etc
 (or modeling clay such as Model Magic synthetic clay)
- colored poster board
- scissors

**THE LESSON:**

**Suggested Pre-Lesson:** In the following lesson, the students are asked to create a structure with tag or poster board without using tape, staple or glue. Have the students experiment with the material to discover the different ways they can manipulate the paper to make it attach. Start by brainstorming the different ways the paper can be handled, i.e., fold, twist, crumple, notch, fray, etc., and then ask students “play with” the paper to find more ways to manipulate it.

**Day One – Two-dimensional vs. Three-dimensional space**

**Teacher:** Introduces lesson concepts of two-dimensions and three-dimensions.

***Prompts:** 2-D means you can measure the height and width of something; 3-D means you can measure the height, width and depth. A shape, such as a square, is 2-D, and cube is 3-D. Can you tell me the difference between the two? Or, you can think of a loaf of bread as a 3-D form, and a slice of bread as a 2-D form?*

*We are going to explore how to translate 3-D geometric forms into 2-D shapes and then how to go back from 2-D shapes into a new 3-D form. Let's first create a 3-D form with blocks.*

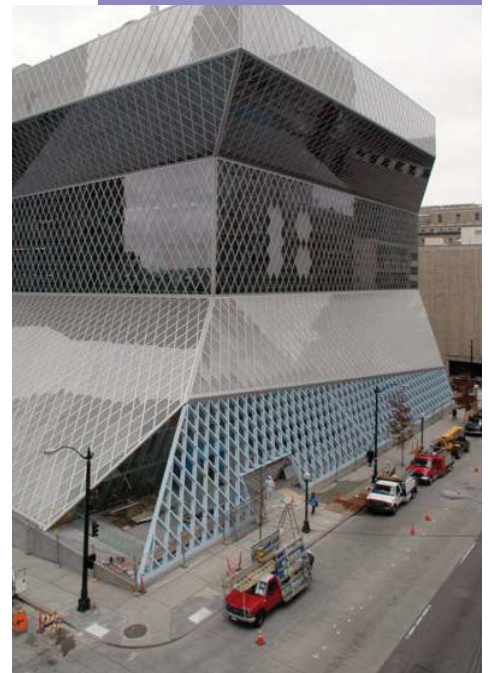
Hands out blocks. (For older students, have them use modeling clay to create forms such as cubes, cones, cylinders, spheres and then attach them.)

**Student:** Explains differences between 2-D and 3-D forms. Manipulates blocks (or modeling clay) to create 3-D forms.

**Teacher:** Instructs students to observe their 3-D form from two different view points and sketch the shapes that they see.

***Prompts:** Look at your form from different angles, perhaps from the side and from above. Draw the 2-D shape that you see. For example, if you are looking at one side of a cube, you can represent this side of the cube by drawing a 2-D square, or a sphere can be represented by a 2-D circle. These shapes take up space we can call these “planes of space.”*

**Student:** Draws various 2-D shapes represented by the 3-D forms of the overall form they have built.

**TEACHER NOTES:**

Seattle Architecture Foundation

**TEACHER NOTES:****Day Two – Planes of Space in Architecture**

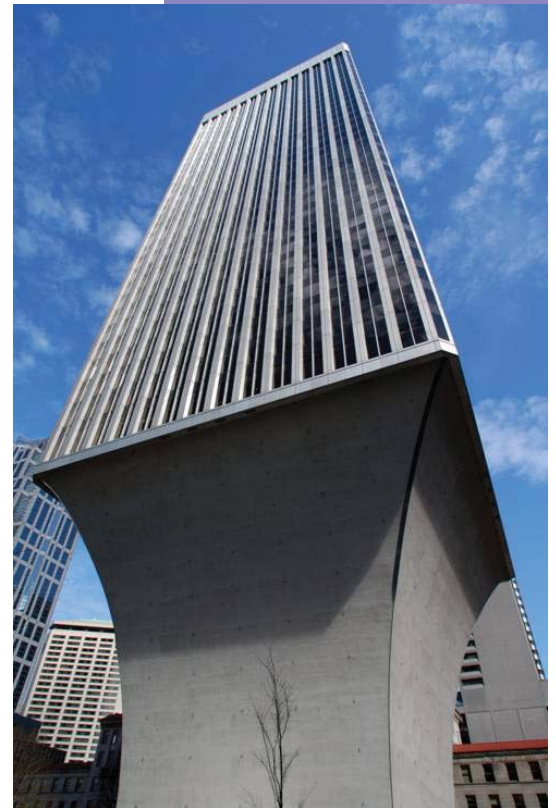
**Teacher:** Shows examples of the use of shapes in architecture and how architects use “planes of space” to design various building forms.

**Prompts:** *Shapes are an important part of architecture. As you look at this photograph of the Seattle skyline, what shapes do you see? Each of these shapes make up buildings.*

*Architects draw plans on paper in 2-D but have to envision how those shapes will look when they become a 3-D building. Architects think about how the 2-D shapes they draw on paper are like “planes of space” or shapes that take up space. Architects experiment with many different ways to arrange planes of space. For example, connecting four rectangular planes of space can create a tall box shape like you see in skyscrapers.*

Shows image of downtown Seattle skyscraper, such as Key Tower. Demonstrates how four planes connect by showing the four sides of a rectangular box, such as show box on its side.

**Prompts:** *Some architects change the planes of space a little bit to make the building more interesting or surprising. Show image of Rainer Tower, pointing out the concave walls at the base of the building. Other architects experiment even more with the planes of space to make you think differently about what a building should look like. The architect of the new downtown library, Rem Koolhaas, seems to have taken rectangular and triangular planes of space and shifted them around. Some are tilted up; some are tilted down; some lie vertically, and some are horizontal. Show images of The Seattle Public Library – Central Branch. Still other architects look like they have twisted, twirled and pulled the planes of space to really challenge people’s ideas of a building as a structure with four straight walls. Show images of Frank Gehry’s Experience Music Project.*



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**Student:** Observes examples of architectural uses of planes of space.

**Day Three – Constructing 3-D Forms from 2-D Shapes**

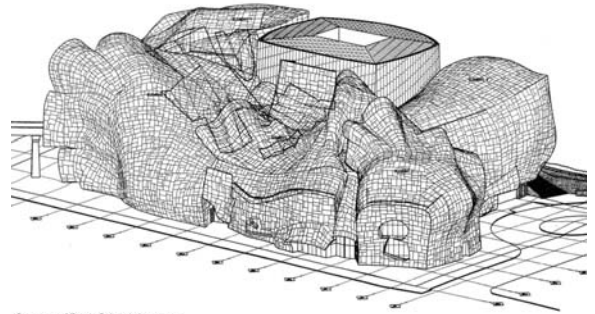
**Teacher:** Guides students to review the 2-D shapes they drew from observing the 3-D form. Leads them in re-configuring the shapes back into a new and unique 3-D form.

**Prompts:** *You took the 3-D form and translated it into various 2-D shapes, now I would like you to experiment with re-organizing those 2-D planes of space back into a new 3-D form. This time we are going to use a new material, colored poster paper. The criteria for this project will include that 1) you attach the paper so that you create height, width and depth; 2) that you use only scissors to attach the paper, no glue, staples or tape; 3) that you find at least two different ways to manipulate the paper, which represents your planes of space; and 4) your 3-D form will need to stand on its own, so consider how you will create a stable base.*

*I am challenging you to attach the paper without any tape, glue or staples because I want to use your creativity within a set of limits. Often architects are charged to find new solutions to a problem. A client might have specific criteria for a building (such as the space in the library had to be flexible enough to be able to add new books to its collection), and the architect needed to find a unique way to work within that criteria.*

Reviews pre-lesson on how to manipulate the paper or brainstorms with students. Writes student responses on the board.

**Student:** Reviews the shapes they drew. Brainstorms ways to manipulate the planes of space, such as fold, fan, twist, curl, crumple, ball, notch, score and cut-out.



Courtesy of Frank Gehry & Associates



© Experience Music Project photo by Stanley Smith

shapes, forms and planes of space: **unit 5**

**Teacher:** Demonstrates use of measuring tools (ruler, compass and protractor) to draw geometric 2-D shapes directly onto the colored poster board. Assists them in measuring their shape sketches or approximating the measurement visually. Demonstrates cutting skills, if necessary (holding the scissors still with the blades upright and turn the paper to smoothly cut the edges). Models how to notch papers to attach them.

**Prompts:** *I make a small cut on both the shapes I want to attach. I make sure that my cut, called a notch, is deep enough that the paper does not fall out. But before I notch the papers to attach them, I want to consider how to manipulate each shape. Do I want to fold it, twist it, crumple it, etc.?*



© Experience Music Project photo by Lara Swimmer

**Student:** Measures sketches and draws the 2-D shapes onto the colored poster board. Cuts-out shapes and experiments with manipulating the paper. Considers placement of the paper to create height, width and depth to the overall form.

## CREATIVE SOLUTION !

By limiting how the students can attach the paper (no glue, tape, staples) you are asking the students to solve a problem that many of us are faced with in our every-day lives:

### How to work creatively within limits.

Often when students are given some limits, it encourages them to focus on the solutions and more creative ways to find them.

**Day Four – Class Critique of 3-D Structures**

**Teacher:** Leads criteria-based critique.

**Prompts:** *Let's go back to the four criteria we set up. Use your self-assessment checklist to review your work. Describe the challenges in re-organizing your planes of space. When were times you had to experiment and you found that it worked? Did you find more ways to manipulate the planes of space as you were working that we did not list earlier? You didn't need to create a form that would become a building, but if your form was a building, what kind of building might it be?*



Robert Purser

**Student:** Participates in class critique based on criteria.  
Completes self-assessment of work.

**TEACHER NOTES:**

**LESSON ADAPTATIONS:**

For students grades K-1:

The above lesson can be taught, but instead of students measuring and drawing shapes onto the poster board, provide them with pre-cut geometric shapes. Omit the discussion about planes of space and focus more on the shapes they see in architecture and the built environment in their own classroom.

Instead of using cut paper, have students experiment with creating unique shapes for structures using blocks or Legos. Ask students to write or talk about what their structures would be used for.

For students grades 6-8:

Use the above lesson as a pre-lesson to explore the concept of planes of space. Then ask students to observe a building and sketch the exterior of the building so the three-dimensions are represented. This could be done with their school building. Next have students walk the interior of the building and diagram the floor plan. To combine the two skills of drawing three-dimensions and diagramming a floor plan, ask students to draw a cut through of the building (from whatever direction they choose), showing the placement of the rooms, and their height, width and depth.

**SHAPING YOUR COMMUNITY:**

- Identify 2-D and 3-D shapes around your home. Find the shapes and sketch them from various angles.
- Then go on a "sketching tour " and visit the different buildings. Sketch them from various angles.
- Does the building look different on different sides?
- What is your opinion of buildings such as EMP or the Central Library that use building shapes in unique ways?
- How do people express their opinions about what a building looks like?

*TEACHER NOTES:*

**ADDITIONAL LESSON OPTIONS:**

- Use paper 3-D forms as a model for building. Students can fill out each plane of space so that each one has volume. Using clay, foam, plywood or heavier paper, they can build the form using other ways to attach the forms besides just scissors. Students can experiment with the stability of different thicknesses of the forms.
- Write and draw instructions on how to construct the 3-D forms students created, similar to instruction manuals for assembling toys or furniture.
- Reconstruct 3-D forms using found materials, such as aluminum foil, wire, ribbon, mesh, feathers, or beads. Students can consider the influence of adding texture to the three dimensions. For example, how textures emphasize either height, width or depth.
- Have students select an object of special significance to them, and inspired by Frank Gehry's methods (Experience Music Project's design was inspired by the shapes of broken guitars), observe and sketch the various planes of space. Then reconstruct these planes into a new object or a design for a fantastical dream home.
- Interview an architect about what inspires them when designing structures. Does he/she get inspired by other buildings or other objects, like Frank Gehry's use of broken guitar pieces as his inspiration for the EMP? Ask the architect how they have had to solve problems creatively in their projects.
- Create a pop-up book of students' neighborhoods. Use tag board or heavy construction paper to create the buildings that 'pop up' as each page is opened. Students might want to first take apart a pop-up book (ask the school library for some old ones) to see how it is constructed. Students can write a story about their neighborhood to go along with the images.

**TEACHER NOTES:**



**BACKGROUND INFORMATION:****Tower at Rainier Square**

The Tower at Rainier Square rises from an 11-story pedestal, leaving the streetscape around it open. Despite its 40-story height and 600,000 square foot size, the Tower occupies only 25 percent of the block. Before the building was built, its unique design was tested for strength in the event of a severe earthquake and then for stability during high winds. Finally, it was tested for comfort and was found to eliminate the “canyon effect” that creates strong winds that can occur around high-rise buildings.

**Central Branch of the Seattle Public Library**

The new downtown branch of the library, opening May 2004, is an easily navigable set of sloping floors for its nonfiction collection with dramatic views of the city and Elliot Bay. Components of the building include a “book spiral” which is a set of long ramps – each rising six feet as it extends the length of the library. There is also a 15,000 square-foot Children’s Department with sloping exposed concrete columns. Entering from the Fifth Avenue entrance, visitors will walk into the “living room” at the base of the building’s dramatic atrium. An area called the “Mixing Chamber” is where visitors find the reference desk, and Mixing Chamber staff can talk with librarians in the book spiral using wireless devices. The Meeting Floor consists of balconies, where visitors can watch others and scan the floors they want to visit next.

**Experience Music Project**

To design this building, architect Frank O. Gehry looked to music for his inspiration. To understand rock ‘n’ roll, Gehry bought several electric guitars, took them back to his office and cut them into pieces. The guitar pieces were the building blocks for an early model design. Influenced by the colors in the early model, Gehry’s final design brightly displays the red and blue hues of electric guitars. The outside of the building is as stimulating as what is on the inside. A fusion of textures and myriad of colors, the museum structure symbolizes the energy and fluidity of music. The exterior consists of stainless steel and painted aluminum shingles, each individually cut and bent to fit exactly in its designed location. The stainless steel has three finishes: mirrored purple, lightly brushed silver, and bead-blasted gold. The red and blue sections are painted aluminum. Each finish takes on an exciting and unique shade when viewed from different angles around the building. The red will fade with time, altering the appearance of the building’s exterior and reflecting how music is ever changing.

**List of Images:**

- *Seattle Skyline*
- *Seattle Central Library Ext.*
- *Rainier Tower*
- *Experience Music Project*
  - *Drawing*
  - *Model*
  - *Photograph*
- *Space Needle*

Images for each unit can be found on the SAF website @ [www.seattlearchitecture.org](http://www.seattlearchitecture.org)

**Related Lesson Plans**

*Community Geometry, Mathline Lesson Plan Grades 3-7* ([www.pbs.org/teachersouce/mathline/concepts/architecture/activity2.shtml](http://www.pbs.org/teachersouce/mathline/concepts/architecture/activity2.shtml))

*Pattern that Thump, Bump and Jump, Educator Resource Packet, National Building Museum, 2001* ([www.nbm.org/education/educator/guides/html](http://www.nbm.org/education/educator/guides/html))

**Websites:**

*Experience Music Project* ([www.emplive.com/visit/about\\_emp/building.asp](http://www.emplive.com/visit/about_emp/building.asp))

*Seattle Central Library* ([www.spl.org](http://www.spl.org))

**VOCABULARY:**

**Diagonal** – Having a slanted or oblique direction.

**Form** – A shape that is, or appears to be, three dimensional having height, width and depth.

**Geometric** – Shapes, such as squares, triangles and circles, derived from man-made objects as opposed to more organic shapes found in nature.

**Horizontal** – Parallel or in line with the horizon line.

**Model** – A small object, usually built to scale, that represents in detail another, often larger object.

**Notch** – A cut in a paper that can be used to hold another piece of paper.

**Plane** – A surface.

**Space** – An element within art that refers to the distance or area between, around, above, below or within object.

**Three-dimensional** - Having or appearing to have extension in depth.

**Two-dimensional** - Having only two dimensions, especially length and width.

**Vertical** - Being or situated at right angles to the horizon; upright.

**Viewpoint** - A position from which something is observed or considered.



Date: \_\_\_\_\_

Student Name: \_\_\_\_\_

**Scale**

- 1 - Well below target
- 2 - Approaching target
- 3 - Meeting Target
- 4 - Exceeding Target

Teachers: Indicate assessment in each target area by circling the number that best describes student's participation.

<b>Two-Dimensions</b>				
Sketches 2-D shapes apparent in a 3-D form	1	2	3	4
Uses measuring tools to transfer 2-D shape onto poster board	1	2	3	4
TEACHER'S COMMENTS:				

<b>Three-Dimensions</b>				
Attaches 2-D shapes as planes of space with height, width and depth	1	2	3	4
TEACHER'S COMMENTS:				

<b>Craftsmanship</b>				
Cuts notches to attach shapes	1	2	3	4
Manipulates paper in at least two different ways	1	2	3	4
Forms stable base				
TEACHER'S COMMENTS:				

**Lesson Goals & Assessment Criteria**

**Target:** Student represents the planes of space in a 3-D form.

**Criteria:** Student sketches the 2-D shapes observed from different viewpoints of a 3-D form.

**Target:** Student transfers sketches of 2-D shapes onto poster board paper.

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**Target:** Student creates a self-standing form.

**Criteria:** Student forms a stable base.

# CHECK YOUR WORK!

Student Name: \_\_\_\_\_ Date: \_\_\_\_\_

Give yourself a check, if you completed the tasks below to the best of your ability.

## Did I .....?



Attach 2-D shapes as planes of space with height, width and depth?	
Cut notches with scissors to attach shapes?	
Manipulate planes of space in at least two different ways?	
Form a stable base?	

## These tasks were the most challenging for me:



Attaching 2-D shapes as planes of space with height, width and depth.	
Cutting notches with scissors to attach shapes.	
Manipulating planes of space in at least two different ways.	
Forming a stable base.	

## These tasks were easy for me:



Attaching 2-D shapes as planes of space with height, width and depth.	
Cutting notches with scissors to attach shapes.	
Manipulating planes of space in at least two different ways.	
Forming a stable base.	

# Shapes, Forms, Planes Reflection Questions

1. Describe a time when you had to experiment and it worked:

2. Did you create your own way to make your forms and shapes?  
Write step-by-step directions below so that someone else can follow them.

3. If the form you created was a building, what kind of building would it be?  
If it was not a building, what was it?

4. What would the building or form be used for?

5. Who would use the building or form?

6. Why did you pick this type of building or form and not another type?

**Optional: Draw your building idea on the back of this page!**