Lesson Title	Area in Origami
Length of Lesson	50 minutes
Created By	Sean Owens
Subject	Mathematics, Geometry
Grade Level	10^{th} – 12^{th}
State Standards	9^{th} - 12^{th} Pre-Algebra: 4 a, c Geometry: 2 a,
DOK Level	DOK 1 – Pre-Algebra DOK 2 – Pre-Algebra, Geometry
DOK Application	Measure, Tabulate, Calculate, Summarize, Construct, Modify, Estimate, Make Observations
National Standards	9-12: B: Geometry C: Measurement
Graduate Research Element	This lesson will explain the concept of surface area and how we can reduce an objects area in one dimension by layering it in another dimension. In my research, I study how we can create a smaller footprint for a design on a single chip. The method I'm researching is reducing the area by having certain design components occupy the same space on the chip (i.e. layered in the third dimension).

Student Learning Goal:
After performing this lesson, students will be able the concept of surface area and how smaller areas can be achieved by layering material on top of itself, thereby occupying the same 2-dimensional space.

This lesson will address Mississippi 9-12 Mathematics standard: Pre-Algebra 4a and 4c and National 9-12 Mathematics standards B and C by giving the students the opportunity to construct and measure the surface area of different 2- and 3-dimensional origami objects

State Standards: 9^{th} – 12^{th} Mathematics

Pre-Algebra – 4a: Solve real-world application problems that include length, area perimeter, and circumference using standard measurements.

Pre-Algebra – 4c: Use formulas and/or appropriate measuring tools to find length and angle measures (to appropriate levels of precision), perimeter, area, volume, and surface area of polygons, circles, spheres, cones, pyramids, and composite or irregular figures.

National Standards: 9^{th} – 12^{th} Mathematics
B (Geometry):

- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop
- Mathematical arguments about geometric relationships.
- Use visualization, spatial reasoning, and geometric modeling to solve problems.

C (Measurement):

- Understand measureable attributes of objects and the units, systems, and process of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.

Materials Needed (supplies, hand-outs, resources):

- Origami paper (4 per student) (have extras in case of mistakes)
- Rulers (1 per student)
- Guided practice instructions (see origami_guided_instruction.doc)
- Individual practice instructions (see origami_independent_instruction.doc)
- Worksheet (see origami_area_worksheet.doc)

Lesson Performance Task/Assessment:
Students will construct various two- and three-dimensional origami objects. They will demonstrate their understanding of different physical properties (e.g. footprint area, surface area, footprint perimeter) by obtaining measurements for each object created. They will use the measurement data obtained to make observations about how the footprint area of an object can be reduced through layering. In this lesson, "footprint" refers to the extents of an object when viewed only in a single dimension (i.e. top view).

Lesson Relevance to Performance Task and Students:
The students will create origami objects and use measurement techniques to demonstrate their understanding of geometry concepts such as surface area, footprint area, and perimeter. They will analyze the measurement data collected to demonstrate their understanding of the relationship between the number of layers and the footprint area.

Anticipatory Set/Capture Interest:
The lesson should begin with the observation that the empire state building has a footprint of about 2 football fields, but if the empire state building was only 1 story tall, it would have a footprint of about 538 football fields. The instructor can then pose the question, “why is this so?” and lead into the guided practice section of the lesson.

Guided Practice:
In the guided practice section of the lesson, the instructor will hand out the origami paper and the rulers to the students. The instructor will then lead the students in creating the first two origami objects (the money gift and the windmill; see origami_guided_instruction.doc). The instructor will then explain the instructions for the independent practice section of the lesson.

Independent Practice:
In the independent practice section, the instructor will hand out the instruction handout (origami_individual_instruction.doc) and the worksheet (origami_area_worksheet.doc). The students will construct two more origami objects using the instructions provided in the handout. Then, students will use their rulers to fill out the worksheet provided. In the worksheet, the students will need to sketch a representation of the top view of each object and show how they partition the space to obtain the footprint area. They will also have to fill out a table that asks for the footprint area, footprint perimeter, and total surface area. They will then have to estimate the greatest number of layers at any part of the object.

Remediation and/or Enrichment:
Remediation: Individual IEP; have instructor assist with origami construction.
Enrichment: Have the students try to obtain the smallest footprint area they can and make observations about the correlation between the number of layers and the total footprint area.

Check(s) for Understanding:
How do you calculate footprint area? How do you calculate surface area? Does the number of layers affect the overall footprint area?

Closure:
Discuss how the footprint areas of the objects were different from one another and from the original paper size. Discuss the estimations made in the individual practice section and give students the actual values; have students compare the estimates to the actual values. Discuss the real-world applications of layering techniques in areas such as architecture or computer engineering where programs can be virtually layered on top of one another to reduce circuit size and cost.

Possible Alternate Subject Integrations:
None

Teacher Notes:
Teachers should have a thorough understanding of the steps needed to construct the origami objects or have the reference steps, provided in the included files, available during instruction.