MESA Mathematics Engineering Science Achievement

Lesson Activity

Title	**Toothpick Dome (60 minutes)**
ID Number	MS-E-C1
Sequence and Duration	• Lead In (20 minutes) • Activity (20 minutes) • Closure (20 minutes)
Age Level	Middle School
Essential Question	**What makes a geodesic dome strong?**
Learning Objectives	• TSW identify the triangle as a very stable shape used in engineering and construction. • TSW describe qualities that make a triangle very stable. • TSW identify the weak point in a triangle (joint area). • TSW apply their understanding of triangular strength to the engineering of a geodesic dome. • TSW discuss, re-explain, and demonstrate how a geodesic dome distributes the weight load over all the different triangles that compose it. • TSW apply their overall understanding of geodesic domes to design and construct one using the given materials in the given time. • TSW describe the construction process of their dome and evaluate its strengths and weaknesses by comparing it to other domes constructed by their peers.
Other Objectives	• TSW develop a working plan with their group to develop a cooperative environment. • TSW communicate with their group by contributing their vocal input.
Key Terms	• Geodesic dome • Polygon • Triangle • Compression • Tension • Weight distribution
Materials Needed	Per Group • Pictures of geodesic domes: Epcot, Biosphere Per student • Handout: MESA Notebook Per team (2-3 students) • 100 round toothpicks • 30-40 small marshmallows or gum drops
Lead In	20. Pass out the MESA Notebook handout. (If necessary, tell them that they will be completing this handout for each MESA activity. Tell them you will guide them through the handout today.) 21. Show the students images of some geodesic domes. 22. Ask them to point out similarities. Write these on the board. 23. Ask them to point out differences. Write these on the board. 24. Guide students to identify the types of shapes used in geodesic dome design, specifically triangles. 25. Write the term 'Geodesic Dome' on the board. Instruct them to write it in the 'key term' section of the MESA Notebook Handout. 26. Ask one student to find the definition in a dictionary and read it aloud. Write this

definition on the board but instruct them not to write it on their handout. Simplify the definition into grade-appropriate terminology using the images as teaching tools. Students will create a communal oral definition, write this on the board, and have them copy this into their handout.

> *Example of a Dictionary Definition: A domed or vaulted structure of lightweight straight elements that form interlocking polygons.*
> *Example of Student Definition: A structure made of connected polygons.*

27. Write the term 'polygon' on the board and have them follow the same procedure as above. When they come to writing their own definition, one suggestion is to have them draw types of polygons next to the definition instead of using vocabulary.

> *Example of a Dictionary Definition: A closed plane figure bounded by 3 or more line segments.*
> *Example of a Student Definition: A shape made of straight lines. (drawn polygon shapes)*

28. Write the term 'triangle' on the board and follow the same steps as for 'polygon'. They will draw the definition on the handout.
29. Show students a toothpick square. Ask them to identify what makes it a square. Discuss.
30. Ask students to point out where they think the weakest area/point of the square is. Most students will point to the joint area at the marshmallows.
31. Show the students a toothpick triangle. Ask them to identify what makes it a triangle. Discuss.
32. Ask students to point out where they think the weakest area/point of the triangle is. Most students will point to the joint area at the marshmallows.
33. Hold up both the toothpick square and the toothpick triangle. Point out obvious shape differences.
34. Ask, "Which of these two toothpick structures is more stable or stronger?" Solicit answers, write them on the board, and discuss.

> *A dome must support its own dead load as well as the live load of wind, rain, snow, or ice. The geodesic dome's strength is due to the fact that triangles are very stable shapes. It is difficult to distort a triangle; compression at one joint is balanced by tension along the opposite side. The geodesic dome's design distributes loads over all the different triangles that comprise it.*

35. Have one student come up to apply pressure to both toothpick structures. The square toothpick structure should collapse easily. You may also choose to do this part of the demonstration yourself to ensure it does.
36. Ask students, "Why is the triangle toothpick structure more stable?" Solicit answers and discuss.
37. Put the following terms on the board: 'compression' and 'tension'
38. Use the demonstration to help the students define these terms or use the dictionary as a starting point and the students can come up with their own definition again. Have students write the definition on their handout.
39. Show students pictures of geodesic domes again and ask them to describe how they would build one using toothpicks and marshmallows. Point to the toothpick triangle as a starting off point. Discuss and draw on the board or model for them by adding to the triangle.
40.

Activity	1. Tell students that they will be engineering and constructing a geodesic dome using the concepts they just learned. 2. Pass out supplies to each group. 3. Tell students to write what materials they are using under the 'Materials Used' section of their MESA Notebook handout. 4. Students will begin activity. 5. Monitor student progress. Check to make sure the base of the geodesic dome is reasonable. Some may try to make a very large base and not complete their dome in the remaining time. 6. As groups finish, instruct them to begin the 'Procedure' section of the MESA Notebook handout. They will write down all the steps they took to build their geodesic dome. 7. Allow time for clean up.
Closure	1. Put pressure on top of each group's dome with books to check the strength and stability. Use one group's dome as a class model. 2. Ask students to describe how the whole structural design makes it strong. Discuss. Mention how the dome design gives even weight distribution and briefly explain what weight distribution means by going back to the book support model. 3. Have student groups hold up and demonstrate their constructed domes. 4. Each group will describe what difficulties they had in constructing their domes. 5. Point to the MESA Notebook Handout. 6. Instruct students to complete the 'Procedure' section if they did not complete it. 7. Write the following question on the board: 'What makes a geodesic dome strong?' Instruct students to answer this question on the 'Conclusion' section of the MESA Notebook handout. 8. Point out the back of the handout. It is up to you whether or not to have them draw a picture of their completed dome before the next meeting. They can label it, pointing out joints, tension, and compression. **Note: Students may complete the 'Procedure' and 'Conclusion' section of the MESA Notebook at home before the next MESA meeting if time is an issue.*
Informal Assessment	48. Monitor students to check for understanding. 49. Monitor students to check for participation.
Formal Assessment	• Completed Geodesic Dome. • Completed MESA Notebook Handout (They may complete this before the next MESA meeting).
Trouble Shooting	• Keep an eye on the time. Don't linger too long over a single component or you will run out of time. • Have additional supplies ready for groups that work quickly. They can add to the base of their dome. • Make sure all students participate in clean up.

SEI Strategies Used

Preparation	Scaffolding	Grouping Options
☒ Adaptation of Content	☒ Modeling	☐ Whole class
☐ Links to Background	☒ Guided practice	☒ Small groups
☐ Links to Past Learning	☐ Independent practice	☐ Partners
☒ Strategies incorporated	☒ Comprehensible input	☐ Independent

Integration of Processes	Application	Assessment
☒ Reading	☒ Hands-on	☐ Individual
☒ Writing	☒ Meaningful	☒ Group
☒ Speaking	☒ Linked to objectives	☒ Written
☒ Listening	☒ Promotes engagement	☒ Oral

Arizona Science Standards Addressed	• S1C1: TSW formulate predictions and questions based on observations. • S1C2: TSW design a controlled investigation and keep a record of their observations, notes, and sketches. • S1C4: TSW communicate the results of their investigation and create a list of instructions that others can follow. • S2C2: TSW understand how science is a process for generating knowledge and apply scientific processes to problem solving situations.