Lesson Title	Using Concept Maps to Design 3D Spheres
Length of Lesson	2 days
Created By	Kylie Nash
Subject	Math
Grade Level	10^{th} – 12^{th} (Geometry)
State Standards	9^{th} -12^{th} Measurement 4c.
DOK Level	DOK 2
DOK Application	Construct, Interpret, Use Context Cues, Show, Predict, Distinguish
National Standards	9^{th}- 12^{th} Geometry
Graduate Research Element	Investigating Impact of Mental Schemas on Human Performance and Design

Student Learning Goal:
State Standards for 9^{th} – 12^{th}: Measurement 4c.
(c)Solve real world and mathematical problems involving the lateral area, surface area and volume of three-dimensional figures, including prisms, cylinders, cones, pyramids, and spheres.

National Standards for 9^{th} -12^{th} : Geometry: Use visualization, spatial reasoning, and geometric modeling to solve problems

- Analyze properties and determine attributes of two- and three-dimensional objects; Draw and construct representations of two-and three-dimensional geometric objects using a variety of tools.

Identify key meaning and terms associated with a sphere through the use of context cues generated by concept maps. Distinguish the differences between formulas for surface area and volume. Understand the measurement units for calculating surface area and volume of a sphere. Construct a 3D representation of a sphere using appropriate techniques and materials. Determine parameters need to calculate the surface area and volume of the sphere through physical measurement of the 3D sphere. Calculate the surface area and volume of a sphere given various parameters. Make any predictions concerning an increase or decrease in the length or radius.

Students will be able to practice and use appropriate techniques to collect, calculate and analyze data for measurement and critical analysis between relationships results equations.

Materials Needed (supplies, hand-outs, resources):
Notepaper, calculator, writing utensils, ruler (1 per team), drinking straws, glue (1 per team), scissors (1 per team), 6 paper plates (per team), 10 toothpicks (per team),

construction paper (as much as needed per team), hole puncher (1 per team) projector for presentations; markers.

Lesson Performance Task/Assessment:
Students will be able to develop concept maps and use those ideas to construct a 3D model of a sphere, and then calculate the surface area and volume of the sphere using the appropriate equations to demonstrate their knowledge and understanding of three-dimensional properties of shapes and figures. They will need to include: a visual representation of definitions and concepts related to 3D objects (concept map of "sphere"); the physical model of the sphere using provided materials and supplies; answers to the surface area and volume of the 3D sphere they created; and discussion of questions relating to an increase or decrease in certain parameters of the surface area an volume equations affecting the size of standard 3D objects. Each team will need to produce one concept map, one 3D sphere model, three-dimensional object equations calculations and interpretations variable manipulations to change the size of the 3D model. Students will be asked to discuss answers of the results the data found from the activity.

Lesson Relevance to Performance Task and Students:
Allowing students to develop concepts maps related to the ideas about a sphere will assist students in constructing a 3D representation of a sphere. It will provide a physical component to the concepts related to surface area and volume. Students will be able to measure a physical object that they created and calculate equations based on their own product design. These lessons and performance tasks will strengthen the students, interest, knowledge and understanding of mathematical equations of three-dimensional shapes through the use of hands on activities (concepts maps and 3D sphere model) to synthesize and interpret concepts learned in the classroom.

Anticipatory Set/Capture Interest:
Each small group will be given a single sheet of construction paper with colored markers. To begin, students will be asked to brainstorm as many words or short phrases that they can think of related to the term "sphere". Student groups will generate single words, terms, ideas and concepts that are specifically related to the word sphere. Students should be told to think of as many words or short phrases as possible as long as they are listed once on regular notebook paper. Students should look for patterns or relationships among the word bank created by the teams. This brainstorming activity will serve as the first section of one day's activity and lead into the second section of the first day's activity; it is to occur in no more than 10 to 15 minutes.

Guided Practice:
<u>Day One:</u>
Instructor will review key terms, variables, definitions and equations related to the design dimensions of a sphere using a presentation including images and real world examples.

Then the instructor will explain the activities associated with project including concept mapping topics and general outlines to guide the activities on both day 1 and 2.

The instructor will introduce the relevance to the topic of concept mapping. The instructor will develop a concept map on another shape with the class as an example (circle_cm.doc). The instructor will ask students to form small groups and pick one spokesperson.

Remind the students that the concept map should resemble some type of hierarchal structure with the word "sphere or basketball" as the center and supporting words and phrases arranged around the main concept. Encourage students to try grouping any words with similar meanings.

Once students have completed the concepts maps the instructor can ask the groups who want to share their designs with the rest of the class, then the instructor will share his/her example concept map of a basketball with the class, so the students can see how theirs compared to the instructor (basketball_cm.doc).

The instructor will go through examples of calculating the surface area and volume of their 3D spheres. Instructor will also refer back to concept map to compare any variables that may have been included. Make sure students remember the order of operations: PEMDAS.

Equation 1: Surface areas of sphere S= $A = 4\,\pi r^2$ (cm^2/in^2)
r is the radius of the sphere
π is the constant pi = 3.14

Equation 2: Volume of sphere V= $\frac{4}{3}\,\pi\, r^3$ ($cm^3/in^{3)}$

Day Two:
Then a short presentation will continue from day 1 to discuss to the variables needed for equations, as well as the measurement units needed to calculate the surface area and volume of a 3D object. This will be demonstrated by reviewing the real-world examples from day 1.

Once students have completed examples, they will be asked to create a 3D sphere. Each small group will be given paper plates, construction paper, tape, scissors, straws, glue, toothpicks, ruler and a hole-puncher. They should be told that all of the materials do not have to be used. The teams will have total control over what materials they will use to construct the 3D sphere. Then students should be told that there is no one correct way to construct a 3D sphere, as long as it follows the geometric dimensions of a sphere (round

sides). The students will be reminded to refer back to their concept maps and knowledge of the equations while building the sphere.

Once the students find building their 3D models they will calculate the surface area and volume of their 3D sphere, then the instructor can show the dimensions of an actual basketball and compare each group to the dimensions of an actual NBA regulation size basketball brought to the classroom. They will be able to see which group(s) have the closet dimensions to the real basketball and possibly give a reward for the best representation.

Next, the instructor will lead the discussion of how what role the concept maps played in the design of their 3D maps or if a relationship existed at all. What predictions can be made concerning the size of a sphere when there is an increase or decrease in one or more variables? The discussion would also include real-world applications, benefits and usefulness of the topics learned from this lesson or activity.

Independent Practice:

Day One:

Activity one, the students will develop a concept map based on the example provided by the instructor (an example should be provided by the instructor; this part can be done on white paper using pencil or pen). Students will place the word "sphere" (inside an oval shape) at the center of the construction paper and place the supporting words derived earlier that were agreed upon by the group members. Next, the students will connect all the words and short phrases to each other as well as the main concept, making as many connections as possible. The spokesperson from each group will describe their concept map with the class if desired.

Student teams will analyze the density of their concept maps of a "sphere" in order to find any relationships between the 3D spheres created and concepts or short phrased generated. Students can make inferences to how well their 3D model matched the mental accuracy of what the group perceived as a sphere and discuss ways on their sphere could be improved. Students will be able to see any direct mapping of concepts in the design of the 3D sphere, realizing how design concepts can come to life.

The second activity will practice some example problems of calculating the surface area and volume of the other shapes such as the circle (from concept map of day 1) and a few examples of a sphere of real world applications.

Day Two:

The first activity will involve students creating a 3D sphere using the supplies and material provided by the instructor. Students will use the concept maps created on day 1 to help make the sphere; the students may or may not use all of the materials provided. Students should be given as much creative freedom as possible.

Then the teams will calculate the surface area of their 3D spheres and then they will be able to compare their results to the actual dimensions of a regulations size basketball to see who had the closest match using the appropriate mathematical equations.

The students can ask questions and answer questions that help tie real world applications to mathematical problems.

Remediation and/or Enrichment:

Remediation:

Shorten the length of the activity, by excluding the concept mapping section; focus on one equation either surface area or volume calculations, partner help throughout the activity, individual assistance, individual IEP.

Enrichment/Extension:

1. Given the circumference of the sphere, calculate the surface area of the sphere.

2. Add more shapes including prisms, cylinders, cones, and pyramids.

3. Given the volume of a sphere calculate the surface areas and given the surface areas find the diameter of the sphere. What percentage of a sphere fills a square?

4. Calculate and graph the surface area to volume ratio for spheres increasing in one unit increments.

Check(s) for Understanding:

Day One:

1. Explain the development of the concept map for a sphere, were there any patterns or unique grouping, how did you develop the concept map? What type of process or scheme did you use to generate the concept map?

2. Did you uses ideas, concepts developed in the concept map to guide the creation of the 3D model? Did the concept make building the 3D model easier?

Day Two:

1. What parts of the presentation and activity did you feel was the most important to helped create the 3D model of the sphere and why?

2. What parts of the presentation and activity did you feel was the least important to helped create the 3D model of the sphere and why?

3. Do you have a better understanding and improved knowledge of how to measure 3D objects and manipulate associated equations?

4. Do you think that with the skills and knowledge learned through this exercise that you can apply the concepts of a sphere to other 3D objects such as cylinders, pyramids, and spheres, etc?

Closure:

Day Two:

Explain the benefits of being able to apply the concepts learned from the activity to other three-dimensional shapes and objects even if the equations differ. Discuss some real world applications (who, what, when, where and how) that would benefit from understanding and measuring the surface area and volume of 3D objects.

Possible Alternate Subject Integrations:

Science - Analyze how the surface area to volume ratio impacts the limits or constraints on an organism's size.

Astronomy – Calculate the surface area of the planets and asteroids in the earth atmosphere /space to search for any patterns as well as compare them to Earth including the Moon and Sun.

English/Grammar- Strengthening vocabulary and use of context clues to determine the meaning of ideas or topics. Show the strength and relationship between words and short phrases.

Chemistry- Find the surface area and volume of an atom, etc.

Teacher Notes:

References:

1. http://mathforum.org/library/drmath/view/62238.html
2. http://www.wonderhowto.com/topic/make-3d-sphere-of-paper/
3. http://www.ehow.com/how_5065496_make-cardboard-sphere.html