LESSON PLAN ONE

Teacher: Mike Mills **Subject/Lesson Title:** How does the volume of a pyramid (or cone) compare to the volume of a prism (or cylinder) with the same base? (Day one of volume and surface area unit) **Grade:** 9-12

Curriculum Context/Rationale:

This unit blends knowledge that the students will need to know for both common core standards and their end of course exam on the volume and surface area of objects.

On day one of this unit students investigate the question: "How does the volume of a pyramid (or cone) compare to the volume of a prism (or cylinder) with the same base?" At the start of the lesson the **literacy strategies** of slicing (by breaking apart that vocabulary-laded investigatory question) and **vocabulary review table** (by making a table with the word, description and picture of new, potentially difficult vocabulary) are employed. By investigating this question students measure and estimate as well as try to uncover the formula (or method) for finding the volume of an object. They eventually come to the very interesting finding that there is a 3 to 1 ratio for volume of a prism to volume of a pyramid, when they share bases and heights.

This lesson builds on the students' knowledge about two dimensional areas. It encourages mathematical practices such as estimation, prediction, measurement-taking and calculating using formulas. There is also a large communication aspect and it is very hands-on; the manipulatives will provide engagement.

EALRs/GLEs/PEs/Common Core Standards:

CCSS.MATH.CONTENT.HSG.GMD.A.1
Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone.

CCSS.MATH.CONTENT.HSG.GMD.A.3
Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.

Short Term Learning Targets/Objective(s) for This Lesson:

Knowledge:

- The volumes of prisms, and cylinders can be thought of as a stack of 2D areas.
- Formulas can be used to calculate volume of objects.
- A pyramid with the same base and height as a prism has 1/3 the volume of the prism.

Performance:

- I can explain how to find the volume of pyramids, prisms, cylinders, and cones.
- I can measure and calculate the volume of pyramids, prisms, cylinders, and cones.

Academic Language Objectives:

Demand

Students are asked to investigate **volumes** of **prisms, pyramids, cylinders,** and **cones.** To do this they measure different dimensions such as **vertical height,** and the dimensions needed to find the area of the **base.** They will put these measurements and predictions into the **graphic organizer (prediction table)** provided. In this table **two-dimensional representations of the different three-dimensional objects** will be provided and the students will need to use **symbols to represent the dimensions** (such as h= height).

Function
With this language students are asked to **discuss** in small groups and **compare** volumes of different objects. They must be able to **explain their reasoning** as well as **make measurements** so that they can **estimate, predict** and **calculate** volumes.

Language Supports:
The vocabulary words will be explicitly taught by using the attached vocabulary review table (modified Ferndale notes strategy) which has the word, a written description and a picture. Also attached is the graphic organizer that they will be provided which has a picture of the object, on which they can write their measurements, predictions, and calculations. Embedded in this graphic organizer is a sentence stem that helps the students make sense of what it means to compare two volumes.

Assessment Plan & Rationale for Assessments (Why these types?):

Pre-Assessment: We have a short class discussion about what volume means to the students. This will allow students to use their own language to see what they know about the topic.

Formative Assessment: Students will be trying to figure out the volume without knowing the formulas. I will walk around to each group and listen to how their discussion is going. This will inform me how well they are doing. By discussing with each other they will be able to assess how each other are doing as well.

Summative Assessment: No summative assessment piece for this activity.

Student Voice: There is a fair amount of student voice in this activity. By breaking down the beginning question (which is essentially the learning target) with me, the students will express that they know the learning target. There is also a discussion after the investigation that will highlight the learning target again.

INSTRUCTIONAL SEQUENCE

Activating Prior Knowledge: When I introduce the question for investigation of the day I ask what the word volume means to them and they fill out a short probe worksheet that asks them what they think volume is, how to calculate it, and if they have ever had to find the volume of something before.

Communicating Learning Targets: By introducing the question for investigation and dissecting it together, I will be introducing the learning target.

Learning Experiences:

Time	Teacher Tasks	Student Tasks
	As students come in I will hand them a number and send them to their table, thus splitting them up into their groups of three.	Divide up to find their table.
0-15	Introduce the topic of volume. "Here is the question we are trying to answer today: How does the volume of a pyramid (or cone) compare to the volume of a prism (or cylinder) with the same base? So first of all, this question is asking about volume. What does the word volume mean to you all? Have you ever been asked to find the volume of something? Think about it for a minute." Then call on them when they offer their interpretation, or call on someone if no one raises their hand.	Listen and raise hands to offer answers to questions and questions that they have.
	"Ok, now what do I mean by prism, pyramid, and base?" We make notes in the space provided.	Listen and raise hands to offer answers to questions and questions that they have.
	"Now that we have gone through all of the new terms, does anyone want to read the directions of what we will be doing?" Directions get read.	Offer to read directions out loud.
15-45	"Alright, so you will have three minutes to get your measurements and 1-2 minutes to discuss and compare. When you hear the gong, then it is time to move to the next two objects. Does anyone have any questions about what we are doing?"	Ask clarifying questions about the activity

45-55 55-65 65-75	Then I let them start their measurements and time them and let them know when to switch. At this point I will go around and check in on groups, helping out when necessary. Once we are done, I will as people what their predictions were for each set. Then I will pour rice into each one and show that it is 3 to 1. Then I will ask if anyone found a formula they think will work for the prism. Now that we know the relationship between prism and pyramid I will see if anyone can think of a formula for the pyramid. Once we have the formulas then I ask them to calculate the volumes for real for each object. I instruct them to work on the summarizing questions. If there is extra time then I will pass out a volume practice worksheet.	Measure the dimensions of the objects and discuss predictions to the question of the day. Offer up predictions and see what the results of the rice pouring is. Offer up their formulas. Calculate the volumes. Answer summarizing questions Work on worksheet.
	I go over worksheet and we discuss the summarizing questions.	Closure Students talk about summarizing questions

Classroom Management:
This activity will require a lot of management. I will divide the tables into 3 person groups and hand each student a number 1-9 when they come in to break them up into groups. Then they will go to a station with an object for measuring that has their number on it. I will need to keep close track of time and tell them when to circulate around. I will front load that I would appreciate if the students not goof around when going from station to station.

Instructional & Assessment Accommodations/Modifications for Diverse Learners:
Students work at very different paces in this class. The initial task of measuring all of the shapes is fairly basic and they will be in groups which will help students who are having trouble with directions. There is a fair amount of discussion of what students think, predict or estimate so all students should be able to participate in that.

One student has an IEP. He has high-functioning autism. He will be allowed to go at his own pace and I will be flexible about his grouping. If this doesn't work for him, I have a back-up worksheet that he can do by himself that relates to volume. This is a good back up option because he is very rule/logic driven and also often has trouble in groups. Therefore, by giving him a clear task and letting him work by himself, this option could be an easier way for him to participate. Additionally he has a para-educator with him at all times to assist with instruction.

There are also three students who are learning English and have comprehension difficulties. The vocabulary table that we do in the beginning is designed so that they can use pictures to help remind them of what the vocabulary word is, so that they do not get caught up in the written or verbal description. The learning targets are both written up on the board and verbalized by myself, with the idea that everyone benefits from seeing and hearing the learning target throughout the lesson. The structure of the lesson allows me to visit with all of the groups several times to check progress and so I will plan on spending one-on-one time with the English-language learners to check for understanding.

Instructional Materials, Community Resources, and Technology:
-Relational Polyhedra set
-Rulers (one per group)
-Worksheet (one per student)
-Name tents for each shape
-Timer (phone)
-Document camera with screen
-Classroom whiteboard

School/Home Interactions (if applicable):
N/A

LESSON PLAN TWO

Teacher: Mike Mills **Subject/Lesson Title:** How are nets used to find surface area? (Day two of volume and surface area unit) **Grade:** 9-12

Curriculum Context/Rationale:

This unit blends knowledge that the students will need to know for both common core standards and their end of course exam on the volume and surface area of objects.

On day two of this unit students use polydrons (a manipulative) to learn about making nets to describe surface area. They first go through the activity "building blocks" to introduce the idea of nets with a simple context (a cube). After a quick discussion about what a net of a more complex object might be the students are asked to use the measurements from the objects on day one and the polydrons as a visualization tool to make nets and calculate surface area for the eight objects investigated the day before.

This lesson uses their previous knowledge of two-dimensional areas and a new concept of nets to help them learn how to find surface area. It also uses an engaging manipulative to make the concepts easier to digest for more visual or kinesthetic learners.

EALRs/GLEs/PEs/Common Core Standards:

There are not common core standards for surface area at this grade level. However, the geometry end of course exam and the high school for which this lesson is designed ask for students to know this concept.

Short Term Learning Targets/Objective(s) for This Lesson:

Knowledge:

- Surface area is the collection of the areas of all of the faces of an object
- Nets are a useful way to turn surface area into an easily measurable two-dimensional object.

Performance:

- I can calculate the surface area of different objects using nets and formulas

Academic Language Objectives:

Form: The students will be introduced to the idea of using **nets** to find **surface area** of different three-dimensional objects. When manipulating and discussing the three-dimensional objects they will need to use the new terms **face, edge, vertex,** and **apex. Nets** are themselves a form of academic language, since they are a different representation of a characteristic of three-dimensional objects.

Function: Students will be asked to **draw** nets to **calculate** surface area of different objects. They will need to **reason spatially** and then **explain** their reasoning to each other.

Language Supports:

The students are provided a worksheet that includes a table structured to help them organize their net pictures and surface area calculations. The specific terms involving the objects such as

face, edge, vertex, and apex are described and emphasized using actual physical 3D objects to give the students clear, tangible examples.

Assessment Plan & Rationale for Assessments (Why these types?):

Pre-Assessment: I will ask if anyone can describe what surface area means and how they might find it. This will get them thinking about it and will allow me to hear where they might be in their thinking about this topic.

Formative Assessment: I will circulate around the room to help students out with the worksheet and with their nets. If nets are seeming hard for them then I will switch back to whole group instruction and work through more examples.

Summative Assessment: No summative assessment for this activity.

Student Voice: They will respond as to what surface area means to them and be able to explain in their own words what a net is.

INSTRUCTIONAL SEQUENCE

Activating Prior Knowledge: I will ask the students what they think surface area means and how you would find it. I will also make a connection to the previous day's lesson on volume and we can talk about how that relates to surface area.

Communicating Learning Targets: I will post on the board what the learning target is and engage that topic when I ask them about surface area in the beginning.

Learning Experiences:

Time	Teacher Tasks	Student Tasks
0-5	"Ok, welcome, today we are going to be learning about something called "nets" to find surface area. First of all, what do I mean when I say surface area? Does anyone have an idea about how we would find that?"	Listen, raise hands to answer questions.
5-10	I will respond to their offers of what they know and then show them how to use the polydrons and pass them out. I will give them 5 minutes to play with them and then introduce the "building blocks" activity and show a few examples of nets that work and ones that don't. Then, as they do the	Complete worksheet in pairs.

10-30	activity, I circulate around helping out and keeping students on task.	
30-40	Once they complete the activity then I get the whole class's attention again and ask whether or not that was difficult for them. Then I will pass out the activity sheet for making nets for all of the same objects that we worked with the previous day. I will introduce the triangle polydron and remind them how to find the area of a triangle. I will show them an example of making a net for these other objects.	Listen to instructions and raise hands to ask questions.
40-60	While they are working in their pairs to try to make the nets for these objects I will circulate around and help out and ask probing questions.	Write out the nets and calculate surface areas for the objects.
60-75	Once they have made their nets I will pass out a formula sheet that has the formulas of the objects as well as a worksheet for them to calculate the surface area and volume from formulas.	Work on new worksheet. Assigned as homework.
	There is not a specific closure exercise for this activity. Students end by getting practice with the worksheet and then we pick up the next day still working with polydrons.	Closure

Classroom Management:
Students do not do a lot of moving around for this activity. However, there are manipulatives that they will likely be distracted by. I will give them five minutes to play around with them before I have them start the activity, hopefully this will somewhat mitigate their desire to play with them while I am talking.

Instructional & Assessment Accommodations/Modifications for Diverse Learners:
One student has an IEP. He has high-functioning autism. He will be allowed to go at his own pace and I will allow him to work on his own for this activity. I will be sure to give him clear

directions and be patient with him. This strategy seems to work regularly. He also has a para-educator in the room for extra assistance.

There are three students who are English-language learners. The table and physical representations are aids intended to help them learn the vocabulary needed to complete the activity. There is a considerable amount of time spent working in pairs on creating the nets, so I will be able to check in with them often and see if they understand the directions.

Instructional Materials, Community Resources, and Technology:
- Set of polydrons (6 squares and 6 triangles per student)
- Worksheets (Building blocks, Let's make some nets!, EOC formula sheet, Surface area and volume of 3-D shapes)
- Document camera
- Relational Polyhedra from day one

School/Home Interactions (if applicable): N/A

LESSON PLAN THREE

Teacher: Mike Mills **Subject/Lesson Title:** Build your own 3D object **Grade:** 9-12

Curriculum Context/Rationale:

This unit blends knowledge that the students will need to know for both common core standards and their end of course exam on the volume and surface area of objects.

In this lesson pairs of students are given a set of polydrons and are asked to create their own closed three-dimensional object. Once they create their object they write out the net of it and calculate the surface area. Then they calculate the volume of it by "breaking" it up into smaller objects which they know how to calculate the volume of. After doing that on their own sheet, they pass their written net plan (without calculations) to another pair and the other pair recreates the object and calculates the surface area and volume. Since every group has to use the same polydrons, they all have the same surface area, but they will likely have different volumes. This will lead us to a discussion about the fact that surface area and volume are not intrinsically linked.

This lesson builds on the previous two lessons by providing a more complex object to measure surface area and volume of. It also addresses a common misconception that volume and surface area are dependent on each other. By discovering that there can be lots of different objects that have the same surface area but different volumes they will likely be confronted with a discrepant result.

EALRs/GLEs/PEs/Common Core Standards:

CCSS.MATH.CONTENT.HSG.GMD.A.1
Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone.

CCSS.MATH.CONTENT.HSG.GMD.A.3
Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.

Short Term Learning Targets/Objective(s) for This Lesson:

Investigation question: "What is the connection between volume and surface area?"

Knowledge

- Volumes of complex polyhedra can be broken up into smaller more manageable polyhedra to find the total volume.
- Surface area is the collection of the areas of all of the faces of an object.
- Nets are a useful way to turn surface area into an easily measurable two-dimensional object.
- Surface area and volume of objects are not dependent on each other.

Performance

- I can calculate surface area complex polyhedra by using nets.

- I can calculate volume of complex polyhedra by thinking of it as multiple simpler polyhedra and adding those volumes up.

Academic Language Objectives:

Demand

This is a synthesis activity, so there will not be any new vocabulary words or forms in addition to what was introduced on days one and two.

Function

Students will be asked to **create** an object out of polydrons by using a **net** made by another group. They will then be asked to **compare** the surface areas and volumes of the different objects to make a **claim** about the how the surface area and volume **relate** to each other.

Language Supports:

On the worksheet there will be a sentence stem that provides a framework about how to talk about comparing different aspects of an object.

Assessment Plan & Rationale for Assessments (Why these types?):

Pre-Assessment: The first two days of this lesson are essentially the pre-assessment. Therefore, the worksheets from the first two days will provide me information of where the students are at in their learning on this topic.

Formative Assessment: Students will be working in pairs, so I will have time to circulate around to the groups to check in on their understanding.

Summative Assessment: These lessons are preparing the students for the end of course exam.

Student Voice: Students will fill out an exit slip that asks them to explain in their own words whether or not there is a connection between surface area and volume.

INSTRUCTIONAL SEQUENCE

Activating Prior Knowledge: I will start the class by asking students what we have been working on the past two days. This will get them thinking about volume and surface area again.

Communicating Learning Targets: Learning targets will be written on the board and students will be asked to read them and pair-share to discuss what these targets mean to them.

Learning Experiences:

Time	Teacher Tasks	Student Tasks
0-10	Engage students in a discussion about what we have been learning about and introduce the activity for the day.	Listen and raise hands to answer questions.

10-30	Circulate around classroom helping students with their structures, nets and calculations.	In pairs, create a complex 3D object from polydrons, draw its net, and calculate its surface area and volume.
30-45	Facilitate the switching of nets and then circulate around classroom helping students.	Find another pair to switch net plans with and then create their object. Once created, they calculate its volume and compare that to their own volume.
45-55	Facilitate discussion about the connection (or lack of) between volume and surface area.	Participate in discussion.
	Hand out exit ticket.	Closure Write their answer on exit ticket.

Classroom Management:
Students will not be moving around very much in this lesson, however there is a lot of open work time involved, which will be somewhat unstructured. Therefore, I will need to be sure to set the directions up well and move around the room keeping students on task. There is a chance, since we are working with polydrons for students to get off task building something not relevant to the task. I will state at the beginning that if they are doing that, they must need more work, and so I have an extra worksheet for them if that is the case.

Instructional & Assessment Accommodations/Modifications for Diverse Learners:
One student with high-functioning autism will be allowed to work on his own if he chooses. Giving him the option to work in groups/pairs has worked in the past, since group work sometimes upsets him.

There are three English language learners in this class. The easy to read and understand learning targets and worksheets are intended to help them understand the lesson. Also, the use of manipulatives to assist in calculating surface area and volume gives them another representation besides words and pictures to work with.

Instructional Materials, Community Resources, and Technology:
- Set of polydrons (6 squares and 6 triangles per student)
- Worksheets
- Document camera

School/Home Interactions (if applicable):
N/A