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A Project Based Learning Approach to Teaching Geometry in a 7th Grade Classroom

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Introduction

A chief concern in the formation of the Common Core State Standards is the need to have a set of learning standards that can be universally applied across the United States. With the implementation of these new standards, educators have had to create new curriculum to incorporate the goals of these new standards within the classroom. The new standards have pushed for students to utilize higher order thinking and problem solving skills (Porter, 2011). This has caused some trouble for educators as "the majority of such textbooks are designed to teach students particular mathematical techniques and procedures rather than to help students develop thinking skills necessary for analyzing the kinds of quantitative information they will encounter in their professional lives" (Green, 2010).

The focus of this curriculum project is to demonstrate how to utilize a project based learning approach to help 7th grade students better understand the concepts such area and surface area, and to demonstrate higher ordered thinking and problem solving skills. Specifically, this curriculum will teach students to "solve real-life and mathematical problems involving angle measure, area, surface area, and volume" (Common Core, 2010).

The project based learning approach used in this curriculum project is based upon the instructional design known as the STAR Legacy Cycle. The STAR Legacy Cycle was based on a set of studies performed in the Vanderbilt-Northwestern-Texas-Harvard/MIT (VaNTH) Engineering Research Center for Bioengineering Educational Technologies, which was intern based on the How People Learn Framework from the book *How People Learn* by Bransford, Brown and Cocking (1999). It states that instructional design should be judged on the following criteria:

1. Knowledge Centered:

   Instruction must be grounded in the domain knowledge of the subject. Facts, theoretical constructs, and skills that students need to acquire constitute the knowledge base of a subject.

2. Student Centered:

   This refers to the need to present material to students in their current context and state of knowledge.

3. Assessment Centered:

   This refers to the process of continually assessing eh effectiveness of instruction in both formative and summative ways.

4. Community Centered:

   Learning is enhanced when learners can form a community that pursues a body of knowledge.

A project based on the Legacy Cycle should contain six important elements. The first element is that of a challenge, or a problem that is designed to "awaken student interest" and should be a problem that the student doesn't immediately know how to go about finding a solution. The second element is to give the students the opportunity to use knowledge they already have to look at this new problem. The third element is that students must gain multiple perspectives of experts in field. These perspectives can come in the form of videos, interviews, news articles, etc. The fourth element is that students should be researching and revising their understanding of the problem and their solution to the problem. The fifth element is testing. Students should test their solutions and revise their research and learning. The last element is going public. Students will present and summarize their solution to the problem (Corday, 2009).

STAR Legacy Model (2017). vanderbilt.edu

Literature Review

Project based learning

One way to demonstrate the deep conceptual understanding called for in the CCSS is through Project-Based Learning (PBL). The goal of PBL is "a greater understanding of a topic, deeper learning, higher-level reading, and an increased motivation to learn" (Bell, 2010). Past efforts to improve critical thinking skills, such as problem solving, through traditional classroom approaches were not as effective as many educators desired. As a result many educators have now turned towards PBL approaches based on science, technology, engineering, and mathematics (STEM) topics to improve these skills as well as encourage student interest in STEM fields (Walker, 2017).

In the PBL approach small groups of students work together and learn what they need to know to solve a problem. The teacher acts as a supervisor and guide in the process, advising

students on what approaches might be helpful and approving actions before students proceed to the next step of their solution (Silver, 2004). One critical component of PBL is that it is a student-driven learning method and student choice is a key idea in the approach. This student driven method is "a key strategy for creating independent thinkers and learners"(Bell, 2010).

PBL begins with a problem or scenario that is presented to the students. At this point the students work collaboratively to identify the relevant facts. The goal of this step is to assist students with understanding the problem in a deeper and more meaningful way. As students develop a more detailed description of the problem presented, they are able to generate possible solutions, and identify the pieces of knowledge they need to acquire to advance these possible solutions. After seeking out the needed information the students work on applying this new knowledge to their approach. In the course of applying this knowledge the students also evaluate their approach to the problem and evaluate their understanding the gained knowledge in an abstract sense (Silver, 2004).

When deciding to implement PBL in the classroom there are five important guidelines to consider. First is to understand that PBL projects are not an activity in the curriculum, instead they are the key element of the curriculum. The project is the central teaching strategy that drives student learning of the concepts. While traditional classroom approaches may still be needed to advance project work, these traditional approaches are merely providing examples for materials being taught or as additional practice to help the project move forward. The second thing to consider is that PBL projects should focus on questions and problems that will drive students to encounter the concepts and principals that the teacher wants the students to understand. Therefore, defining the central question or scenario is a vital part of designing a PBL project. Additionally the projects should ultimately have a solution that requires the

students to seek new knowledge to achieve, and not solely rely on previously learned concepts. The project should not be a simulation, but instead focus on real-life challenges. Lastly projects must be primarily student centered exercises, not projects such as laboratory exercises or other traditional approaches where there is a predetermined outcome (Thomas, 2000).

Learner Centered Education

The National Research Council has made three important discoveries when examining how students learn. The first is that students will come to the classroom with preconceptions about the way in which the world operates. If they don't relate course topics to their initial understanding of the material, then they may fail to grasp the new concepts being introduced. Alternatively they may only learn the new material for the purpose of passing a test, but then revert back to their initial preconceptions after leaving the classroom. The second discovery was that students must possess a strong base of factual knowledge, understand these facts in the context of the material being examined, and reorganize these previously understood ideas in a way that allows for retrieval and application. The third discovery was that a metacognitive instructional approach helps students by defining their own learning goals and evaluating their progress towards meeting their goals. (Donovan, 2005)

These three discoveries are the basis for what has become known as a learner centered approach to teaching. There are 14 principles that a learner centered approach includes. These principles can be divided into cognitive and metacognitive factors, motivational and affective factors, developmental and social factors, and individual difference factors. These are the principles for a learner centered approach (Pierce, 2003):

Cognitive and Metacognitive Factors.

1. Nature of the learning process – The learning of a complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience.
2. Goals of the learning process – The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.
3. Construction of knowledge – The successful learner can link new information with existing knowledge in meaningful ways.
4. Strategic thinking – The successful learner can create and use a repertoire of thinking and reasoning strategies to achieve complex learning goals.
5. Thinking about thinking – Higher order strategies for selecting and monitoring mental operations facilitate create and critical thinking.
6. Context of learning – Learning is influenced by environmental factors, including culture, technology, and instructional practices.

Motivational and Affective Factors

7. Motivational and emotional influences on learning – What and how much is learned is influenced by the motivation. Motivation to learn, in turn, is influenced by the individual's emotional states, beliefs, interests and goals, and habits of thinking.
8. Intrinsic motivation to learn – The learners creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, relevant to personal interest, and providing for personal choice and control.

9. Effects of motivation on effort – Acquisition of complex knowledge and skills requires extended learner effort and guided practice. Without learners' motivation to learn, the willingness to exert this effort is unlikely without coercion.

Development and Social Factors

10. Developmental influences on learning – As individuals develop, there are different opportunities and constraints for learning. Learning is most effective when differential development within and across physical, intellectual, emotional, and social domains is taken into account.
11. Social influences on learning – Learning is influenced by social interactions, interpersonal relations, and communication with others.

Individual Differences Factors

12. Individual differences in learning – Learners have different strategies, approaches, and capabilities for learning that are a function of prior experience and heredity.
13. Learning and diversity – Learning is most effective when differences in learners' linguistic, cultural, and social backgrounds are taken into account.
14. Standards and assessment – Setting appropriately high and challenging standards and assessing the learner as well as learning progress - including diagnostic, process, and outcome assessment - are integral parts of the learning process.

Each of the fourteen principals of a learner centered environment can be found within the context of this project. Project based learning allows for the integration of every one of the student centered principles. PBL creates an environment that is in large part under the control of the learner. The learner is the one who drives forward the educational process and controls what information is needed and how that information is to be incorporated into the overall goal of each

individual project. This type of environment helps students make connections between previous knowledge and newly acquired knowledge. By allowing students the opportunity to confront their preconceptions the student is able to examine what conceptions they were factually correct and which ones are incorrect. As the student examines these preconceptions and incorporates newly understood information they are actively engaging in the learning process. Using a PBL approach, instruction is given meaning and helps create connections between the student's goals and the goals laid out by the goals laid out in the CCSS. By giving the student choice is their approach to solving the problem presented the student is able to present a number of methods to demonstrate their learning and thus further providing the opportunity for students to reevaluate their understanding of the material that is being learned. Giving students the choice of how to approach and solve a posed problems allows students to use their own experiences to influence the development of not only their solution, but also of their approach to the problem solving process.

Perhaps the biggest strength though of PBL is that the authentic nature of the problem posed and the social process which is used to solve the problem are intrinsically motivating. Several studies have shown that "students are more engaged in school when social support for students is combined with a strong academic curriculum, which in turn significantly influences students' motivation and learning (Turner, 2011)." As Protheroe (2004) points out, students who are disengaged from the learning process need the same opportunities and meaningful classroom experiences that other students receive—differentiation, standards-based instruction, relevance, autonomy, and a concerned, caring teacher to sustain and support them while they learn.

While student centered instruction has great benefits, this doesn't mean that the transition to a student centered classroom is by any means easy. Students who have become use to having

teachers lead classroom discussion and carefully mapping out each step the student takes in their journey through the curriculum, may find this change of expectation and withdrawn structure challenging at first. When forced to take on more responsibility for their own learning, they may feel overwhelmed and unsure where to begin. For this reason it is important that teachers using this approach take steps to anticipate the difficult moments in a project's development and have plans to offer support to the students while they work their way through this transition (Felder, 1996). Woods (1994) identified eight stages students who are having difficulty with this transition may demonstrate, they include shock, denial, strong emotions, resistance and withdrawal, surrender and acceptance, struggle and exploration, return of confidence, and integration and success.

Particular attention should be paid attention to the stages of strong emotions and resistance/withdrawal because students can have some difficulty getting past these stages. This is where careful planning of supports by the teacher should be introduced. One frequent cause of student frustration can be that a select group of students in a group are doing most of the work on the project. This is a very legitimate concern, however one method for dealing with this situation is to have the groups set up individual responsibilities and expectations for each group member. Then have the students assess their own level of success at achieving those responsibilities and expectations. Another concern is how to ensure that students are able to use this approach to solving problems presented on tests. While the problem solving approaches developed by a PBL and student centered approach has many benefits with regard to testing, "there is also merit in assigning some individual homework problems to give students practice in the problem-solving mode they will encounter on the tests" (Felder, 1996). A final concern that some have expressed is that this approach while appropriate for older students that have more experience with the

subject matter, may not be suitable for younger learners who are relative novices in the subject. However it has been shown that it is "easier and more effective to introduce students to adaptiveness through the Legacy Cycle when they still have a novice or early intermediate knowledge base" (Rayne, 2006).

Community Building Project

Challenge Question

The city council is planning to build a 40,000 sq ft building with the purpose of "improving the community". Several ideas that have been suggested include a sports complex, a museum, a concert venue, and an educational facility. The council however has been unable to settle on the purpose and design of the building. The building does not need to be rectangular in shape, and unique elements in the building's design would be attractive to the council. Can you develop a building proposal that will meet these criteria?

Project Expectations

This project should take 8 class periods to complete. Each day students will hand in a group report that will update their status to ensure that the project will be completed on time. In preparation for the final proposal, students will hand in rough drafts of their building layout and budget. Included in the proposal will be a blueprint of the building, a rough budget for the buildings design, and a computer model of the space. Students will then need to create a presentation to explain their design and show how this building will improve the community. Each part of the project's development is designed to fulfill one of the stages in the Legacy Cycle.

This project will require several resources

Internet – to research similar buildings, needed dimensions for room usage, and material costs.

Graph Paper, Compass, and Straight Edge – to create the building layout/blueprint.

Computer Software – Microsoft Word, Powerpoint, Sketchup

Grading of this project will be based upon a rubric that can be found in the appendix section of this project. Grading based upon a rubric is critical for this project because it clarifies the qualities that the student group's work should possess. The rubric allows the teacher to coordinate instruction and assessment and it helps the student in their learning and reflection processes.

After each lesson, there will be two daily learning logs that will be submitted. The first is a "Group Daily Learning Log", which helps the student groups identify the goals for the day's lesson, identify the next steps in the project, reflect on the misunderstandings, identify possible problems with their approach, and suggest topics that need further research. The second log is the "Student Daily Learning Log". This log aides students in identifying their tasks for the day, monitoring their progress towards completing their goals, and identifying the problems, concerns and questions they have encountered in achieving their goal.

Project Schedule

Day 1: Introduction, creating groups, and deciding on a purpose for the building.

Introduce key ideas and vocabulary needed for building design including

Area formulas

Circumference (circles)

Day 2: Introduce key ideas and vocabulary needed for building layout

Scale drawings

Ratios

Proportions

Have students begin to draw out the building's layout

Day 3: Introduce the key ideas and vocabulary for building layout

Surface Area

Volume

Finalize building layout and calculate the square footage.

Start rough blueprint draft and calculate dimensions.

Make a list of each room and its purpose of each room. Be sure to include facilities such as bathrooms, electrical rooms and offices.

Day 4: Finish rough blueprint draft and submit.

Begin to work on budget rough draft.

Day 5: Finish and submit budget rough draft.

Day 6: Create computer model of building and layout

Day 7: Submit final budget and blueprint

Day 8: Present your building design.

Community Building Project - Day 1

The Challenge

Introduction

In this lesson, groups of students will be presented with a scenario in which they will be asked to design a building layout. They will be then decide how to organize their group and begin researching possible building usages and designs. Students will also review previously learned area and perimeter formulas and will be introduced to the concepts of area and circumference of a circle. This lesson is intended for seventh grade mathematics students and is designed to be completed in one eighty minute class session.

Objective

At the end of the lesson, each group of students should have defined roles for each team member, and selected the type of building that they would like to design for the community. Students should have an understanding of area and circumference formulas and how to apply them to various shapes.

Relevant Professional Standards

This lesson is intended to follow the NYS Common Core Mathematics Standards.

> 7.G Solve real-life and mathematical problems involving angle measure, area, surface area, and volume
>
> 7.G.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between circumference and area of a circle.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three- dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

Materials/Equipment

1) Pencil and Paper
2) Project Information Packet
3) Area and Circumference Practice Problems
4) Computer and Internet Access

Agenda

1) Instruction on area, perimeter, and circumference concepts – 10 minutes
2) Introduction to Community Building Project – 10 minutes
3) Assignment of groups and discussion of responsibilities – 10 minutes
4) Research of community needs and benefits of different types of buildings – 30 minutes
5) Selection of building type and summery of how it will benefit the community – 15 minutes
6) Complete and turn in Day 1 Project Update – 5 mins

Name: _____ Date: _____

Math 7 Building Project – Day 1

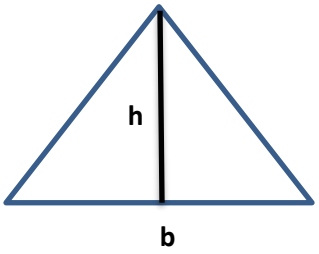
Key Vocabulary Terms:

Perimeter:

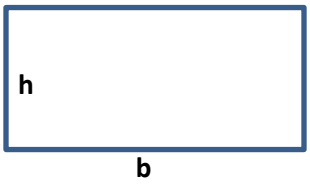
Area:

Circumference:

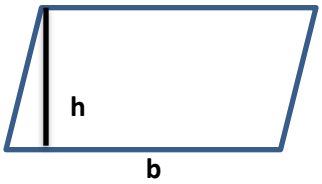
Review of Area formulas:



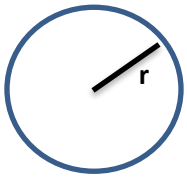
1) Find the area of a triangle with a height of 8 ft and a base of 12ft.



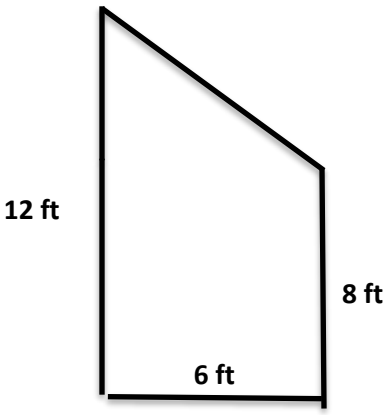
2) Find the length of the base of a rectangle with an area of 90 in^2 and a base of 10 in.



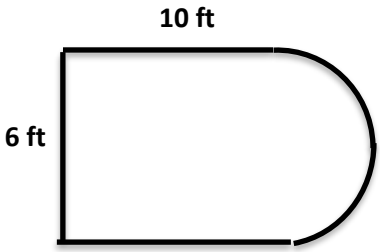
3) Find the area of a parallelogram with a height of 10 m, a slant height of 12 m, and a base of 20 m.



4) Find the area and circumference of a circle with a radius of 5 cm.



5) Find the area of the figure to the left.



6) Find the area and perimeter of the figure to the left.

Day 1 Project Update

Directions: After getting into your assigned groups, read through the driving question in your project packet. As a group submit one project day 1 report page.

List the members of your group below:

_____

_____

_____

_____

_____

Write down 5 ideas you have for a building that would be beneficial to our community:

1. _____
2. _____
3. _____
4. _____
5. _____

Select one of these ideas that you think would best serve the community and explain why this would be the best building to improve the community.

_____

_____

_____

_____

_____

_____

Community Building Project - Day 2

Generating Ideas

Introduction

In this lesson, groups of students will research comparable building types to the one they have selected to design. Using this information they will begin work on the building layout based on their research and generated ideas. To assist with the development of the building layout, students will be introduced to the concepts of ratios, proportions, and scale drawings. This lesson is intended for seventh grade mathematics students and is designed to be completed in one eighty minute class session.

Objective

At the end of the lesson, each group of students should have developed a basis for their building layout and understand how the concepts of ratios, proportions, and scale drawing will be used in their building layout.

Relevant Professional Standards

This lesson is intended to follow the NYS Common Core Mathematics Standards.

7.RP.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas, and other quantities measured in like or different units.

7.RP.2 Recognize and represent proportional relationships between quantities.

b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three- dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

Materials/Equipment

1) Pencil and Graph Paper for generating building layout
2) Project Information Packet
3) Ratio, Proportion, and Scale Drawing Practice Problems
4) Computer and Internet Access

Agenda

1) Instruction on ratios, proportions, and scale drawings – 15 minutes
2) Research of similar buildings and their features and layouts – 30 minutes
3) Work on building layout including rooms and usage, room shapes, room dimensions and size, and other information relevant to building layout. – 30 minutes
4) Complete Day 2 Project Summery and Reflection. – 5 minutes

Name: _____ Date: _____

Math 7 Building Project – Day 2

Key Vocabulary Terms:

Ratio:

Proportion:

Scale Drawing:

1) Suppose a scale model has a scale of 2 inches = 3 feet. What is the scale factor?

2) Suppose the scale is 2 inches = 4 yards. What is the scale factor?

3) The length of a patio is 4.5 cm in a scale drawing. If the scale of the drawing is 1 cm = 0.5 m, find the actual length of the patio.

4) The actual distance between a house and tree is 12 ft. If the scale of the drawing is 1ft = 1.5 in, find corresponding distance on the drawing.

5) The bed of Jerry's pickup truck is 6 ft long. On a scale model of the truck the bed is 8 inches long. What is the scale of the model?

6) On a map two towns are $5\frac{3}{4}$ cm apart. The scale on the map is $\frac{1}{2}$cm $= 3$ mi. What is the actual distance between the towns?

7) A drawing of your classroom has a scale of 1 in = 8 ft. If the actual length of the classroom is measured to be 36 ft, what should the length of the classroom in the drawing be?

Day 2 Project Update

List the members of your group below:

_____

_____

_____

_____

_____

Directions: Using graph paper, straight edge, and compass; continue to create a rough draft for your building layout.

1. Be sure to include rooms for office space for workers, restrooms, electrical rooms, and any other rooms that would be needed for your building to fulfill its purpose.

2. This building should include several different shapes as aesthetics and a unique design will be important to the committee members.

3. Be sure that your building layout contains all relevant dimensions. For example, if your building has a basketball court, be sure the space for the court will meet the proper dimensions (you will need to research the dimensions of a basketball court).

4. This building layout is a scaled drawing, therefore you will need to decide on an appropriate scale factor and include a key on your drawing that will indicate the scale factor you have chosen.

5. Calculate the area, volume, and wall surface area for each room. **Be sure to show all work!**

Group reflection: Circle the answer that best describes your progress on today's goal.

Have you completed drawing all needed rooms	Yes	No
Have you listed the purpose for each room	Yes	No
Have you labeled dimensions for rooms	Yes	No
Have you calculated the square footage for each room?	Yes	No
Have you calculated the wall surface area for each room?	Yes	No

Community Building Project - Day 3

Multiple Perspectives

Introduction

In this lesson, groups of students will finalize their ideas for their building layout. They will pay particular attention to the number, size, shape and usage of each room they plan to include in their building and how these rooms will be situated with the building itself. Student will be introduced to the concepts of surface area and volume which will be used to describe the size of the rooms. This lesson will expand the students understanding of two dimensional figures to three dimensions through an investigation of the transition from an isometric representation to an orthographic representation. This lesson is intended for seventh grade mathematics students and is designed to be completed in one eighty minute class session.

Objective

At the end of the lesson, each group of students should have developed detailed description of the rooms in their building layout by using the concepts of area, volume, perimeter, circumference, and surface area.

Relevant Professional Standards

This lesson is intended to follow the NYS Common Core Mathematics Standards.

> 7.G Draw, construct, and describe geometrical figures and describe the relationships between them.

7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

7.G.3 Describe the two-dimensional figures that result from slicing three-dimensional figures, as in plane sections of right rectangular prims and right rectangular pyramids.

Materials/Equipment

1) Pencil and Paper
2) Project Information Packet
3) Surface Area and Volume Practice Problems
4) Computer and Internet Access

Agenda

1) Instruction on Surface Area and Volume – 25 minutes
2) Finalize building layout including rooms and usage, room shapes, room dimensions and size, and other information relevant to building layout. – 45 minutes
3) Complete Day 3 Project Summery and Reflection. – 10 minutes

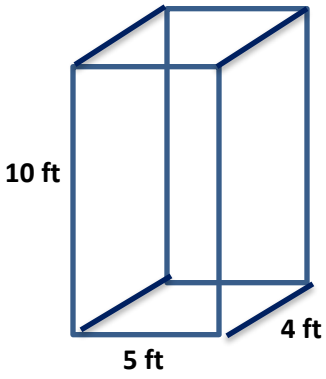
Name: _____ Date: _____

Math 7 Building Project – Day 3

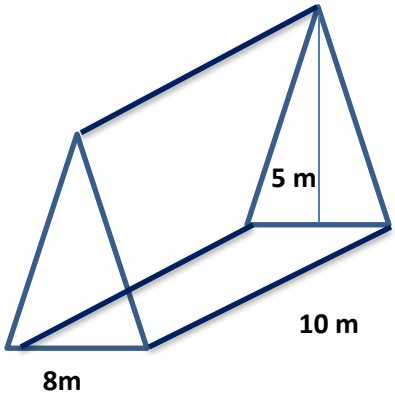
Key Vocabulary Terms:

Surface Area:

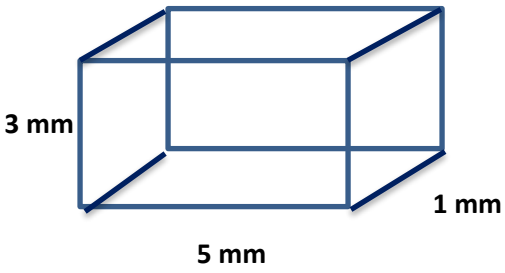
Volume:



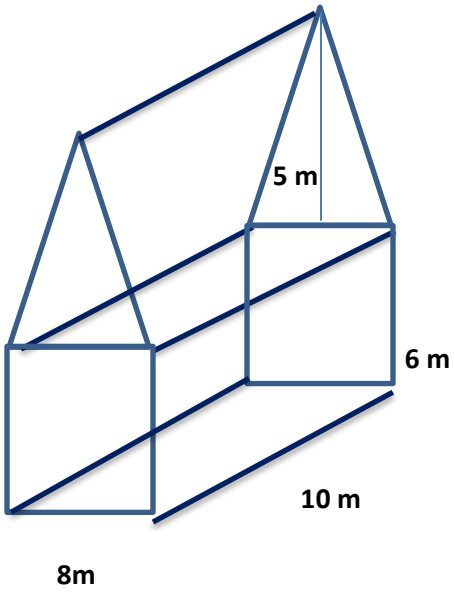
1) Find the surface area and volume of the rectangular prism.



2) Find the volume of the triangular prism.



3) Find the surface area and volume of the rectangular prism.



4) Find the surface area and volume of the figure to the right.

Day 3 Project Update

List the members of your group below:

_____

_____

_____

_____

_____

Directions: Using graph paper, straight edge, and compass; continue to create a rough draft for your building layout.

1. Be sure to include rooms for office space for workers, restrooms, electrical rooms, and any other rooms that would be needed for your building to fulfill its purpose.

2. This building should include several different shapes as aesthetics and a unique design will be important to the committee members.

3. Be sure that your building layout contains all relevant dimensions. For example, if your building has a basketball court, be sure the space for the court will meet the proper dimensions (you will need to research the dimensions of a basketball court).

4. This building layout is a scaled drawing, therefore you will need to decide on an appropriate scale factor and include a key on your drawing that will indicate the scale factor you have chosen.

5. Calculate the area, volume, and wall surface area for each room. **Be sure to show all work!**

Group reflection: Circle the answer that best describes your progress on today's goal.

Have you completed drawing all needed rooms	Yes	No
Have you listed the purpose for each room	Yes	No
Have you labeled dimensions for rooms	Yes	No
Have you calculated the square footage for each room?	Yes	No
Have you calculated the wall surface area for each room?	Yes	No

Community Building Project - Day 4

Research and Revise

Introduction

In this lesson, groups of students will begin their work on a rough draft for the blueprint of their building layout. Students will take the concepts of area, volume, surface area, perimeter and circumference, as well as ratios and proportions to create a blueprint that will act as the basis for their building proposal. They will then research the costs for flooring, paint, and other materials needed for their buildings intended purpose. This lesson is intended for seventh grade mathematics students and is designed to be completed in one eighty minute class session.

Objective

At the end of the lesson, each group of students should have researched what a blueprint is and begin to put together a rough draft that will be the basis of their building project. Additionally they should be putting together a list of required materials needed for completion of their building's intended use.

Relevant Professional Standards

This lesson is intended to follow the NYS Common Core Mathematics Standards.

> 7.G Draw, construct, and describe geometrical figures and describe the relationships between them.

7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

7.G.3 Describe the two-dimensional figures that result from slicing three-dimensional figures, as in plane sections of right rectangular prims and right rectangular pyramids.

Materials/Equipment

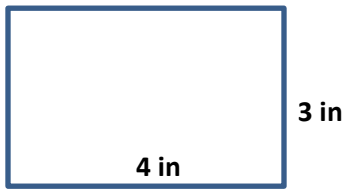
1) Pencil and Paper
2) Project Information Packet
3) Surface Area and Volume Practice Problems
4) Computer and Internet Access

Agenda

1) Review of proportion problems needed to find flooring costs. – 10 minutes
2) Research blueprints and begin to put together a rough draft of a blueprint for their building project. – 40 minutes
3) Research materials needed for their buildings intended use and their associated costs. - 25 minutes
4) Complete Day 4 Project Summery and Reflection. – 5 minutes

Name: _____ Date: _____

Math 7 Building Project – Day 4



1) The figure to the right is a scale drawing of a bedroom such that 1 in on the drawing is equal to 3 ft for the actual room. Calculate the actual area of the bedroom.

2) If carpet costs $1.50 per sq ft, how much would it cost to carpet the bedroom?

3) If the bedroom on the drawing is 3.5 in tall, what would the surface area of the wall be for the actual room?

4) If paint costs $1.25 per sq ft, how much would it cost to paint the walls of the bedroom?

Day 4 Project Update

List the members of your group below:

_____

_____

_____

_____

_____

Directions:

Start rough draft of the building layout.

Research the cost for flooring, paint, wallpaper, etc.

Begin calculation of the cost for each room (show all work).

Group reflection: Circle the answer that best describes your progress on today's goal.

Have you started rough draft of blueprint?	Yes	No
Have you researched the cost of material?	Yes	No
Have you begun the calculation of cost for each room?	Yes	No

Budget Worksheet:

Item	Description	Cost (per sq ft)	Sq ft Needed	Total Cost

Community Building Project - Day 5

Research and Revise

Introduction

In this lesson, groups of students will complete their rough draft of their building's blueprint. In addition students will complete their budget for costs associated with their buildings intended use. This lesson will utilize the concepts of area, surface area, volume, ratios, and proportions and further the students' understanding of these concepts and how they are utilized in an authentic setting. This lesson is intended for seventh grade mathematics students and is designed to be completed in one eighty minute class session.

Objective

At the end of the lesson, each group of students should have completed and submitted their rough draft blueprint and a list of materials and their costs that are associated with their building's intended use.

Relevant Professional Standards

This lesson is intended to follow the NYS Common Core Mathematics Standards.

> 7.G Solve real-life and mathematical problems involving angle measure, area, surface area, and volume
>
> 7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

7.G.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between circumference and area of a circle.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three- dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

7.RP.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas, and other quantities measured in like or different units.

Materials/Equipment

1) Pencil and Paper
2) Project Information Packet
3) Computer and Internet Access

Agenda

1) Research and calculation of associated building costs – 35 minutes
2) Complete rough draft for building's blueprint – 35 minutes
3) Complete and turn in Day 5 Project Summery and Reflection – 10 minutes

Day 5 Project Update

List the members of your group below:

_____

_____

_____

_____

_____

Directions:

Finish your rough draft of the building layout.

Research the cost for flooring, paint, wallpaper, etc.

Calculate the cost for each room (show all work).

Begin work on the budget rough draft.

Group reflection: Circle the answer that best describes your progress on today's goal.

Have you completed rough draft of blueprint?	Yes	No
Have you researched the cost of material?	Yes	No
Have you calculated the cost of each room?	Yes	No
Have you started the budget rough draft?	Yes	No

Community Building Project - Day 6

Test Your Mettle

Introduction

In this lesson, groups of students will use Google Sketchup to create a computer three dimensional model of their building's layout. Students will also complete and submit the budget rough draft that was started the previous lesson. This lesson is intended for seventh grade mathematics students and is designed to be completed in one eighty minute class session.

Objective

At the end of the lesson, each group of students should have completed their three dimensional computer model of their building's layout as well as their budget rough draft.

Relevant Professional Standards

This lesson is intended to follow the NYS Common Core Mathematics Standards.

> 7.G Solve real-life and mathematical problems involving angle measure, area, surface area, and volume
>
> 7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
>
> 7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

7.G.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between circumference and area of a circle.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three- dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

7.RP.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas, and other quantities measured in like or different units.

Materials/Equipment

1) Pencil and Paper
2) Project Information Packet
3) Computer and Internet Access
4) Google Sketchup software

Agenda

1) Create a three dimensional computer model – 45 minutes
2) Complete and submit the budget rough draft – 15 minutes.
3) Review rough draft for building's blueprint – 15 minutes
4) Complete and turn in Day 6 Project Summery and Reflection – 5 minutes

Day 6 Project Update

List the members of your group below:

_____

_____

_____

_____

_____

Directions:

Create a three dimensional computer model of your building's layout using Sketchup.

Finish your budget rough draft.

Review and reflect on the rough draft of your building's blueprint. Decide on changes that need to be made for your final blueprint.

Group reflection: Circle the answer that best describes your progress on today's goal.

Have you completed budget rough draft?	Yes	No
Have you completed the computer model?	Yes	No
Have you reviewed the blueprint rough draft?	Yes	No

Community Building Project - Day 7

Test Your Mettle

Introduction

In this lesson, groups of students will finalize their budget and blueprint for their building project. Students will then work on creating a presentation that will outline the student's proposal for a building that will improve the community. This lesson is intended for seventh grade mathematics students and is designed to be completed in one eighty minute class session.

Objective

At the end of the lesson, each group of students should have completed their final budget and blueprint. They should have decided on how their building proposal will be presented and assign role for each team member in that presentation, and create the presentation that they will use for the proposal.

Relevant Professional Standards

This lesson is intended to follow the NYS Common Core Mathematics Standards.

> 7.G Solve real-life and mathematical problems involving angle measure, area, surface area, and volume
>
> 7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
>
> 7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three

measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

7.G.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between circumference and area of a circle.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three- dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

7.RP.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas, and other quantities measured in like or different units.

Materials/Equipment

1) Pencil and Paper
2) Project Information Packet
3) Computer and Internet Access

Agenda

1) Complete the final budget report – 15 minutes
2) Complete the final blueprint proposal – 15 minutes.
3) Decide on a presentation method and team roles in the presentation – 10 minutes
4) Create the presentation – 35 minutes
5) Complete and turn in Day 7 Project Summery and Reflection – 5 minutes

Day 7 Project Update

List the members of your group below:

_____

_____

_____

_____

_____

Directions:

Complete final budget report.

Complete final blueprint proposal.

Decide on a presentation method and assign roles for each team member.

Create the presentation for your building proposal.

Group reflection: Circle the answer that best describes your progress on today's goal.

Have you completed budget report?	Yes	No
Have you completed the final blueprint proposal?	Yes	No
Have you decided on a presentation method?	Yes	No
Have you decided on roles for team members?	Yes	No
Have you completed your presentation?	Yes	No

Community Building Project - Day 8

Go Public

Introduction

In this lesson, groups of students will present their building proposal to the class and interested members of the community. This lesson is intended for seventh grade mathematics students and is designed to be completed in one eighty minute class session.

Objective

At the end of the lesson, each group of students should have completed their building proposal to the class and interested members of the community.

Relevant Professional Standards

This lesson is intended to follow the NYS Common Core Mathematics Standards.

> 7.G Solve real-life and mathematical problems involving angle measure, area, surface area, and volume
>
> 7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
>
> 7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle.

7.G.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between circumference and area of a circle.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three- dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

7.RP.1 Compute unit rates associated with ratios of fractions, including ratios of lengths, areas, and other quantities measured in like or different units.

Materials/Equipment

1) Presentation Materials
2) Computer and Internet Access

Agenda

1) Introduce the driving question and each group of students. – 5 minutes
2) Students present their building proposals and take questions and comments from those in attendance – 75 minutes

Validity

This curriculum project and associated lesson plans were reviewed by a tenured mathematics teacher with many years of experience teaching 7th grade mathematics in a suburban Western New York school district. Overall she had very positive feedback regarding the curriculum project, and offered suggestions for further improvement.

Strengths:

- Personalized learning and student centered learning environments are educational approaches that are strongly encouraged in her school district.
- Authentic problems and community involvement are very effective with motivating students to give their best efforts.
- The project based approach is an excellent way to help students develop a concrete understanding of the concepts of area and volume.
- The inclusion of scale models allows for students to develop proportional reasoning and understand the importance of ratios and proportions in an authentic setting.
- The inclusion of both group and individual reflection at the conclusion of each day's lesson is an excellent way to develop deeper understanding of concepts being taught.

Suggestions:

- With the increased emphasis on testing, students need more opportunities to practice with questions of a similar type that they will see on state tests. Including practice problems as part of their homework could help bridge this gap.
- Use of technology, specifically computer modeling software, presents an opportunity to work together with the technology department. If students are being taught how to use

the modeling software in technology class more time can be dedicated to solving the mathematical problems in class.

- Having students make video presentations would allow for additional opportunities for community involvement and feedback.
- Students should explain their reasoning for performing certain calculations, specifically and the reasoning behind the process they are using.
- Students may be overwhelmed at first with this approach and the amount of choice available to them. It might be best to include smaller projects in preceding units to get them use to the process.

Conclusion

The primary goal of this curriculum project was to assist teachers by presenting an example of how to incorporate project based learning into a 7^{th} grade mathematics curriculum while meeting the standards of the Common Core State Standards. It is the hope of the author, that teachers can find ways to implement project based learning into their curriculum, so that students understand the importance of learning the concepts included in the standards.

The authentic nature of the project based learning approach demonstrated in this curriculum project does this while providing a learner centered educational environment that has been shown to be very effective in both motivating students and developing a deep understanding of the concepts being studied.

As a result of the amount of freedom granted to the student groups, the actual models developed by the students and their presentations will likely look vastly different from each

other. The multiple perspectives each group possesses due to the unique makeup of each group of students is a key component of the Legacy Cycle model. When implementing this project, it may be necessary to include additional scaffolding and practice problems to prepare students for the type of problems they will need to solve during state testing. Furthermore it may prove beneficial to build a large project like the one presented in this curriculum project by introducing smaller projects in preceding units.

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Appendix:

Project Rubric				
Criteria	**Weight**	**Emerging (Below Standards)** **1 – 5 points**	**Proficient (Meets Standards)** **6 – 12points**	**Mastery (Exceptional Performance)** **13- 15 points**
Problem interpretation and perseverance in solving	15%	1. Student cannot recognize givens, constraints, relationships, and goals of a problem 2. Student does not monitor progress or adjust approach to problem. 3. Student does not check solution for errors.	1. Student analyzes givens, constraints, relationships, and goals of a problem. 2. Student monitors and evaluations progress and changes approach in necessary. 3. Student checks for solutions for errors.	1. Meets all proficient criteria 2. Student quickly analyzes key aspects of a problem. 3. Student easily monitors progress and adjusts approach to problem. 4. Student routinely checks solutions for errors. 5. Student is able to fully explain solution to others.
Reason abstractly and quantitatively	15%	1. Student cannot represent problem symbolically 2. Student shows limited ability to contextualize the problem	1. Student abstracts a given situation and represents it symbolically 2. Student manipulates the representing symbols and shows the ability to contextualize the problem. 3. Student creates a coherent representation of the problem.	1. Meets all proficient criteria 2. Student represents a problem symbolically in ways that show thorough understanding. 3. Student manipulates the representing symbols in ways that show thorough understanding. 4. Student can explain the representation of the problems to others.

Construct viable arguments and critique the reasoning of others	15%	1. Student cannot state assumptions, definitions, and results in constructing arguments 2. Student makes limited conjectures or builds an illogical progression of statements to explore conjectures. 3. Student shows limited ability to reason inductively or use logic.	1. Student understands and uses assumptions, definitions, and results in constructing arguments. 2. Student makes conjectures and builds a logical progression of statements to explore conjectures 3. Student analyzes situations and can recognize and use counter examples. 4. Student reason inductively and uses logic and reasoning.	1. Meets all proficient criteria 2. Student can construct argument using stated assumptions and definitions, and results in constructing arguments. 3. Students make original conjectures and builds and elegant progression of statements to explore conjectures. 4. Student quickly uses original counter examples to explain or construct problem.
Model with mathematics	15%	1. Students cannot link important quantities with use of tools such as diagrams, tables, graphs, and formulas. 2. Student shows limited knowledge of how mathematics applies to problems arising in everyday life, society and the workplace.	1. Student identifies important quantities with use of tools such as diagrams, tables, graphs, and formulas. 2. Student applies mathematics to solve problems arising in everyday life, society, and the workplace.	1. Meets all proficient criteria. 2. Student maps complex situations with such tools as diagrams, tables, graphs, and formulas. 3. Student has unusual insight into how mathematics applies to solving problems arising in everyday life, society, and the workplace.
Use appropriate tools	10%	1. Student does not use the available tools when solving a mathematical problem.	1. Student considers the available tools when solving a mathematical problem.	1. Meets all proficient criteria 2. Student chooses the best available tools when solving a

		2. Student has limited ability to use technological tools to explore understanding of concepts	2. Student is able to use technological tools to explore their understanding of concepts.	mathematical problem. 3. Student is an expert at using technological tools to explore their understanding of concepts.
Precision	10%	1. Student does not use definitions in discussion with others and in their own reasoning. 2. Student does not calculate accurately and efficiently in the context of the problem.	1. Student uses clear definitions in discussions with others and in their own reasoning. 2. Student calculates accurately and efficiently in the context of the problem.	1. Meets all proficient criteria 2. Student uses clear definitions in a variety of way that helps clarify their own reasoning. 3. Student calculates accurately and efficiently with exact degree of precision in the context of the problem.
Make use of structure	10%	1. Student cannot discern a pattern or structure without assistance.	1. Student looks closely to discern a pattern or structure.	1. Meets all proficient criteria 2. Student can easily identify a pattern or structure in a wide range of settings.
Repeated Reasoning	10%	1. Student overlooks calculations that are repeated, and does not look for general methods or for shortcuts.	1. Student notices if calculations are repeated and looks for general methods.	1. Meets all proficient criteria 2. Student rarely repeats calculations, and first looks for general methods when problem solving.

Team Daily Learning Log

Today's Project Goals	1.	
	2.	
	3.	
	4.	
	5.	

The Next Steps	1.	
	2.	
	3.	
	4.	
	5.	

Important Problems, Concerns, And Questions	1.	
	2.	
	3.	
	4.	
	5.	

Student Daily Learning Log

Name:			
Building:		**Date:**	

My Goals for Today	1.	
	2.	
	3.	
	4.	
	5.	

Important Problems, Concerns, And Questions	1.	
	2.	
	3.	
	4.	
	5.	

What I Did Today	1.	
	2.	
	3.	
	4.	
	5.	

Name: _____ Date: _____

Math 7 Building Project – Day 1

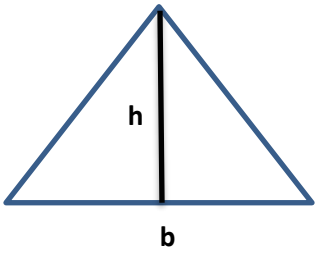
Key Vocabulary Terms:

Perimeter: The sum of the length of a polygon's sides

Area: The number of square units enclosed in a polygon.

Circumference: The distance around a circle.

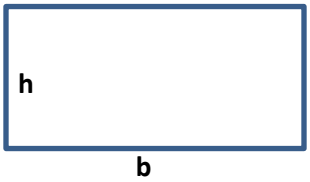
Review of Area formulas:



1) Find the area of a triangle with a height of 8 ft and a base of 12ft.

$$A = \frac{1}{2}bh$$

$$A = \frac{1}{2}12 * 8 = 48\ ft^2$$

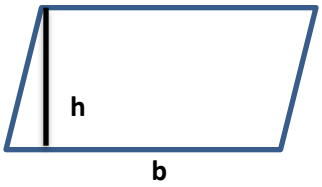


2) Find the length of the base of a rectangle with an area of 90 in^2 and a base of 10 in.

$$A = bh$$

$$90 = 10 * l$$

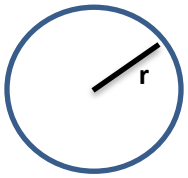
$$l = 9\ in$$



3) Find the area of a parallelogram with a height of 10 m, a slant height of 12 m, and a base of 20 m.

$$A = bh$$

$$A = 10 * 20 = 200\ m^2$$



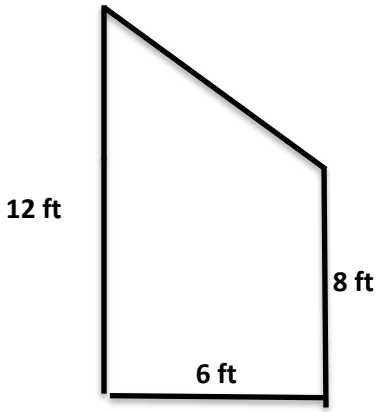
$$A = \pi r^2$$

$$A = \pi(\ 5^2\ ) = 25\pi\ cm^2$$

4) Find the area and circumference of a circle with a radius of 5 cm.

$$C = 2\pi r$$

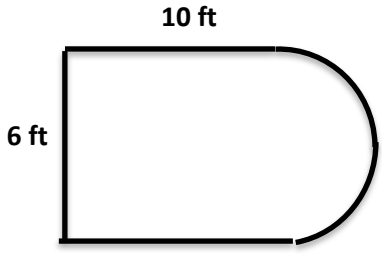
$$C = 2\pi(5) = 10\ \pi\ m$$



5) Find the area of the figure to the left.

$$A = bh + \frac{1}{2}bh$$

$$A = 6 * 8 + \frac{1}{2}6 * 4 = 60\ ft^2$$



6) Find the area and perimeter of the figure to the left.

$$A = bh + \frac{1}{2}\pi r^2$$

$$A = 10 * 6 + \frac{1}{2}\pi(3)^2 = 74.14\ ft^2$$

Name: _____ Date: _____

Math 7 Building Project – Day 2

Key Vocabulary Terms:

Ratio: A comparison between two quantities

Proportion: Two equal ratios

Scale Drawing: A drawing that shows a real object with accurate dimensions enlarged or shrunk by a certain amount.

1) Suppose a scale model has a scale of 2 inches = 3 feet. What is the scale factor?

$$\frac{2\ in}{3\ ft}$$

2) Suppose the scale is 2 inches = 4 yards. What is the scale factor?

$$\frac{2\ in}{4\ ft}$$

3) The length of a patio is 4.5 cm in a scale drawing. If the scale of the drawing is 1 cm = 0.5 m, find the actual length of the patio.

$$\frac{4.5}{x} = \frac{1}{.5}$$

X = 2.25 m

4) The actual distance between a house and tree is 12 ft. If the scale of the drawing is 1ft = 1.5 in, find corresponding distance on the drawing.

$\frac{12}{x} = \frac{1}{1.5}$

X = 18 in

truck is 6 ft long. On a scale model of the truck the bed is 8

e of the model?

$\frac{6\ ft}{8\ in} = \frac{3\ ft}{4\ in}$

6) On a map two towns are $5\frac{3}{4}$ cm apart. The scale on the map is $\frac{1}{2}$cm $= 3$ mi. What is the actual distance between the towns?

$\frac{5.75}{x} = \frac{.5}{3}$

.5x = 17.25

x = 34.5 mi

7) A drawing of your classroom has a scale of 1 in = 8 ft. If the actual length of the classroom is measured to be 36 ft, what should the length of the classroom in the drawing be?

$\frac{x}{36} = \frac{1}{8}$

8 x = 36

x = 4.5 in

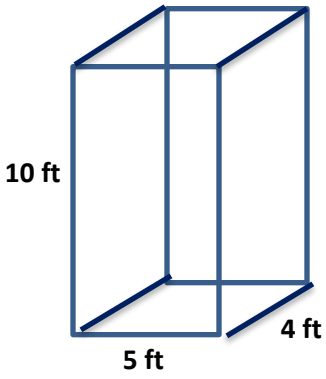
Name: _____ Date: _____

Math 7 Building Project – Day 3

Key Vocabulary Terms:

Surface Area: The sum of the areas of each surface of a 3 dimensional figure.

Volume: The number of cubic units that can fit inside of a 3 dimensional figure.



1) Find the surface area and volume of the rectangular prism.

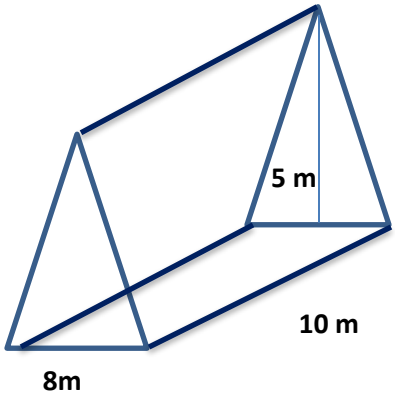
$SA = 2 * 5 * 4 + 2 * 5 * 10 + 2 * 4 * 10$

SA = 40 + 100 + 80

SA = 220 ft^2

$V = lwh$

V = 5*4*10 = 200 ft^3

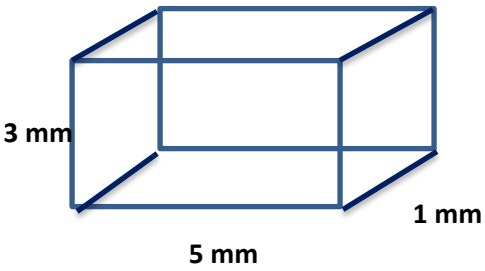


2) Find the volume of the triangular prism.

$$V = \frac{1}{2}lwh$$

$$V = \frac{1}{2}(8)(5)(10)$$

$$= 200\ m^2$$



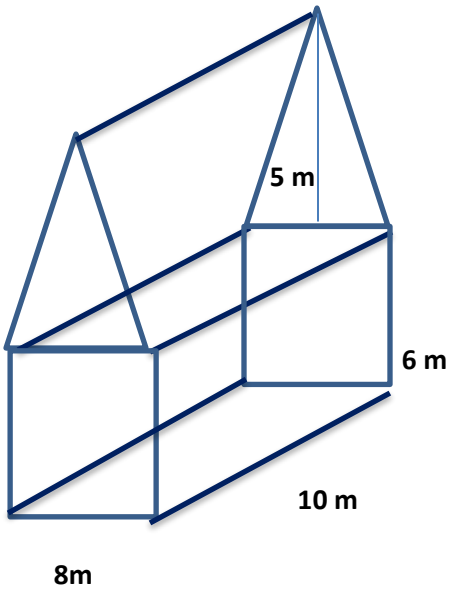
3) Find the surface area and volume of the rectangular prism.

$SA = 2 * 5 * 1 + 2 * 5 * 3 + 2 * 3 * 1$

SA = 46 mm^2

$V = lwh$

V = 3*5*1 = 15 mm^2



4) Find the volume of the figure to the right.

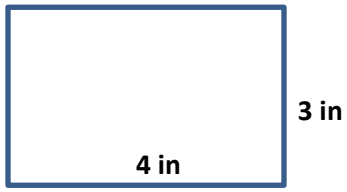
$V = lwh + \frac{1}{2}bhl$

$V = (8)(10)(6) + \frac{1}{2}(8)(5)(10)$

$V = 480 + 200 = 680\ m^2$

Name: _____ Date: _____

Math 7 Building Project – Day 4



1) The figure to the right is a scale drawing of a bedroom such that 1 in on the drawing is equal to 3 ft for the actual room. Calculate the actual area of the bedroom.

$\frac{1}{3} = \frac{3}{x}$ $x = 9$ $\frac{1}{3} = \frac{4}{y}$ $y = 12$ $A = bh$

$A = 9 * 12 = 108\ ft^2$

2) If carpet costs $1.50 per sq ft, how much would it cost to carpet the bedroom?

$\frac{1.50}{1} = \frac{x}{108}$ $x = \$162$

3) If the bedroom on the drawing is 3.5 in tall, what would the surface area of the wall be for the actual room?

$\frac{1}{3} = \frac{3.5}{z}$ $z = 10.5\ ft$ $SA = 2(10.5)(9) + (2)(10.5)(12)$

$SA = 411\ ft^2$

4) If paint costs $1.25 per sq ft, how much would it cost to paint the walls of the bedroom?

$\frac{1.25}{1} = \frac{x}{411}$ $x = \$513.75$