Tiny House Design

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Target Grade: Middle School or High School STEM

Time Required: Eight to ten 90 minute lessons

Standards:

Next Generation Science Standards:

- MS-ET-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- HS-ET1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved though engineering.

Common Core Math Standards

- 7.RP.A.2 Recognize and represent proportional relationships between quantities.
- 7.RP.A.3 Use proportional relationships to solve multi-step ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.
- 7.G.A.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.
- G.MG.A.2 Apply geometric methods to solve real world problems.

Lesson Objectives:

Students will:

- Use the engineering design process to create a prototype for a tiny house.
- Convert full size measurements to scale size and scale size measurements to full size using proportions.
- Recognize scaled drawings of items as a similar figure to the original item.
- Use spatial relations in their design to allow for appropriate spacing.
- Create an orthographic drawing of a tiny house.

- Extension: Use a CAD design program that allows them to design their homes to be 3D printed.

Central Focus:

In this lesson, students will use the engineering design process to design and construct a prototype of a tiny house. This lesson utilizes the math skill of proportions, and also employs research and problem solving. The activity allows students to be creative, while working within tight size constraints. This lesson also has the benefit of students solving real-world problems, like engineers!

Keywords: mathematics, engineer, solve, test, improve, redesign, create, CAD, 3D, print, printer

Background Information:

When the pioneers began to settle the U.S., one of the first things that they needed to do once they arrived was to construct a home. Because trees were plentiful, they built log cabins. In order to begin farming as soon as possible, homes were built just big enough to hold the family and were often a one room building. As time went on, they were able to add to the existing home or build a bigger home.

Throughout the years, with advances in building techniques, homes have increased in size to an average of 2662 square feet in 2013. However, some people started to rethink the large homes of today and started to create smaller homes of 1000 square feet or less. When the depression hit in 2008, the small house movement gained attention. Today many people are moving back to smaller homes due to many reasons such as: mobility, ecological impact, and cost. Tiny houses can cost as little as $10,000 to more than $100,000 for a custom built home.

Students will also need to understand the engineering design process:

- Ask a question that identifies a problem
- Research the problem
- Develop possible solutions
- Plan the solution
- Build a prototype
- Test and evaluate the prototype
- Improve and redesign

Materials

- Oversized graph paper
- Computers with internet access
- One sheet of foam board per group
- Scissors
- Pencils

- Glue
- Hot glue
- Calculator (optional)
- Scale Conversions worksheet (attached)
- Blue painters tape
- Tape measures if you do not have tiled floors
- 3D Printer (for extension)

Instruction

This unit is designed to be used either in part or as a whole.

Day 1:
Show students this video (https://www.youtube.com/watch?v=05MCdROh32I) to give context on tiny houses and garner interest. Divide students into groups of 2-4 and give them their challenge: design and build a scaled version of a tiny home.

Research:
Student groups should conduct internet research to answer the following questions:
- What qualifies as a tiny house?
- What are 3 reasons people chose to buy a tiny house?
- What are 3 positive features of a tiny house?
- What are 3 negative features of a tiny house?

Groups should document answers to these questions in their notebooks, including citations of resources used.

Create a Design Board:
Students will use a Google Doc to create a design board within their group. Using Google Docs allows for each of the members to edit the document, and also gives the teacher the ability to look at the edit history to see which members are contributing more or less. Students will do more research on tiny homes and add pictures of elements that they would like to add to their home design. Students should make decisions on items such as flooring, paint colors, kitchen counter materials, tile for the bathroom, etc.

Optional: To further extend research (will extend research to multiple days)
- Students can research how tiny houses could be used in disaster areas to help with housing deficiencies.
- Students can research the already existent process of 3D printing houses using concrete to write an argumentative paper outlining the pros and cons of 3D printed houses.

- Students can design their house specifically for a fictional character. They would need to have evidence of characteristics of the character and be able to justify how their design fits the needs of the character.

Days 2-5:

Define Specifications:
In this step, students will need to plan the layout of their home. Things students should consider would include, but are not limited to:

- Will there be a loft room?
- Will the bathroom be closed off?
- Will rooms be combined? Ex: dining room and sitting room
- Will a porch be included?

The teacher may decide that there will be certain requirements. Examples might include: bathroom must have a shower, plans should account for 3 people living in the house, etc.

Prototype:
Students will be given a piece of oversized graph paper to design the floor layout of their house. Houses cannot exceed 500 square feet. A good scale for actual size to scale on graph paper is 1 foot to 0.5 inches. For students with difficulties, this can be modified so that the house is already outlines on the graph paper, and the student can work solely on the inside layout.

Research: Use the attached worksheet
Students should identify the following, filling in the actual size, scale size, and adding a photo to their design board:

- Furniture
- Cabinets
- Appliances

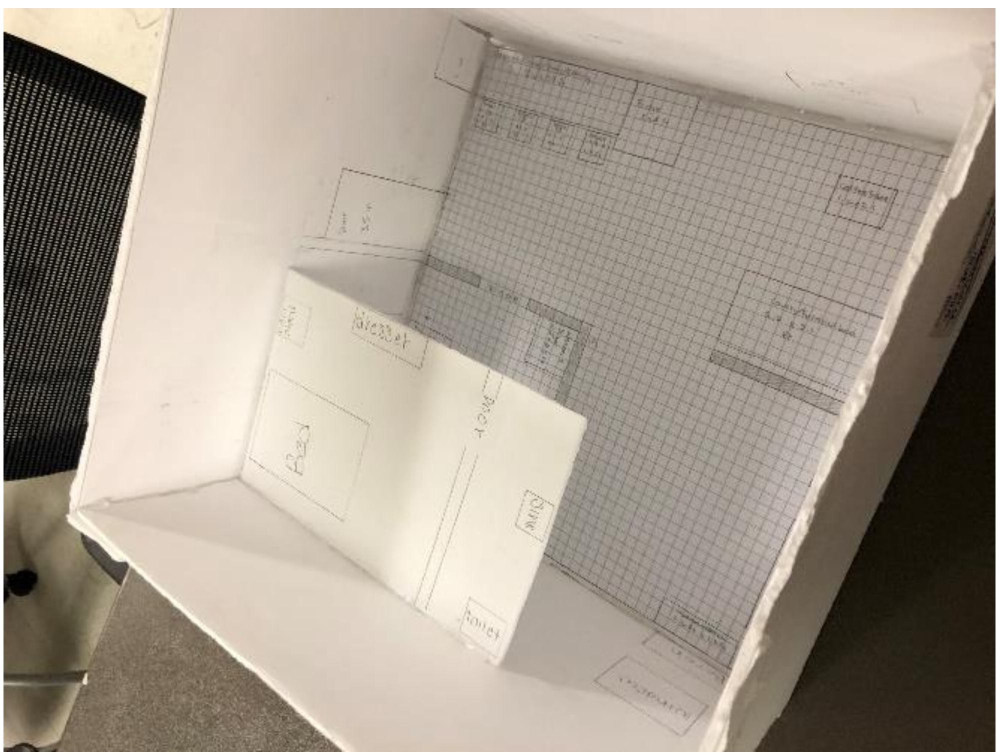
Once each group has completed their table, they should make a copy of it, deleting the figures in column 1 (actual size). Groups will exchange tables and calculate the actual size of the items using the scaled figures. Based on the actual dimensions calculated, students will use painters tape to map out one room (full size) from the other groups' house layout. They should critique if the design works well (are the sizes of the room and furniture reasonable? Is there space to walk? Will dresser drawers have enough room to open? Etc.)

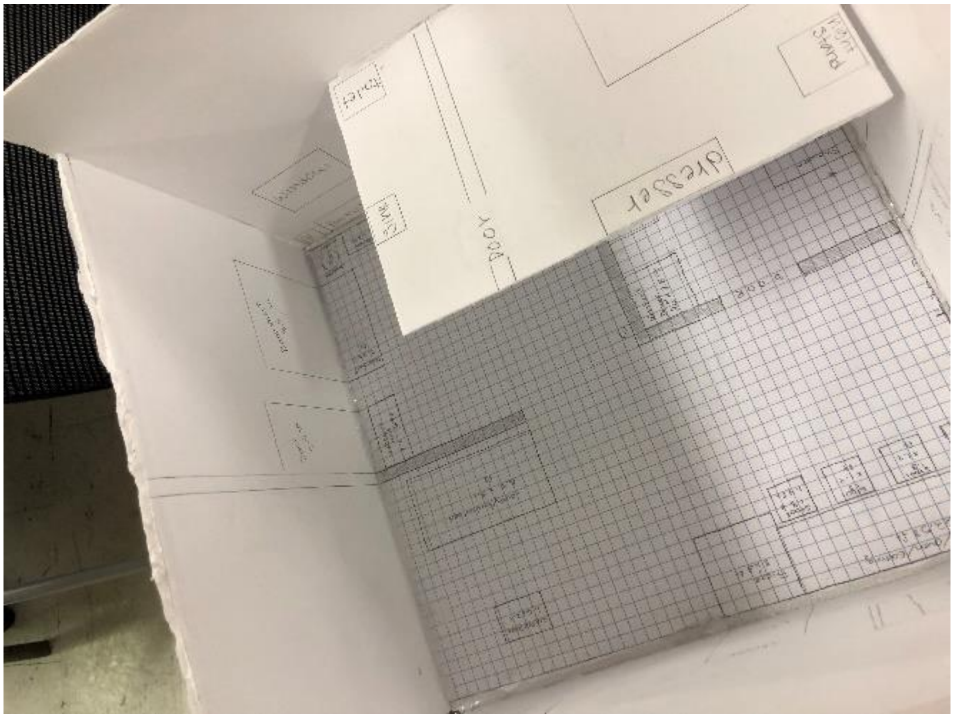
Days 6-8
Redesign:
Each group will walk through each of the rooms set out with painters tape and write feedback on a piece of paper for each room, including their own. Feedback should be well thought out and include both positive and negative aspects of the design. Groups will receive the feedback and be given time to redesign on their graph paper.

<u>Finish Prototype:</u>

Using the completed paper prototype of the scaled version of their house, students will now build a prototype. All places that students will cut should first be marked in pencil and the whole group should consult before cutting. Groups will be given a foam board to do the following:

- Measure and cut a piece of foam board that includes the size of the floor plan and inner/outer walls (allowing for the depth of the foam board at the bottom on the outer walls).
- Glue the graph paper to the floor piece of foam bard.
- Cut out windows and doors as appropriate.
- Mark wall features, such as outlets (which should be to scale).
- Mark furniture heights on walls, allowing for the depth of foam board at the bottom.
- Using hot glue, glue the wall pieces to the floor layout to create a 3D orthographic drawing of their tiny house.





Optional Additions/modifications:

- Allow students to decorate the exterior of the house.
- Have students use a program like TinkerCad to create a 3D printable version of their tiny house.
- Considering tiny houses in disaster areas, have students do research on what materials could be used. What are some of the constraints that would be placed on a tiny house in a specific disaster area? How long would tiny houses in disaster areas be used? Would that affect the design?
- Use a design program like Floorplanner.com to design in 3D with size constraints.
- Design the home for a fictional character. Have them research the characters traits and decide what style of home that character would have, etc.

Closure:

After the final products are completed, have the students present their design process, focusing on difficulties, problem solving, and an overall reflection of the tiny home. Additionally, have the students discuss the peer feedback from the first design and the modifications made.

Assessment

Formative Assessment:
The students will be assessed through peer feedback after the first design process. The students will receive both positive and negative feedback of their tiny house, which will allow the students to make necessary modifications to their final product.

Summative Assessment:
Use the attached rubric to assess the students' tiny houses. Each house is graded to 100 points, with 20 of the points graded individually.

Scale Conversions Worksheet

- If you have a scale of $\frac{1}{2}$inch = 1 foot, find the scale size for each of the following.
- Must back up with documentation from a website like Ikea - add the picture to your design board, and write dimensions and website on the chart below.

Item	Actual Size	Scale size	Website
Couch	Length Width Height	Length Width Height	
Bed	Length Width Height	Length Width Height	
Shower or tub	Length Width Height	Length Width Height	
Kitchen Cabinet	Length Width Height	Length Width Height	
Stove	Length Width Height	Length Width Height	
Fridge	Length Width Height	Length Width Height	
Table (eating)	Length Width Height	Length Width Height	

Grading Rubric for Final Product

Total: __________/100

	0 Points	5 Points	10 points	15 Points	20 points
Design board	Pictures/examples of design components are missing. No photos of appliances or furniture are included.	One or two pictures/examples of design components are included. One or two photos of appliances and furniture are included.	Three or four pictures/examples of design components are included. Three or four photos of appliances and furniture are included.	Five or six pictures/examples of design components are included. Five or six photos of appliances and furniture are included.	Six or more pictures/examples of design components are included. Six or more photos of appliances and furniture are included.
Floor layout	Floor plain is not included.	Floor plan is included but is missing several required elements and is not drawn to scale.	Floor plan is included but does not contain all of the required elements. Most of the items included are drawn to scale.	Floor plan is included with most of the required elements. There are a few errors in drawing to scale.	Floor plan is included with all required elements and all items are correctly drawn to scale.
Scale Conversions Worksheet	Calculations are not attempted.	Calculations are mostly completed, >40% are correct.	Calculations are completed, 40-70% are correct.	Calculations are completed, 70-95% are correct.	Calculations are completed, 95-100% are correct.
Final Prototype	Did not complete the prototype.	Several key elements missing or did not follow the majority of instructions.	Half of the elements from the floor plan are included, but the scale of items is not correct.	Most of the elements from the floor plan are included, but there are a few errors in scale.	All of the elements from the floor plan are included, and the scale of items is completely correct.
Participation (Individual)	Did not participate.	Low participation; did not contribute much to the group.	Participated in about half of the project.	Did an adequate amount of participation and contribution.	Did fair share or more of work for the group; was a main contributor.