Egress Mobility: Staircase Design

A Solidify Understanding Task

Purpose: In this activity, students will first measure a staircase in their school building to determine if they are "up to today's building codes". Then students will design a staircase for new construction.

Career Field:

Architecture
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NC Math 4 Standards:

Unit Alignment:
NC Math 4 – Not applicable (could fit NC MATH 1 or 2 – slope and area topics)
WTCC Math 121 – Area

Common Core State Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.

Prerequisite Skills

- Area given a building dimension
- Unit conversion (specifically square units)
- Slope – rise and run ideas

Time Required
The time required to complete this activity is approximately 90 minutes, depending on the building.

Materials Needed

- Tape measure
- Floor plan of your building (or give students the building square footage).
- Desmos and calculator/excel

The Teaching Cycle:

Launch: Students should work individually on the Teacher Desmos Launch, which includes the video. Or watch the video as a class and then have a class discussion on some of the ideas in the video.

Explore: Task 1 is more about terminology and understanding parts of the building code related to stairs. There are 2 codes that determine the minimum stair width. One deals with the size of the building and what it is used for, which specifies how many people can occupy the building. The code states that for every occupant, width needs to be .3 inches for each occupant. If this is small, then the minimum width for any commercial staircase is 44 inches.
Task 2 is measuring the tread, riser, stair width, distance between the stairs on the switchback, and landing width. Then determine if these measurements are within the building code for stairs. Groups need a building layout to determine the total building square footage, and then using each student requires 50 sq ft, they can determine the school building occupant load, which then can be used to determine the minimum stair width. If you give the students the building occupant load or the building square footage, this task becomes much easier.
Task 3 is calculating the minimum riser needed to connect the two floors 13 feet apart and the staircase must fit inside the stairwell of 16 feet by 10 feet. The risers all need to be the same height and they can be prefabricated to a 3 decimal place accuracy. For example, a riser of 6.783 inches is the best. You can have a different number of steps before and after a landing. In fact, you need 12 risers on one side of the landing and 11 risers on the other. The tread width is based on keeping the stairs within the 16 feet of stairwell length. Lastly, the landing is not considered a tread, so you will always have one less tread than riser on each section of stairs.
Task 4 is like task 3 except the landing must be above the added exit door. Again, keep all risers the same height and have more steps before the landing and fewer steps after the landing.

Discuss: Students will share their results and compare what they arrived at compared to other groups. Groups can explain the process they used to arrive at their result. You could have groups trade their answers and have groups compare their results with the results of the paper they are reviewing. Again, time is a factor in how you handle the discussion part of the activity. Have each group explain how they arrived at their results. You could have each group record their Staircase dimensions for Task 3 on the board. Then compare the various results (which will be different) to determine if they all are within code and acceptable. Which one would be less costly? Why? Another option, especially for online classes, would be for groups to meet virtually and record their meeting explaining their method of solution to Task 3. Then have other groups view and respond to another group's video.

Exit Ticket:
Is a stair landing width of 52 inches within code if the total square footage of the building is 15250 sq ft and the building is designed for 82 sq ft per occupant? Ans: 15250 / 80 * 0.3 inch = 57.2 inches minimum, so, NO, 52 inch landing is too small.

Two example assessments for testing:

1. What is the minimum stair riser rounded to the nearest 3 decimals needed to connect two floors that are 12.5 feet apart? (Risers need to be between 4 and 7 inches by code) Ans: 12.5ft * 12 in = 150 inches from floor 1 to 2. 150 inch / 7 in max riser = 21.4 risers, so we will need 22 risers. 150 inch / 22 risers result in 6.818 per riser, which is within 4 to 7 inch code range.

2. Will a staircase fit in a 15 foot horizontal space stairwell with one 44 inch landing halfway between the first and second floors if 25 risers are needed? Justify your answer mathematically. (Treads need to be between 11 and 12 inches by code) Ans: 13 risers before landing means that 12 treads are needed before the landing. Using 11 inch minimum tread, total horizontal distaince is 12treads*11inch+44inch landing = 176 inches. Divide by 12 inches results 14.6667 feet, which is under the 15 feet of provided space. So, YES it will fit.