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Adapt It! Create Your Own Skyscraper Puzzles

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Adapt It! Create Your Own Skyscraper Puzzles

A puzzle task is adapted for students to not only solve but also create their own. This task promotes problem solving, perseverance, and students' spatial thinking.

Susan Boyd, Liza Bondurant, and Annalise Johnson

Building activities can be used any time in the school year in mathematics classes to promote problem solving, perseverance, and to develop students' spatial thinking (Weiland & Poling, 2022). Spatial visualization skills are the "ability to mentally manipulate, rotate, twist, or invert a pictorially presented stimulus object" (McGee, 1979, p. 893). We were guided by the notion that "students at all grade levels can benefit from the use of physical and virtual manipulative materials to provide visual models of a range of mathematical ideas" (National Council of Teachers of Mathematics [NCTM], 2014, p. 82) and that PK–12 programs "should enable all students to use visualization, spatial reasoning, and geometric modeling" (NCTM, 2000, p. 41). In this article, we describe how we adapted the typical skyscraper puzzle activity to become an amazing task in which students not only solved but also created their own skyscraper puzzles.

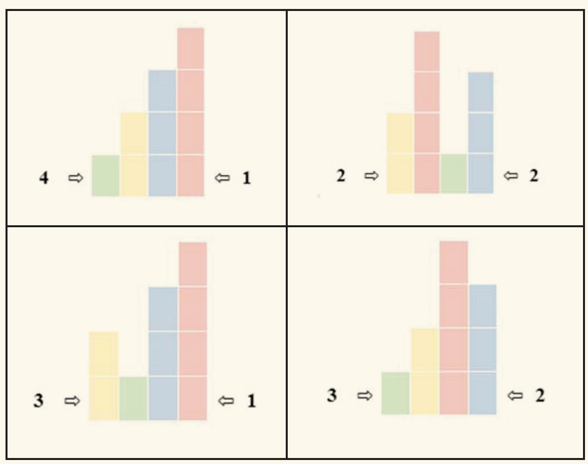
SKYSCRAPER PUZZLES

In a skyscraper puzzle, the numbers 1 to n are written along the perimeter of a grid. These numbers or clues represent the number of skyscrapers the puzzle-solver can see, not the height of the skyscraper. Each clue also has an arrow, which indicates the direction that the puzzle-solver is looking at the skyscrapers from (see Figure 1). When looking in that direction, taller skyscrapers block shorter skyscrapers. Therefore, the puzzle-solver can only see skyscrapers taller than the ones in front of them. Finally, only one skyscraper of each height exists in a row or column. The puzzle-solver strategically decides how to arrange their skyscrapers.

Introducing the Puzzles

To begin, we randomly grouped students and gave each group 40 snap cubes and a puzzle grid. We

Figure 1 Skyscrapers



provided each group with a Task Sheet. We did not provide any initial guidance on effective strategies because we wanted students to collaboratively discover strategies. We obtained our grids from the following websites: Julia Robinson Math Festival (link online), Kevin Stone's BrainBashers™ (link online), and Mark Chubb's Thinking Mathematically (link online). There are a variety of levels of difficulty available. We invite you to go to these websites and encourage you to solve some of the puzzles before moving on with the article.

It took some time for some students to make sense of the puzzle directions. Students needed to physically touch the blocks and talk about the directions to internalize what they meant. For example, some thought the clue number indicated the *height* of the tallest skyscraper, instead of *how many* skyscrapers of any height will be visible from that position. As you try these puzzles with your students, one way to mitigate confusion about the rules is to have them act out each direction with the cubes and revoice or rephrase them.

Adapt It! Create Your Own Skyscraper Puzzle

After learning how to solve puzzles, we adapted the task by challenging students to create their own skyscraper puzzles. Creating their own puzzle offers several benefits:

- It allows for creativity and personalization, as students have the freedom to design a unique puzzle they find challenging;
- Creating a puzzle is intellectually stimulating, as developing a puzzle requires critical thinking and problem-solving skills, enhancing cognitive abilities like analytical thinking and logical reasoning;
- It enables students to produce something original and leave a mark on the puzzle-solving community, offering a rewarding and exciting experience. Moreover, designing puzzles improves students' problem-solving abilities and deepens their understanding of the puzzle mechanic; and
- Sharing their puzzles sparks social interaction and engagement, creating conversations, collaborations, and friendly competitions.

As we transitioned into this part of the activity, we capitalized on the success and confidence students had after successfully solving the provided puzzles. The presentation of this task came in the form of a follow-up question: "What do you need to consider as you create your own puzzle?" Some of the responses and approaches we heard from students included the following:

- Suggestions to build all the towers needed first and just drop them in randomly.
- Strategizing the importance of the placement of the 4-tall towers first.
- Randomly placing the numbers on the grid first and then building the towers to match the perspective number.

Initially, we gave little guidance. We wanted to further encourage the confidence that students were feeling. We continued to monitor groups' progress. When a group reached a stuck-point, we prompted their reflection with questions about their previous approach, such as "What strategies have you been using and can those help you when creating your own?" We recorded students' strategies on a provided handout (see the Task Sheet). These strategies helped students transition from solving to creating their own puzzles.

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We observed different approaches from different groups. Some began their efforts by placing random numbers on the outside of the grid and then attempting to place the towers. Other groups built their towers of each height (four skyscrapers one block tall, four that were two blocks tall, and so on) and placed those on the grid first. Then, they labeled the appropriate heights on the grid. Students referred back to the printed directions (see the Task Sheet) often as they worked to create their own puzzle.

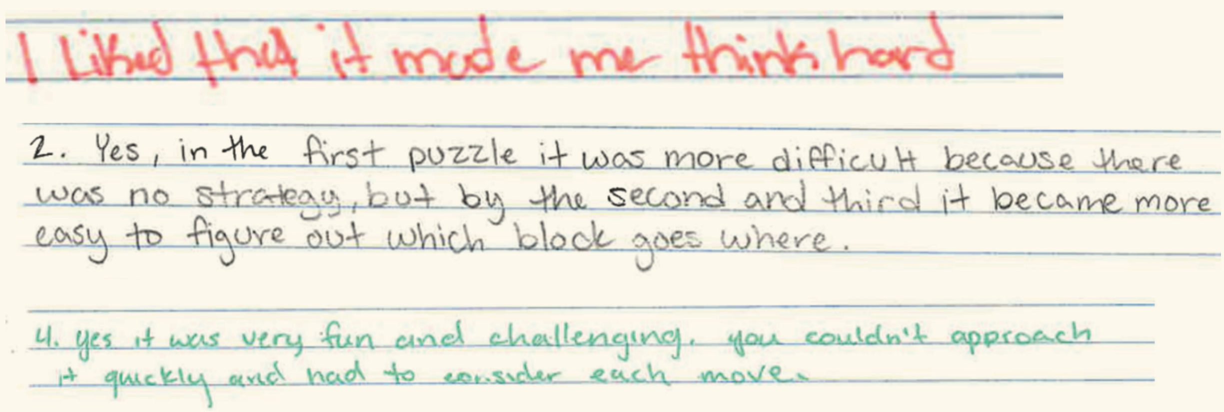
To support students as they worked, we used similar questioning strategies to those at the beginning of the task. We had asked scaffolding questions when needed, such as "Could there be a relationship between the clue number and the height of the skyscraper?," "How tall should the skyscraper in front of the 1 clue be?," and "What would happen if you moved this skyscraper here?" Asking these questions again was helpful to promote students' reasoning. It encouraged students to use their experiences in solving the puzzles as they worked to create their own. Although students' initial strategies—like randomly writing the clues around the grid to create their puzzle—might have been unsuccessful, they were quick to recognize troubles and work together toward a different strategy. As we talked with students, they described noticing on the initial puzzles the "large number of 2s." They used this observation as they worked to create their own, noting that "2s were convenient, because we could hide other skyscrapers." We suggest allowing time for students to swap their created puzzles with other groups. Our students were excited to swap their puzzles with others, but unfortunately there was not enough class time.

We loved using the snap cubes for this activity. The physical blocks allow students to easily manipulate and try skyscrapers in different locations. However, physical blocks or snap cubes may not be readily available. Using other stackable objects (link online), such as LEGO® blocks, checkers, or bottle caps, could also be a way to adapt this task. An additional idea for adaptation is the use of electronic versions of the puzzle: they are available to anyone with a device, and students who love technology may prefer them. However, electronic versions do not offer tactile sensorimotor stimulation.

SUMMARY

We provided students prompts and gave them five minutes to write a reflection on their experiences with the puzzles. This reflection opportunity required students to think about the purpose of this activity and its impact on their learning. Although these skills are not explicitly mentioned in the Common Core State Standards, proficiency in spatial visualization can support students' comprehension and problem solving in various mathematical domains (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; National Research Council, 2001). For example, these skills lay the foundation for students' ability to describe two-dimensional cross-sections of three-dimensional figures (CCSS.HSG.GMD) and make transformations of geometric shapes (CCSS.HSG.SRT) and functions in the coordinate plane (CCSS.HSF.BF).

Figure 2 Students Describe Their Productive Struggle


I Liked that it made me think hard

2. Yes, in the first puzzle it was more difficult because there was no strategy, but by the second and third it became more easy to figure out which block goes where.

4. yes it was very fun and challenging. you couldn't approach it quickly and had to consider each move.

Most students in both classes indicated that they enjoyed working on the skyscraper puzzles with their group members. In their reflections, students articulated benefits that aligned with those we had previously identified. Students said they valued or benefitted from this challenge for these reasons:

- it was hands-on and they got to work together;
- mistakes were expected and part of learning;
- it was not a race;
- everyone was able to participate; and
- there were multiple strategies for solving.

Although students struggled, they were *productive*, remained engaged, and persisted throughout the activity (see Figure 2). Students liked this challenge. All students finished at least one puzzle and exuded pride in their work.

Solving and creating their own skyscraper puzzles can enhance each student's spatial thinking skills. Additionally, students make sense of the problems and persevere in solving them, use appropriate tools strategically, construct viable arguments and critique the reasoning of others, and identify and make use of structure.

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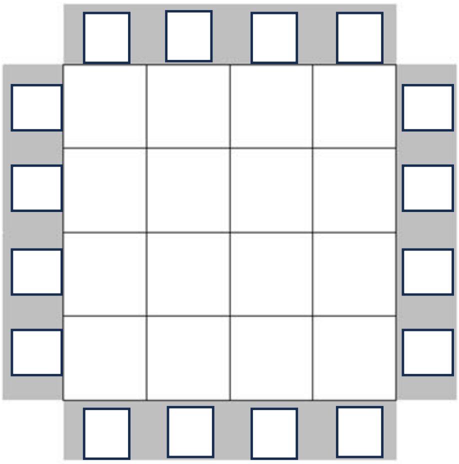
Building Skyscraper Puzzles

With your group, use snap cubes to build skyscrapers of different heights according to the puzzle grid.

Directions:

- Build towers in each of the squares sized 1 through 4 tall.
- Each column and row have skyscrapers of different heights (1 through 4), no duplicate sizes.
- The rules on the outside of the grid tell how many skyscrapers can be seen from that direction.
- Taller skyscrapers block your view of shorter ones.

Complete the grid below to reflect your puzzle and solution. Copy the directions in the gray space and write the number (1-4) to represent the height of the tower you built in each space.



Adapt it – Create Your Own Puzzle
Work with your group to create your own Skyscraper Puzzle. Once you have successfully created your puzzle, write your clues in the boxes provided.

What strategies have you been using, and can those help you when creating your own?