Using Visual Representations in Mathematics

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INTRODUCTION

All students can benefit from using visual representations, although struggling students may require additional, focused support and practice. Visual representations are a powerful way for students to access abstract mathematical ideas. To be college and career ready, students need to be able to draw a situation, graph lists of data, or place numbers on a number line. Developing this strategy early during the elementary grades gives students tools for engaging with—and ways of thinking about—increasingly abstract concepts. Over time, they will work toward developing Common Core Standards for Mathematical Practice:

- **CCSS.Math.Practice.MP2** Reason abstractly and quantitatively.
- **CCSS.Math.Practice.MP4** Model with mathematics.
- **CCSS.Math.Practice.MP5** Use appropriate tools strategically.

WAYS TO SUPPORT STUDENTS

Helping students choose the “right” visual representation often depends on content and context. In some contexts, there are multiple ways to represent the same idea. Show your students a variety of examples in order to demonstrate when (and why) they should choose each one (see UDL Checkpoint 2.5: Illustrate through multiple media). Consider how you could use the following strategies to support your students:

- Check for understanding to determine a starting point. For example, you could ask the following questions: Why do you think that? How do you know that is correct? How does that picture represent the problem? Can you explain your answer? Is there another way you could do that?
- Ask students about features of the visual representation (including labels and scales, when appropriate).
- As students create visual representations, ask questions to ensure that they understand all the features of the representations. Prompt students to focus on the information the visual representations provide.
When possible, include alternative visual representations and discuss the similarities and differences between them.

Vary the shapes and orientations of representations so that students focus only on the important features as they learn about the objects and situations represented.

Show your students a specific representation—a graph or a table—that is missing an important feature. Ask them to identify the missing feature.

DRAWING ON TECHNOLOGY TOOLS

New technologies are constantly expanding our ability to visualize data and explain mathematical concepts. For teachers looking to incorporate technology into the classroom, using virtual manipulatives (instead of physical ones) can be a good start. Students can begin with simple graphical representations of mathematical concepts and then work toward more complex modules that require them to create the data or work within a system of rules, like a game. Infographics—visualizations that are designed to communicate complex information effectively—have become increasingly popular. They can be used to “tell a story” with numbers, such as international democracy rankings or climate change impacts. Learning to create infographics gives students additional tools to communicate data and other quantitative information.

3D printing is a technology that, until recently, has been too expensive to make use of in a classroom. However, thanks to falling prices, they have now started to appear in high schools and it may not be long before elementary schools and middle schools also embrace this technology. 3D printing allows you to create solid, three-dimensional models from a digital design. You can explore what others have created to get a sense of what is possible. Imagine having students design and create their own mathematical models and manipulatives!

For more ideas on using technology to create visual representations, visit the Tech Matters blog or PowerUp’s Pinterest page. You can also check out the “Virtual Manipulatives” video, which supports students’ use of visual representations.
IN THE CLASSROOM

Geometry lends itself naturally to teaching with visual representations, as can be seen in Ms. Richardson's Grade 6 class. So far, students have learned how to classify different quadrilaterals and triangles, and they are beginning to decompose polygons. They have also started using software (e.g., GeoGebra) that can support their understanding by emphasizing the connections between mathematical language and visualization.

Ms. Richardson's lesson objective is to have students decompose polygons into triangles, rectangles, and trapezoids. She will address two Common Core State Standards in this lesson:

- **CCSS Math 6.G.1** Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.
- **CCSS Math MP4** Model with mathematics.

Ms. Richardson has students work on these standards within the context of a real-world example—a painting by the artist Sol LeWitt.

Students will build on their existing technology skills and create a model of this work, decomposing polygons and creating their own virtual LeWitt in the process. Ms. Richardson's lesson plan is organized into three sections: a warm-up exercise to review concepts, the main learning task, and a closing discussion and assessment.
Lesson Plan

Launch

- Warm up with a review problem.
- Have students demonstrate and explain different solutions to the problem.
- Compare and contrast students’ visual representations.
- As a class, identify additional solutions to the problem.

Learning Task

- Introduce the learning task.
- Connect the review problem to the real-world problem.
- Have students begin work on the problem in pairs.
- Circulate, listening to discussions and supporting students as necessary.
- Have students view all the solutions during a gallery walk.

Closure

- Lead a class discussion on students’ different solutions.
- Have each student complete an exit ticket.

ONLINE RESOURCES FOR VISUAL REPRESENTATIONS

This article draws from the PowerUp WHAT WORKS website, particularly the Visual Representations Instructional Strategy Guide. PowerUp is a free, teacher-friendly website that requires no log-in or registration. The Instructional Strategy Guide on visual representations includes a brief overview with an accompanying slide show; a list of the relevant mathematics Common Core State Standards; evidence-based teaching strategies to differentiate instruction using technology; short videos; and links to resources that will help you use technology to support mathematics instruction. If you want to dig deeper into the research foundation behind best practices in the use of virtual manipulatives, take a look at our Tech Research Brief on the topic. If you are responsible for professional development, the PD Support Materials provide helpful ideas and materials for using the resources. Want more information? See PowerUp WHAT WORKS.