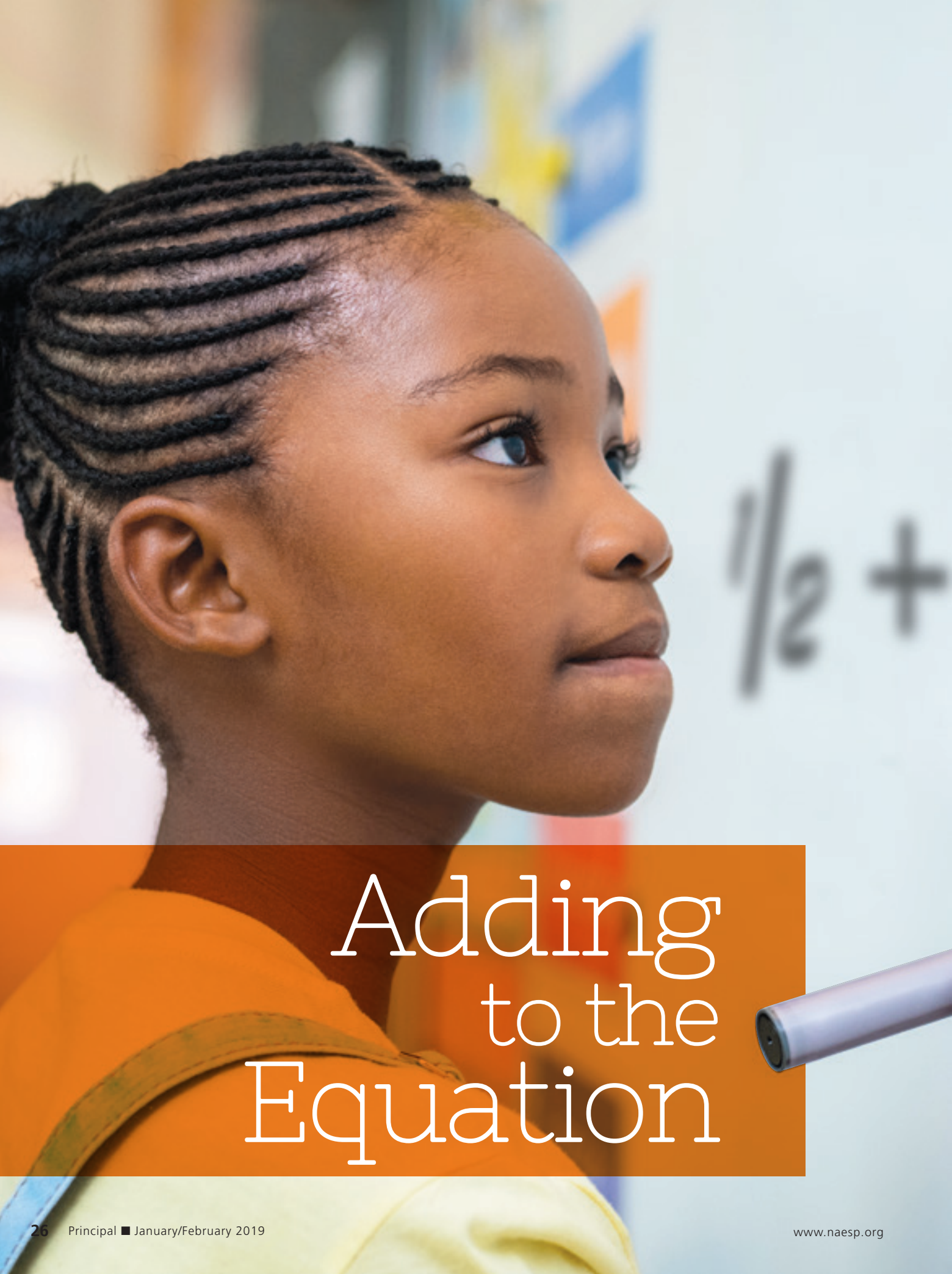


Adding to the Equation

Teaching fractions in middle school math classes using universal design for learning

By Michele L. Stites and Heather L. Walter

A group of teachers attending a professional development session on teaching mathematics recently examined a photograph of an old school and were asked, "What could be done to the building to make it easier for all people to use?" At first, they weren't sure how to reply, but then a stream of responses emerged. Some suggested that the long set of steps up to the front door would need to be replaced, or that ramps needed to be built; one thought installing an elevator to accommodate a wheelchair would be an important addition.

Why would attention to a school's architectural features be a starting point for a session on teaching mathematics? Because architecture is where the framework of universal design for learning (UDL) first emerged. Its philosophy is to lower barriers for people while maintaining high expectations. By removing barriers for some, the situation is enhanced for everyone, and it is achieved not by retrofitting, but by planning with accessibility in mind from the start.

The concept of planning before implementation has been translated to the education sphere through a parallel attempt to remove obstacles to student learning. Instruction grounded in UDL principles plans and implements instruction that's designed for all learners, providing multiple means of engagement, representation, and expression.

Using UDL to Teach Fractions

Although much of the content related to fractions is taught in the elementary grades, many middle school students still harbor a poor understanding of fractions. Recently, principals asked the authors to work with a group of eight knowledgeable middle-level mathematics teachers to examine ways to increase their students' understanding.

Teachers reported that they noticed difficulties with the students' understanding of fraction magnitude, equivalence, and operations. The teachers said that students struggled with seeing fractions as a part of a whole, didn't understand equivalent fractions (e.g., $\frac{3}{6} = \frac{1}{2}$), and didn't recognize that smaller denominators indicate larger parts of the whole (e.g., $\frac{1}{2} > \frac{1}{8}$). This resulted in students' inability to grasp more advanced concepts involving fractions.

We worked with the teachers to examine the curriculum and realized that the teachers needed a framework for putting the concepts together in ways that would reach diverse learners. While the school's districtwide conversations often mentioned UDL, teachers said they didn't understand how to implement a "plan ahead" framework to reach all students. "I feel like we are UDL'd to death, but I have no idea what it is," one said.

How to implement UDL isn't necessarily universal knowledge among teachers, which is why we began the conversation with

architectural photographs. The teachers already had the effective teaching strategies they needed; they just needed to understand the framework better to package those strategies into a cohesive structure that consciously removed students' obstacles to learning while maintaining high expectations for everyone.

Getting Started With UDL

To begin the process, we stressed the importance of fully understanding the complexity of the content objective and the trajectory of students' prior knowledge. One of the teachers, Jack, reminded us that curriculum guides aren't always perfect: "You really have to look at the lesson and decide what you need the kids to learn," he said. "Don't assume the lesson matches the objective or that the kids are ready for the lesson."

We began by unpacking some of the teachers' curricular objectives related to fractions. We selected the following objective: "Simplify a fraction by dividing its numerator and its denominator by a common factor." Each small group worked through the UDL approach to provide multiple means of engagement, representation, and expression for the objective, blending UDL components into their own repertoire and curriculum. Here's what happened:

Engagement

The group started by thinking of engagement in the context of presenting motivating tasks and helping students organize the new information. The teachers shared strategies for helping any students facing challenges in executive functioning skills organize their information and stay on task, including using framed paragraphs (Fig. 1) and rubrics (Fig. 2).

Two teachers shared lessons that engaged students in the division and multiplication of fractions by using recipes and cooking. "I like to create a recipe and then cut it in half," Francine said. "For example, if the recipe calls for ½ cup of flour, students have to use a 1 cup measure and fill it halfway."

Jack, a special educator who works with a class of seven boys, pointed out that he thought some of his students might not be interested in cooking, and others suggested he use sports themes such as the fraction of completed three-point shots in a basketball game. The most important UDL connection, he noted, is to "consistently consider what our students are interested in to make the work relevant."

Francine uses a seek-and-solve activity to help students see fractions in real-world contexts—another means of engagement. "When I introduce fractions, I give them the fraction and they travel around the room looking for ways that fraction is represented," Francine said. "I make sure there are some obvious examples, but they always find fractional representations I hadn't planned on. I begin with very basic fractions like ¼ to engage their prior knowledge and remind them that fractions aren't difficult."

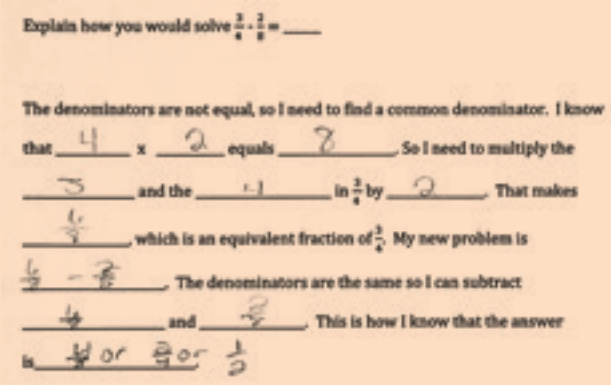
Technology is often incorporated into UDL to make instruction more engaging and accessible, but it is not the only option. Some teachers had students communicate their thinking on math problems by debating and defending an answer with one student serving as judge, through peer-to-peer conversations, and by doing mental math games with a friend.

Fig. 1: Sample of framed paragraph

Fraction Task Rubric

	Points Earned
My word problem asks a question that reflects the number sentence. (2 points)	
My drawing represents the number sentence (2 points)	
My explanation is clear (2 points)	
My explanation gives step-by-step directions on how I solved the problem (3 points)	
My answer is correct (1 point)	

Fig. 2: Sample rubric



Representation

To emphasize the next UDL principle, representation, we focused on three levels: concrete (e.g., manipulatives or physical models), semiconcrete (e.g., pictures), and abstract (e.g., algorithms). Teachers started with concepts related to fractions on a concrete level, recommending showing different parts of the fractions to create a whole using manipulatives such as circular fraction pieces, pattern blocks, and fraction strips. The concept can be represented simultaneously at the semiconcrete level by drawing representations of concrete models using pictures, diagrams, or similar visual depictions. Then, fractional symbols (abstract) are written to show the links among the three representations.

Technology can help apply semiconcrete representations. Multiple apps and programs help students work with fractions in a variety of representational forms. Focus on using technology to represent the concept while remaining in the space between concrete ideas and abstract understanding. The teachers in our group said that the semiconcrete level is the one they typically skip when teaching fractions.

Using symbolic representations alone should occur only after students have had time to explore concrete and semiconcrete understandings linked to a more abstract symbolism, but the symbols should be connected to the models from the start. Many students struggle to understand fractions when they are presented only at the abstract level, and they need repeated reinforcement of the concepts by going back to a concrete or semiconcrete level. UDL encourages front-loading those models into the planning rather than trying to "fix" a problematic situation after the fact.

Expression

The UDL triad is completed with the third principle: using multiple means of expression to demonstrate conceptual understanding. Francine reminded us that "having students express their understanding of the mathematical ideas needs to occur throughout the lesson and not just at the end of the lesson." Allowing for multiple means of expression also means that students can verbally present information, provide a representational understanding, or use symbolic representations such as equations, depending on what needs to be assessed.

As with the other two UDL principles, technology may be used to demonstrate understanding. Students can use cameras, voice recordings, a drawing, or manipulatives to explain their understanding. "I have the students create anchor charts for the classroom," Connie said. "These charts serve as reminders but also allow the students to work together to express their understanding."

When planning ways for students to express their understanding, teachers pointed out the importance of keeping options in mind that support executive functioning skills, so that students who struggle with organization, attention, and multiple tasks can get the help they need.

Teachers should revisit the objective when planning the expression component. For example, if it asks students to demonstrate a conceptual understanding of how to multiply fractions, using the algorithm alone might not be the best way for students to provide evidence or show conceptual understanding. One teacher said she likes to give her students an expression card with a problem such as $\frac{3}{4} \times \frac{4}{5}$. The students' job is to select a corresponding model from a collection of cards, and then tell why they chose that specific card; many excelled with the cards when they were unable to describe the concept in words.

When students can generate multiple expressions of understanding, teachers can uncover their strengths and weaknesses to tailor future instruction.

Principals are under increased pressure to improve mathematics learning in their schools. Our teachers highlighted how they use the three UDL principles—engagement, representation, and expression—when teaching fractions. But when beginning a new concept, teachers described a need to ensure that students have the chance to work at concrete and/or semiconcrete levels before moving on to abstract representations exclusively.

UDL proved effective in addressing the needs of students with differing levels of understanding. "I am loving using UDL in my class!" Jenny said. "I feel like it is making me a better teacher because I am better prepared to work with all of my kids. Every time I plan, I think about those multiple means. My class is fun, [and] my students are engaged!"

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