MATHEMATICS TEACHER
Learning & Teaching
PK 12

Mathematics Teacher: Learning and Teaching PK-12, is NCTM's newest journal that reflects the current practices of mathematics education, as well as maintains a knowledge base of practice and policy in looking at the future of the field. Content is aimed at preschool to 12th grade with peer-reviewed and invited articles. *MTLT* is published monthly.

ARTICLE TITLE:

Cultural Responsiveness and Mathematical Practices

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DIGITAL OBJECT IDENTIFIER: 10.5951/MTLT.2021.0262

VOLUME: 115

ISSUE NUMBER: 10

Mission Statement

The National Council of Teachers of Mathematics advocates for high-quality mathematics teaching and learning for each and every student.

Approved by the NCTM Board of Directors on July 15, 2017.

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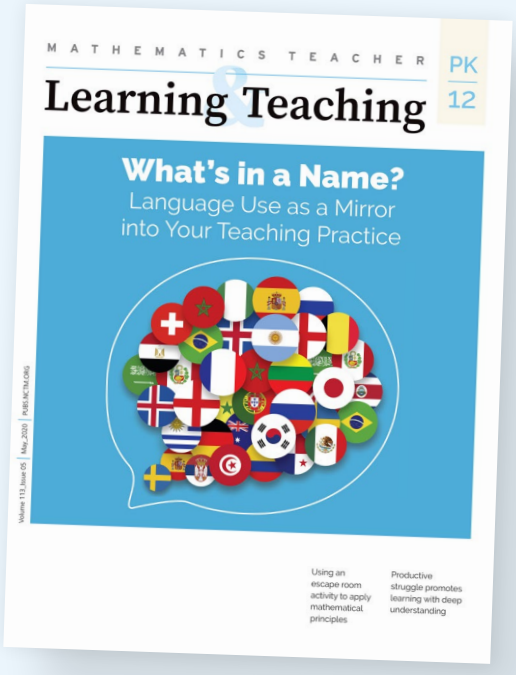

NCTM NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Cultural Responsiveness and Mathematical Practices

Off You Go is a PK–12 mathematical routine that leverages children's home resources and assets to support them in developing conceptual precision. We provide a guide for how to adapt this routine to engage students at any grade in argumentation and attending to precision.

Jen Munson, Geetha Lakshminarayanan, and Thomas J. Rodney

In January 2021 during my (Thomas J. Rodney's) 9th- and 10th-grade geometry class, my students are mentally exhausted from looking at a screen all day and are losing steam with little reprieve during the cold months of winter. I stare at black rectangles all day because students are half asleep in bed or feel too vulnerable to share the state of their tiny apartments. In an effort to improve morale and address some of these obstacles, my coach, (co-author) Geetha Lakshminarayanan, suggests an activity originally designed for elementary school students that might be helpful: Off You Go. In this routine, students attempt to find something in their environment that represents a topic or concept that we are learning in mathematics class, and they explain the connection. At the end of January, my geometry classes are exploring triangle congruence theorems. This topic is often difficult to teach because of the various levels of understanding about triangles and proof, made more so because I am teaching remotely from my home and students are in various places around the globe.

We discuss—verbally, in the chat, and on a digital learning platform—the various properties that students know about congruence. After about 10 minutes, I send students off to work asynchronously to find examples

of congruence in their environments before our next class. I open the next class by inviting students to share what they had found, unsure what students will have done or whether anyone will share.

Black rectangles flicker to life. Students are asking to share their ideas, and I have a hard time choosing who can go first. Their responses are all so amazing. Evelyn shares two slices of pizza she had for dinner the previous night. Frank tells of several coat hangers in the closet that were bought at Target for a new coat. Julian shares the triangle buttons on his video game controllers; they are congruent because he measured all three sides of both triangles even though they are different colors. Aliyah shares several hairclips used to style siblings' hair. Michael offers a pair of triangular wooden Cracker Barrel peg games he got on a road trip to the South; they are congruent because they overlap when you place one game on top of the other. Demetri shares a couple of triangular trowels he uses to smooth the edges of newly laid concrete when he works with his dad, who is an excellent bricklayer. Catherine shares the triangle reflectors that were in the trunk of a newly acquired first car. Students are finally excited to share and discuss the things in their lives that relate to our mathematical work. Nearly all of them found different items in their environment and connected the objects to stories and events that happened in their lives. The entire period is taken up by thoughtful and rigorous discussion about whether some items are truly congruent and what, in some cases, might be preventing them from being congruent. We even get into a heated discussion about whether we could determine if three-dimensional objects were congruent since we cannot necessarily measure the angles. The class ends with students vowing to find more—and more precisely—congruent items for next time and providing better evidence. My heart fills with joy.

In this article, we present Off You Go, an instructional routine that can be used at any grade level from prekindergarten through high school to help students take a concept with which they have initial or informal understanding and explore and test its boundaries to support defining or estimating with precision. Inherent to developing precision in this routine is a deep connection to students' lived experiences with mathematics, two ideas intertwined in Rodney's scenario above. We begin by sharing the routine itself and then explore how this routine simultaneously supports culturally responsive teaching and the development of the mathematical practices of precision and argumentation.

THE OFF YOU GO ROUTINE

The Off You Go routine can be a useful tool when students have some informal, colloquial, or initial understanding of a concept, but their ideas need greater precision, development, or application beyond school mathematics contexts. The structure of the routine is similar regardless of the grade level or concept being explored.

1. Illustrate the Concept: Show students a clear real-world example of the concept in which they can identify how and where the concept is represented (see figure 1 for examples). Invite students to look carefully at the image and name where they see the concept to ensure that they have an initial idea of what they are looking for.
2. Explore and Gather: As partners, in small groups, or individually, send students off to investigate their environment, looking for additional representations of that concept. Students could variously explore their homes, your classroom, a

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doi:10.5951/MTLT.2021.0262

section of the school building (e.g., your hallway, floor, or wing), the entire school, or your outside spaces (e.g., playground, field, or building exterior). Students can collect the examples they find in a variety of ways, depending on your resources or what they find. Students might physically collect examples, draw sketches, take digital photographs or video, or make a written list. Depending on your students' stamina, the complexity of the concept, and the size of the space students are investigating, you can provide students with time ranging from 10 minutes to a full class period or more to collect representations.

3. Share and Discuss: Create a class collection of examples of the concept by inviting students to share what they found. For each item you might ask questions such as these:

    - Is it a _____? Why or why not?
    - How did you look for examples? What were you paying attention to?
    - How did you decide what object(s) to collect?
    - What can a _____ look like?
    - What is a _____?
    - If the task involved estimating, ask the following:
        - How did you decide if something was too little, too much, or about right?
        - How do you know? What were you noticing or thinking about?

Use questions like these to foster discussion about the properties of a concept, how it might be represented in the world, and why any particular representation may or may not be accurate, sharpening the class's collective understanding.

Three Ways to Use This Routine

Originally this routine was developed to create rich opportunities for mathematics when students were learning remotely. However, we have since applied it during in-person teaching, and we see three productive ways it could be implemented depending on your goals, time, and learning environment.

Class activity. As described here, you can use this routine as a class activity in place of one or more lessons, depending on how long you want to give students to explore, how many examples they collect, and the length of the discussion. Teachers can launch the activity by showing students an example physically in their space or a projected image. Students can do a scavenger hunt of their classroom or school environment and gather in the classroom at the end for a discussion.

Fig. 1

a. This picture shows some parallel lines and some intersecting lines. Where do you see parallel lines? Where do you see intersecting lines?

Where can you find parallel or intersecting lines?

b. This picture shows objects that are about 3 inches long.

What can you find that is about 3 inches long?

These are examples of two Off You Go tasks.

Homework. The exploration and gathering stage can be a meaningful replacement for homework, allowing students to look for mathematics in their lived environments and communities outside of the school building. Teachers can launch the routine in the classroom by illustrating the concept and then send students off to explore and gather at home. Students return the next day or later in the week with collected examples to discuss in class as part of the mathematics lesson.

Asynchronous activity for remote learning. During remote instruction, teachers like Rodney launched this activity synchronously by screen sharing to illustrate the concept with an example. Then students explored their own home environments asynchronously to gather examples. Students could be given 20 minutes or a whole week to work on this stage before returning for a synchronous sharing and discussion online.

CULTURAL RESPONSIVENESS AND MATHEMATICAL PRACTICES

Off You Go can feature any number of mathematical practices, but two are foregrounded in the discussion in which students share their representations of the focal concept: attending to precision and argumentation or constructing viable arguments and critiquing the reasoning of others (NGA Center and CCSSO 2010). But this routine—and these mathematical practices—does not exist in a vacuum. We each, teachers and students alike, enter the classroom containing and swimming in culture. Culture is the medium through which we make sense, and given sense making's central role in mathematics, our students' cultures and how they intersect with mathematical thinking must be equally central to our teaching. *Culturally responsive teaching* recognizes that students' cultures are assets for learning. By drawing out and drawing on students' cultures, we as educators support individual children and our classroom communities in constructing mathematical ideas, simultaneously engaging in the practices of mathematics. Cultural responsiveness moves mathematics away from the domination of White, Western ways of thinking and knowing and marginalization of the experiences and knowledge of Black and Brown students often typical of mathematics in schools (Battey and Leyva 2016; TODOS 2020). In the following sections, we take a close look at the two mathematical practices at the heart of Off You Go and then how this routine embodies aspects of cultural responsiveness that support student engagement in precision and argumentation.

Developing Precision and Argumentation in Off You Go

Off You Go engages students in locating, sharing, and exploring a variety of representations of a particular concept, with the broad goal of developing greater conceptual precision. Conceptual precision involves two different but related practices. Students need to *define* concepts with precision by developing a deep understanding of what is and is not a representation of the idea. Students also need to develop fluency with number and unit benchmarks to *estimate* with precision or accuracy (see figure 1 for examples). Whether students focus on defining or estimating with precision hinges on the concept they are asked to represent. For instance, students will work to define with precision if asked to locate and discuss examples of triangles, patterns, half, or similarity, whereas they will move toward estimating with greater precision if tasked with finding objects that are about three inches long, weigh about one pound, or are in a collection of about 100. Often curricula present students with examples of concepts that are simple or clear-cut, leaving students with potentially oversimplified ideas about what, for instance, a triangle can look like. By inviting students to contribute representations of concepts from their lived environments, the resulting discussion will include a greater diversity of examples and raise questions about precisely what counts and does not as an embodiment of the concept under consideration.

Collectively developing precision, then, requires argumentation: explanation, evidence, and justification. When students share examples of a concept, they need to explain and justify this claim to the class, and their familiarity with the artifacts they share can position them as better able to describe the objects' properties as evidence. When they do so, others may be confused by or even challenge the claim, especially when the representations differ from those they have often seen or their understandings of the concept. Questions from other students can spur the gathering of additional evidence and debate about whether the object should be included among other representations of the concept. Through argumentation the class can collectively sharpen its ideas about a concept and the boundaries that define it, while connecting these concepts to the world that students live in and experience daily. These two mathematical practices—attending

to precision and argumentation—are tightly coupled in the discussion, and they are made possible by the objects students choose and bring to share. It is through these objects, the very fuel of precision and argumentation, that cultural responsiveness lives in Off You Go, to which we turn next.

Cultural Responsiveness in Off You Go

Culturally responsive teaching is multifaceted and complex (Gay 2018), and the Off You Go routine we offer in this article does not fully address all of its dimensions. However, in our work we found three ways that this routine allows teachers to be responsive to students' cultures and support learning by validating, empowering, and including students' many ways of thinking. First, the routine allows teachers to get to know students as whole people who have lived experiences outside the classroom that support learning inside the classroom. Second, the routine bridges school mathematics and students' lived experiences, where mathematics occurs every day. Third, the routine positions students' home resources and cultures as strengths to build on in support of learning for all.

Getting to know students as whole people with lived experiences outside the classroom. Rodney prides himself on the relationships he builds with students, founded on students' interests, identities, and selves beyond the classroom. However, the constraints of remote teaching removed informal opportunities to connect with students, such as casual chats during class, or students hanging out in his room after school. Moreover, learning onscreen made bringing their full selves into this virtual classroom more challenging for students. However, through Off You Go, students brought objects and stories that illuminated facets of their lives that previously were mysteries to their teacher. He learned about students who cared for their siblings by styling their hair, the family students visited (and missed visiting), and after-school jobs they worked alongside family members. Off You Go made space for these stories and for affirming students as whole people. Students, in turn, were eager to bring these representations of themselves into the mathematics classroom, to be seen and heard as more than a rectangle on a computer screen.

Bridging school mathematics and students' lived experiences. Off You Go builds a bridge between mathematical abstractions and students' lived experiences and environments. Although the structure and purpose of the routine has similarities to sorting activities, Off You Go is shaped by the objects and examples that students bring, instead of those curated by the teacher, positioning students with the authority to determine how the concept is represented in their own lives. With Off You Go, the students generate the curriculum. Rather than students applying their ideas to a context constructed by the teacher, students explore a mathematical concept in the context of their own choosing. These concepts become tested, explored, developed, and sharpened through the medium of their own and peers' examples. There is no textbook in which to look up the correct answers because the students supplied the problems. The informal nature of the activity belies opportunities for the development of formal argumentation practices by centering and talking about students' ideas—and locating the mathematical authority to construct concepts with students themselves.

Positioning students' home resources as assets to build on. Students live mathematics every day, and they bring with them intuitions, ideas, and experiences that can be positioned as assets on which to build and develop mathematical thinking and practice. The Off You Go routine is predicated on the value of students' home resources, including the materials, stories, and languages that surround them. Teachers using this routine have found that the objects students brought often represented specific aspects of students' lives, from what they ate and how they dressed to interactions with their families and important memories. Storytelling and the mutual exchange of knowledge, wisdom, and information is a common method of communal learning in Black and Latinx cultures (Gay 2018) that many of Rodney's students come from, although storytelling is often absent from the mathematics classroom. Through this routine, students were invited not just to share objects but also to narrate what these objects represent both personally and mathematically. From such initial sharing, the teacher can ask questions to further elicit students' ideas about these objects, press them to provide evidence or explanation, and make connections and comparisons between different objects that might illuminate key mathematical ideas or questions. In this way, Rodney positioned himself as a facilitator who simply kept the discussion revolving around what establishes congruence while students provided the reasoning, evidence, and ideas.

Collectively, these three culturally responsive elements of the Off You Go routine contributed to a sudden and sustained increase in student engagement in Rodney's classroom, highlighting in an extreme year the persistent need for students' lived experiences and whole selves to be meaningfully connected to the work of the mathematics classroom. This activity marked the first time in the remote school year that some students turned on their cameras or spoke on the microphone. Up until this point, Rodney struggled to stimulate student-to-student conversation in the virtual teaching space, even with activities and prompts that had led to lively discussions in previous school years. Off You Go offered a different entry point into mathematical conversation, one founded on students' personal lives, and fueled by the conclusions that they co-constructed with peers—conclusions that were inextricable from the development of precision and engagement in argumentation.

OFF YOU GO ACROSS GRADES

This routine can be used from prekindergarten to high school to incorporate culturally responsive teaching practices while supporting deep, collective engagement in developing increasing mathematical precision through justification and debate. See table 1 for examples of concepts that can be developed in the Off You Go routine. In the following sections, we offer vignettes from multiple grades to add to our story of Rodney's classroom to illustrate how Off You Go can allow students to bring their knowledge and lived experiences to mathematics and how these very experiences fuel doing mathematics together. In each example, the student's home contributions of a concept generate argumentation and debate, expand or test the boundaries of a concept, or press issues of precision to which there are no obvious answers.

Kindergarten: Where Can You Find 10?

While teaching remotely, Francesca, a kindergarten teacher, invited her students to search for objects or collections that represent the number 10, to build students' understanding of what 10 can look like using a variety of units and to give her students the opportunity to engage in counting. She initially showed students an image of a pack of 10 colored pencils. One student, Jamila, returned with a wooden box given to her by her grandmother that she used to hold her collection of hair scrunchies. She shared how much she loved these scrunchies, something Francesca had not known, in part because the camera's angle did not allow Francesca to see the back of Jamila's head and how she put her hair up each morning. The class then used Jamila's scrunchies to compare how a loose collection of soft items can be the same quantity as the neatly organized box of colored pencils. Jamila removed the scrunchies one by one from the box, counting aloud, to prove these were equal to 10 even though they looked very different from the colored pencils, a key concept in early number equivalence that was supported by drawing on Jamila's home experiences and family connections around styling hair.

Third Grade: Where Can You Find Something about 10 Centimeters Long?

During in-person teaching, Cynthia, a third-grade teacher, gave her students the homework task of finding one or more objects that are about 10 centimeters long in any dimension to support students' capacity to estimate with benchmark lengths. One student, Sylvia, brought back a toy bed from her beloved dollhouse as an example of something about 10 centimeters long, from head to foot. When asked to explain her choice, Sylvia said that she had originally wanted to bring the plastic doll that she usually laid in the bed but had decided it was too short. She selected the bed because it was a little longer than the doll. This led to a discussion of what Sylvia and the other students in the class had been paying attention to in order to decide whether one object was about 10 centimeters, or whether it was too short or too long. Many students shared how they used their hands as a reference to make this assessment, an important resource for future estimations. Through Sylvia's contribution from her own home play, the class gained the opportunity to discuss the strategies they used or could use to develop precision in their estimates of length.

Sixth Grade: Where Can You Find a Ratio of 2:1?

When Asha asked her sixth graders to search their homes for something that represented a ratio of 2:1, she expected students to come back with objects like Lego® bricks (that have two raised circles in each column) or shoes (that have two eyelet holes for each row of laces). Instead, Kalani brought a drum. Initially, others could not see the 2:1 ratio, until Kalani explained that she played in a drum circle with her uncle, and each drum was played with two hands. She demonstrated how her hands were used to make a rhythm and how both hands were needed to play one drum. Her demonstration of her home cultural assets was a

Table 1 Examples of Concepts Students Can Explore in the Off You Go Routine

Defining Concepts with Precision	Estimating with Precision
K–Grade 2 • 10 (or 5 or 100) • Half (or fourth or third) • Patterns • Triangle • Rectangle • Equal groups	**K–Grade 2** • A collection of about 100 (or 50 or 20) • Something about 1 inch long • Something about 1 centimeter long • Something about 1 foot long • Something that is a little more (or less) than half
Grades 3–5 • Quadrilateral • Angles (acute, obtuse, right) • Symmetry • Array • Fraction (generally, or a specific fraction such as 3/4) • Perpendicular lines	**Grades 3–5** • Something about 3 inches (or 6 inches) long • Something about 10 centimeters (or 50 centimeters) long • Something that takes about 1 minute to do • Something with a volume of about 1 liter • Something that weighs about 1 kilogram (or 100 grams) • Something that weighs about 1 (or 2 or a half) pound
Grades 6–8 • Congruence • Similarity • Proportional relationship • Rectilinear solid • Solid composed of prisms • Ratio of 2:1 (or 3:1 or 3:2) • A relationship that can be represented with an inequality • A collection that could be described by its mean (or median)	**Grades 6–8** • Something with an angle measure between 45 and 90 degrees (or between 0 and 45 degrees, or another interval) • Something that has a surface area of about 1 square foot • Something that has a volume of about 1 cubic foot • An outcome with a very high, but not 100% probability (or very low, but not 0% probability) • A situation with multiple outcomes, but the outcomes are not equally likely
Grades 9–12 • Angle relationships (vertical angles, adjacent angles, etc.) • Parallel lines and transversals • Three-dimensional figures • A relationship that could be modeled by a linear function • A relationship that could be modeled by a periodic function • A situation that has a maximum or a minimum • A collection that could be represented in a two-way table	**Grades 9–12** • Objects that look congruent • Objects that look similar • Objects for which you could use trigonometry to estimate distance or height • A collection/population that could be described as having a high (or low) standard deviation • A relationship where you expect the variables to have a high (or low) correlation

form of justification, allowing others to see the 2:1 ratio of hands to drum in action, simultaneously allowing Kalani to make connections between the mathematics she experienced in school and the joy she experienced in making music in her drum circle.

High School Geometry: Where Can You Find Two Congruent Figures?

In Rodney's exploration of congruence with his class, Carlos got pushback from the class about whether the two toy cars that he brought from his larger collection were indeed the same size. Carlos then pulled out a ruler and began to measure the edges of the two objects to gather and share evidence of their sizes. Jaden, who brought a pair of cleats from playing soccer, demonstrated how he could match up the soles as mirror images. These strategies for justifying congruence, verifying for congruence of corresponding parts and using rigid motions, are both commonly taught, but the interaction with everyday objects elicited these strategies organically. They also inherently raise questions about sufficiency of information to prove congruence. How many parts of the toys should be measured before we are convinced that they are congruent? Is demonstrating the reflection of the sneaker soles enough to prove that the entire shoes are congruent? When learning about congruence, students are commonly given relatively simplistic figures such as triangles, so many students feel they can intuitively decide congruency simply by whether the figures look the same. The more complex objects that students contributed from their lived experiences at home prompted genuine debate about the definition of congruence and an authentic need for multiple strategies and tools for proving

them. Indeed, Jaden's contribution of soccer cleats raised questions not only among the students but also for Rodney and Lakshminarayanan about whether two mirrored three-dimensional figures were congruent or not. Watch a clip of Rodney and Lakshminarayanan discuss this mathematical issue with two other mathematics teacher colleagues (see video 1 [link online]).

Concepts well suited for this routine are those that students have some familiarity with but for which they could benefit from greater precision. Depending on the grade level you teach, these might include concepts such as those shown in table 1. For more examples, see the concepts from Multiplicity Labs (link online).

Preparing to Use Off You Go with Your Students

Central to using this routine is choosing a concept that is ripe for precision given the current state of your students' understanding and your instructional goals. Table 1 provides some examples of potentially productive concepts, depending on students' readiness. You might ask yourself the following questions to choose a concept and plan an Off You Go activity for your students:

- What concepts are your students familiar with but may be unable to define yet?
- What concepts are your students working to develop ideas about?
- What concepts do the standards for your grade or course suggest that students need to learn with some precision?
- What concepts from previous grades do you want students to have clear and shared ideas about before launching into a new unit?
- What concepts would students benefit from connecting to their lived experiences? Which concepts might seem abstract or irrelevant without connections to the real world?
- How will the setting in which you are asking students to find examples (e.g., homework, in class, asynchronously during remote learning) affect the diversity of the examples that they bring?

Once you have selected a concept, consider the role that this routine could play in the larger unit of study in which it takes place. For instance, you may use it at the beginning of a unit to develop precision around a concept you know students learned in a previous grade but have not revisited in some time. Doing so could set the stage for launching a new unit with shared understanding and language. Alternatively, you may choose a concept that will be introduced in a unit. In this case, use this routine after students have some initial experiences with the concept and are poised to sharpen their thinking. Finally, at the beginning of the school year, Off You Go could serve as an opportunity for you to get to know students both as mathematical thinkers and as humans. For a glimpse inside Rodney's planning for how to use this routine in the future, watch a clip of his discussion with his coach and two colleagues as they consider how to hone the concept students explore (see video 2 [link online]).

Video 1 Professional Dialogue about the Nature of Congruence with Three-Dimensional Objects

Watch the full video online.

Video 2 Generating Ideas about the Future Use of Off You Go

Watch the full video online.

CONCLUSION

Culturally responsive teaching is often seen as separate from the development of mathematical practices, but in Off You Go they are inherently intertwined. Indeed, students' cultural assets are the very mechanism for developing conceptual precision and driving argumentation. When students bring themselves to the discussion, teachers get a more authentic look at what students are thinking and how they reason about concepts. Teachers and students then see and are seen, as humans and as mathematicians, more fully. Teachers can then respond both to a diverse set of mathematical representations and to students' cultural assets, building on each and bridging school mathematics with the more complex and hidden mathematical terrain we each encounter in our lives.

Students are, in turn, positioned with the authority to author the curriculum—one for which there is quite clearly no answer key. In Rodney's virtual classroom, the absence of established answers helped generate an authentic discussion, with debate, questions, evidence, and ambiguity that students were responsible for fueling and examining. Rodney learned more about his students' ideas about congruence because he did not control the objects of their consideration. Students seized the opportunity for authority and voice in a way Rodney had not seen in the months of his remote teaching.

Returning to in-person instruction, we see this routine as providing a pathway for any teacher to connect with students, develop precision, build bridges between school mathematics and students' cultures, make visible students' home resources for sense making, and marshal those resources for deep discourse. Whether prekindergarten students are considering the many ways to represent the number 3 or high school students are pondering the nature of linear relationships, Off You Go can serve as a vessel for seeing and responding to students' ideas while sharpening them. —

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