From Objectives to Evidence:

Using the ASET Toolkit as your GPS for 3D Assessment

DONNA L. ROSS AND CORINNE LARDY

ABSTRACT

This article explores how the ASET Toolkit served as a framework to guide novice teachers in planning assessments for three-dimensional instruction. We highlight the critical importance of aligning learning objectives and assessments, emphasizing the need for coherence across all stages of instruction. We address the challenges of developing ongoing, purposeful assessments that support instruction and capture authentic evidence of student understanding across the Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), and Disciplinary Core Ideas (DCIs). We also examine common challenges and misconceptions faced by novice teachers as they learn how to assess their instruction. We encourage all teachers, but particularly those mentoring new teachers, to use the framework and consider the questions posed, as they plan or evaluate existing assessments.

Keywords: *NGSS*; assessment; prior knowledge; formative; learning objectives

Even as instruction shifts toward an *NGSS*-aligned three-dimensional model, teachers continue to face challenges in developing and implementing assessments that reflect these changes (Stoll and Wertheim 2023). Exams and lab reports still dominate as the primary assessment tools in secondary science classrooms, and minor tweaks to these traditional formats fall short of effectively measuring students' understanding of the integrated dimensions. Creating a single assessment that adequately measures the Science and Engineering Practices (SEPs), the Disciplinary Core Ideas (DCIs), and the Crosscutting Concepts (CCCs) (NGSS Lead States 2013) is a daunting task. However, as Cian, Marshall, and Cook (2019) point out, it is reasonable to have some assessments with a strong focus on one dimension while still addressing the other dimensions to a lesser degree and other assessments that may be used sequentially to address all three.

If we think of assessment as part of the instructional flow of a learning segment, it can be easier to imagine assessing all the dimensions during the unit. For example, multiple authors suggest using rich scenarios during and at the end of units to provide opportunities for students to explain their thinking and connect evidence (German 2019; Kareem et al. 2024). Scaffolding and providing smaller assessments at various points in the unit yields stronger responses, particularly with assessments that require students to explain their thinking and evaluate information (Lui 2022). There is strong evidence and broad agreement that a variety of formative assessments should be used across the instructional unit to gauge student thinking, to offer multiple avenues for students to demonstrate their learning, and to inform instructional decisions (MacKenzie et al. 2020; 2022).

As science teacher educators at two large public universities, we have found that preservice secondary science teachers (PSTs) in our methods courses encounter significant challenges in learning how to design and implement effective assessments during their student teaching experiences. We have come to recognize that this issue extends beyond our individual courses; many practicing science teachers with whom we engage are also seeking clearer guidance in the area of assessment. As a result, we have modified how we implement a unit-organizational toolkit in our courses to better focus on assessment. In this article, we share how we use the ASET toolkit to support beginning teachers in planning assessments that correspond to specific *NGSS*-aligned learning objectives. While this article focuses on strategies we have used to support novice teachers, the guidelines presented here can be useful to any high school science teacher trying to develop meaningful three-dimensional assessments for use throughout their instructional units.

The ASET toolkit

The ASET Toolkit is a set of tools created by a Networked Improvement Community of science teacher educators to support PSTs to unpack and apply *NGSS* (Sinapuelas et al. 2018). The Improvement Science framework (Bryk et al., 2015) informed the development and revision of the toolkit in science methods courses over a three-year period, which has since been used with PSTs and inservice teachers across multiple settings to support understanding and application of three-dimensional teaching. The toolkit consists of a one-page overarching graphic organizer (Three-Dimensional Mapping Tool, i.e. 3D Map; Sinapuelas et al. 2019), a set of eight tools with guiding criteria to support understanding of the individual SEPs (SEP Tools), and a tool to support the evaluation of anchoring phenomena (Phenomenon Tool). A full digital version of the toolkit with suggestions for its use beyond the scope of this article is available online (https://www.nextgenaset.org).

Using the toolkit to support planning for 3D assessment

Finding "assessment" on the 3D map

When planning for a series of science lessons, we first have our PSTs look at the 3D Map (Figure 1) and discuss in small groups what they notice and wonder about the tool. Most groups notice that, although there are many arrows connecting many boxes, there is only one arrow connected to the "Assessment" box, and it is coming from the "Learning Objectives" box. We stress that this is an important connection to recognize, since we as teachers cannot plan for our assessments until we are clear about what we want our students to understand and be able to do.

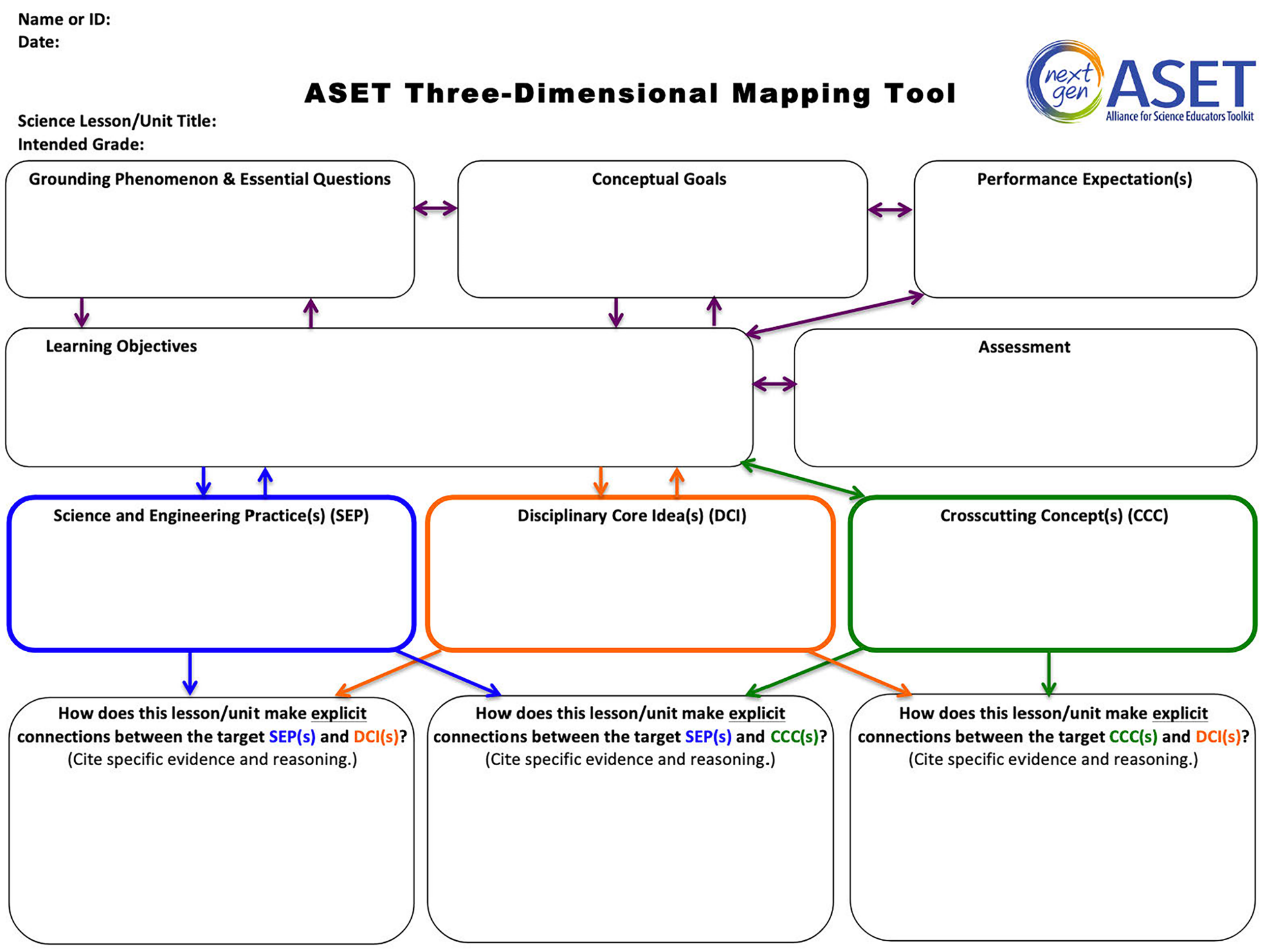
Starting with learning objectives

After they recognize that learning objectives are critical to designing assessment, we ask PSTs, based on the tool, what needs to be considered to complete the "Learning Objectives" box on the 3D Map. Many arrows connect from other boxes on the tool to the Learning Objectives box, including the Phenomenon/Essential Questions, Conceptual Goals, PEs, and the three dimensions (SEP, DCI, and CCC). The 3D Map was purposefully designed in this way to emphasize that there are many aspects of NGSS that need to be considered when writing clear and specific *NGSS*-aligned learning goals. When planning learning objectives, and ultimately assessments, we guide our PSTs to consider the following questions:

- What phenomenon will you use to anchor students' learning in these lessons?
- What are the specific science concepts (Conceptual Goals) that you want students to understand by the end of these lessons?
- What is/are the PE(s) that you are building students' capacity toward in these lessons? Although the lessons and units in a science course are designed such that K-12 students will ultimately be successful in the components of the Performance Expectations (PEs), we find it necessary to clarify that the lesson assessments are not a direct measure of the PEs, but rather the extent to which students have met the specific learning objectives.

FIGURE 1

ASET three-dimensional mapping tool (3D Map).



- What are the *specific* three dimensions (SEP, DCI, and CCC), or parts of the chosen dimensions, that you will focus on building students' ability to do in these lessons?

For PSTs who are just learning to plan and teach, these questions are addressed across a series of class sessions. In effect, PSTs are learning to take apart the complexities of the different components of *NGSS* and put them back together as they work towards writing learning objectives to guide assessment.

Attending to specific components of the NGSS SEPs

One challenge for the teachers with whom we work is identifying specific dimensions of *NGSS* on which to focus a lesson or a series of lessons. When first learning about the three dimensions, we often hear over-generalizations such as, "I taught all eight practices in that lesson." While it may be true that science instruction can address pieces of multiple SEPs, DCIs, and/or CCCs in a lesson, we find that without attending to specific components of the three dimensions on which to focus instruction, learning objectives and assessments become too large at best, and unrelated at worst.

We assist our PSTs in choosing specific components of SEPs on which to focus learning objectives and assessments, using the ASET SEP tools. These tools were designed to break down the complexity of each SEP and to guide analysis, discussion, and planning around 3-dimensional teaching. Each SEP tool includes a list of the components of that SEP and a description of what students are expected to be able to do for that component by the end of a grade band.

For example, a teacher may decide that while there are several SEPs that her students will be engaged with in a lab investigation, she wants to focus student learning and assessment on the SEP Analyzing and Interpreting Data. If we look at the related SEP Tool for the 6-8 and 9-12 grade bands (Figure 2),

FIGURE 2

ASET SEP tool for analyzing and interpreting data (6–8 and 9–12 grade bands).

next gen ASET Alliance for Science Educators Toolkit

ASET Science & Engineering Practices (SEP) Tool: Analyzing & Interpreting Data

Name or ID:
Lesson/Unit Title:
Intended Grade:

Directions for use

Indicate if a component is present using Y (yes) or N (no) and then, if it is present, fill in the right 2 columns.
A single lesson will most likely not address each of the components below.
The numbering of these components is not meant to indicate they should be used in sequence, they are simply for reference.

SEP 4	**Analyzing and Interpreting Data:** Scientific investigations produce data that must be analyzed in order to derive meaning. Scientists use a range of tools-including tabulation, graphical interpretation, visualization, and statistical analysis- to identify sources of error in investigations and calculate the degree of certainty in the results. Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria. Like scientists, engineers require a range of tools to identify patterns within data and interpret results.		
Components of SEP **In this lesson/unit plan, it is clear that students have a structured opportunity to:**	Present? **Y/N**	**What teacher actions were taken to facilitate this component for students?**	**What are the students doing? What sensemaking or intellectual work are students doing?**
1) Clearly **organize** and **display** data to represent phenomena.			
2) Identify and describe relevant and meaningful **patterns** and **relationship**s in data.			
3) Use statistical techniques to analyze data to address a **scientific question** or design solution			
4) Interpret data to provide evidence for, predict, and/or draw conclusions **about phenomena**.			
5) Analyze and interpret **large data sets**.*			
6) Identify and address **variation and uncertainty** in data sets.*			

* This component is not required in K-2 or 3-5 grade bands

Note: Page 1 of this tool serves as a graphic organizer for PSTs to take notes. The second and third pages of this tool, which can be found in the supplementary materials, include details about what students are expected to be able to do as part of this component of the SEP by the end of the grade band.

we see that there are many components to this SEP- too many to focus on for any one lesson, activity, or classroom assessment. Using the tool, PSTs narrow down their chosen SEP to one or two specific components of the practice to focus their learning objective(s) and assessments. By focusing in this way, PSTs can now write more targeted learning objectives, considering questions such as:

- Which part(s) of this SEP do I want my students to be able to do and what might that look like in my lessons?
- How do I want my students to use this component of the SEP in the context of my target DCI(s) and CCC(s)?
- How might I phrase what I want my students to be able to do related to this SEP in a learning objective?
- How can I determine if my students can do this part of the SEP by the end of the lesson(s)? What might competence in this component look like for students in my context?

Putting it all together: writing 3D learning objectives and assessments

Once our PSTs have considered the 3D Map holistically, including identification of the DCIs and CCCs, they come back to the two boxes we started with: “Learning Objectives” and “Assessment.” At this point, PSTs have a much clearer idea about the targeted learning goals for their instruction and can think more deeply about developing a set of assessments and identifying points during instruction when they want to assess students’ thinking. We have the PSTs consider a variety of questions (Table 1) informed by various resources (German 2019; Penuel and Van Horne 2016; Van Horne, Penuel, and Bell 2016) during this process and encourage all teachers to answer the questions as they discuss assessment at each phase of instruction:

TABLE 1

Guiding questions for developing three-dimensional assessments throughout instruction.

Prior Knowledge Assessment (Beginning of Instruction)	Formative Assessment (Throughout Instruction)	Summative Assessment (End of Instruction)
Ask yourself: • Will it be useful to assess prior knowledge about the phenomenon? • Will it be useful to assess prior knowledge about the specific science concepts from the DCI I am addressing? • Will it be useful to assess prior knowledge about skills and practices specific to my target SEP components? • Will it be useful to assess prior knowledge about the crosscutting concepts? • What form of assessment would be most effective in assessing the prior knowledge I've identified as most valuable? For example, do I want to use a Keeley probe, a quick write, an interview of a subset of students, a drawing of an initial model to.explain a phenomenon, invite students to bring and discuss pictures from their environment that represent the science concepts, or use some other assessment? • How do I plan to use the information that I learn from prior knowledge assessment to inform my teaching?	*Ask yourself:* • What formal and informal assessments can I use throughout my lessons to find out how students' thinking is changing and what they are able to do? • What responses, verbal or nonverbal, do I anticipate? What might various responses indicate about my students' thinking? • How will I check that students are making progress toward my learning objectives during instruction? • How can I collect assessment information in multiple ways to ensure that all of my students are able to show me what they know and can do? How can I provide choice and creativity in my assessments? • Which learning objectives or parts of my learning objectives (phenomenon, SEP, DCI, CCC) have I already assessed? It is easy to unintentionally assess the same objectives or dimensions multiple times and miss others. • Formative assessments should be used to guide instruction. How and where in the process will I anticipate student progress and be prepared to make instructional decisions based on the assessment data?	*Ask yourself:* • What form will the summative assessment take so that I can collect evidence on the extent to which students have met all parts of my learning objective(s) (SEP, DCI, CCC, and phenomenon)? What do I want my students to be able to *do*? • How can I include student choice in the summative assessment so that all students can show what they know and what they can do related to my learning objectives? • What criteria will I use to determine the extent to which the summative assessment shows me that students have met the learning objective(s)? How can my students and I develop these criteria together? • How will I make sure that students understand the criteria upon which they are being evaluated? • How will I use the results of the assessment to inform my next steps in teaching?

- Beginning Instruction (Prior Knowledge): It won't be possible to conduct prior knowledge assessments addressing everything your students know and can do, so it is important to prioritize based on your learning objectives. Understanding the background experiences and ideas of your students allows you to disrupt misconceptions and promote deeper understanding and retention of science ideas by linking them to existing knowledge (Sutton 2012).
- During Instruction (Formative): Assessment should happen throughout instruction and be used to inform instructional decisions along the way. Students' science ideas do not follow a predetermined path, nor do students make sense of evidence on the same timeline. This is particularly true in today's increasingly diverse classrooms where students bring a rich array of background knowledge (Mcclearycale Fine, Littich, and Getz 2023). As such, it is crucial to have multiple opportunities for students to show how they are making sense of new ideas.
- End of Instruction (Summative): Summative assessment tasks should involve multiple modalities and authentic contexts to demonstrate the extent to which students have met the specific learning objectives, including all three dimensions (German 2019).

We provide an example of a completed 3D Map (Figure 3) and a completed SEP tool for Analyzing and Interpreting Data (Figure 4) from one of our science methods courses.

FIGURE 3

Example of completed three-dimensional mapping tool.

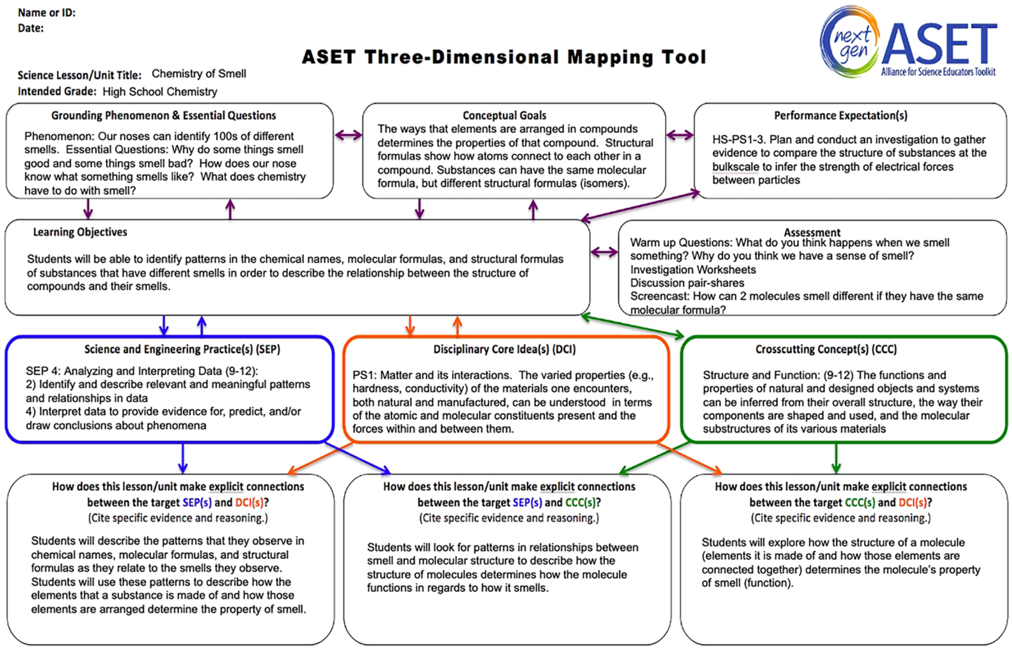


FIGURE 4

Example of completed SEP tool for analyzing and interpreting data.

ASET Science & Engineering Practices (SEP) Tool: Analyzing & Interpreting Data

Name or ID:
Lesson/Unit Title: Chemistry of Smell
Intended Grade: 11th

Directions for use
Indicate if a component is present using Y (yes) or N (no) and then, if it is present, fill in the right 2 columns.
A single lesson will most likely not address each of the components below.
The numbering of these components is not meant to indicate they should be used in sequence, they are simply for reference.

SEP 4	**Analyzing and Interpreting Data:** Scientific investigations produce data that must be analyzed in order to derive meaning. Scientists use a range of tools-including tabulation, graphical interpretation, visualization, and statistical analysis- to identify sources of error in investigations and calculate the degree of certainty in the results. Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria. Like scientists, engineers require a range of tools to identify patterns within data and interpret results.			
Components of SEP	**In this lesson/unit plan, it is clear that students have a structured opportunity to:**	Present? **Y/N**	**What teacher actions were taken to facilitate this component for students?**	**What are the students doing? What sensemaking or intellectual work are students doing?**
1)	Clearly **organize** and **display** data to represent phenomena.	N	Teacher provides data tables for students to fill in	Students do not have to figure out how to organize the data
2)	Identify and describe relevant and meaningful **patterns** and **relationships** in data.	Y	Teacher prompts students to find patterns in data and in structural formulas verbally and in writing	Students discuss patterns with lab group and write descriptions on activity worksheets
3)	Use statistical techniques to analyze data to address a **scientific question** or design solution	N		
4)	Interpret data to provide evidence for, predict, and/or draw conclusions **about phenomena**.	Y	Teacher prompts students to use patterns to make predicictions and explain phenomenon verbally and in writing	Students use data to make predictions about the smell of an unknown compound and to begin to explain how the structure of substances impacts scent
5)	Analyze and interpret **large data sets.***	N		
6)	Identify and address **variation and uncertainty** in data sets.*	N	Teacher prompts students to think about why everyone might not have the same smells data (Why didn't everyone smell the same thing?)	

* This component is not required in K-2 or 3-5 grade bands

TABLE 2

Addressing novice teachers' misunderstandings about assessment.

Q. Isn't assessment just for grading? Nobody ever asks about it in any other form.
No. The most useful part of assessment is for you, the teacher, to understand what your next instructional steps should be. Unless you know where your students are having success with sensemaking and where they are struggling to connect ideas, you won't be able to be responsive in your instruction.

Q. Isn't any task I give students during the unit an assessment?
A. While many tasks can be used as formative assessments, it is not an assessment unless the teacher is analyzing the results. This does not mean it needs to be formally graded or assigned points, only that the teacher must review and consider what the results of the task show about student understanding for it to be an assessment. For example, a quickwrite or worksheet that is assigned participation points, but is never read by the teacher, is not an assessment.

Q. If I'm doing my job, I need to clear up misconceptions during the prior knowledge assessment, right?
No, the prior knowledge assessment provides you information to plan the unit, decide where to begin, and consider how to make the unit more relevant to your students. Trying to "clear up" misconceptions during the assessment will likely lead students to offer fewer ideas.

Q. How do you find time for these 3D assessments?
The assessments should be part of the instructional process. Think about which tasks and activities provide insight about your students ability to meet different components of the three dimensions. For example, a model or scenario-based task may be assessed throughout the process.

Q. Don't I need to give my students a test? Aren't other assessments less rigorous?
Different students in your class have a variety of strengths and needs; not every student can tell you what they know through a traditional written assessment. Teachers apply Universal Design for Learning (UDL): Multiple Means of Expression (CAST 2024), using a variety of different types of assessments, to ensure that all students have the opportunity to show us what they know and can do. As long as you have explicit criteria to measure the components of your learning objectives, any assessment can be rigorous.

Beyond the toolkit: Addressing misconceptions about assessment

In our work with novice teachers, we observe that misconceptions about assessment constrain the accuracy, creativity, and diversity of their assessment design. We outline a few common misunderstandings in Table 2, in the form of a dialogue. We encourage teachers, particularly those who support novice teachers, to discuss them with their colleagues.

Conclusions and implications

Assessments serve as landmarks for instruction, but if you haven't decided on a destination, the landmarks are merely scenery rather than indications that you are on the right path; at the core of *NGSS*-aligned assessments are focused three-dimensional learning objectives. Using supports such as the ASET Toolkit described here, both novice and experienced high school teachers can define clearer learning goals to strengthen the development of a variety of assessments for use throughout science instruction.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

SUPPLEMENTARY MATERIAL

Supplemental data for this article can be accessed online at https://doi.org/10.1080/00368555.2025.2535349.

REFERENCES

Bryk, A. S., L. M. Gomez, A. Grunow, and P. G. LeMahieu. 2015. *Learning to Improve: How America's Schools Can Get Better at Getting Better*. Cambridge, MA: Harvard Education Press.

CAST. 2024. "Universal Design for Learning Guidelines v. 3.0." https://udlguidelines.cast.org.

Cian, H., J. Marshall, and M. Cook. 2019. "Formatively Assessing NGSS." *The Science Teacher* 86 (6): 44–49. https://doi.org/10.1080/00368555.2019.12293396.

German, S. 2019. "Three-Dimensional Classroom Assessment Tasks." *Science Scope* 42 (7): 28–32. https://doi.org/10.2505/4/ss19_042_07_28.

Kareem, M. K., A. Lannin, W. Romine, N. Singer, M. Tyson, K. Kline, M. Kendrick, S. Otten, and S. Apple. 2024. "Using Scenarios to Assess Student Learning." *The Science Teacher* 91 (2): 61–65. https://doi.org/10.1080/00368555.2024.2314683.

Lui, K. 2022. "Idea Bank: Three Steps to Making Assessment Simpler and More Relevant." *The Science Teacher* 90 (1): 16–18. https://doi.org/10.1080/00368555.2022.12293720.

MacKenzie, A. H. 2020. "Editor's Corner: Assessment in the Science Classroom." *The Science Teacher* 87 (6): 6–6. https://doi.org/10.1080/00368555.2020.12293496.

MacKenzie, A. H. 2022. "Editor's Corner: Tests, Quizzes, Exams… Oh My!: Examining Nonverbal Behaviors as a Form of Assessment." *The Science Teacher* 90 (1): 6–8. https://doi.org/10.1080/00368555.2022.12293717.

Mcclearycale Fine, C. G., H. Littich, and M. Getz. 2023. "The (Trans)Formative Assessment Planning Template: Explicitly Welcome Translanguaging During Formative Assessment in Your Science Classroom." *Science Scope* 46 (3): 29–37. https://doi.org/10.1080/08872376.2023.12370437.

NGSS Lead States. 2013. Next Generation Science Standards: For States, by States. Washington: National Academies Press. www.nextgenscience.org/next-generation-science-standards.

Penuel, W., and K. Van Horne. 2016. "Prompts for Integrating Crosscutting Concepts into Assessment and Instruction." *STEM Teaching Tools*. https://stemteachingtools.org/brief/41

Sinapuelas, M., C. Lardy, M. A. Korb, C. L. Bae, and R. DiStefano. 2019. "Developing a Three-Dimensional View of Science Teaching: A Tool to Support Preservice Teacher Discourse." *Journal of Science Teacher Education* 30 (2): 101–121. https://doi.org/10.1080/1046560X.2018.1537059.

Sinapuelas, M., L. S. Lardy, C. Korb, M. A, and DiStefano, R. 2018. "Toolkit to Support Preservice Teacher Dialogue for Planning NGSS Three-Dimensional Lessons." *Innovations* 3 (4). https://innovations.theaste.org/a-toolkit-to-support-preservice-teacher-dialogue-for-planning-ngss-three-dimensional-lessons/.

Stoll, L., and J. Wertheim. 2023. "Performance Assessment as Part of Efficient, Effective, and Equitable Instructional Practice." *The Science Teacher* 90 (7): 64–69. https://doi.org/10.1080/00368555.2023.12315972.

Sutton, S. 2021. "Teacher's Toolkit: Capitalizing on Student Misconceptions." *Science Scope* 44 (3): 70–73. https://doi.org/10.1080/08872376.2021.12291390.

Van Horne, K., W. Penuel, and P. Bell. 2016. "Integrating Science Practices into Assessment Tasks." *STEM Teaching Tools*. https://stemteachingtools.org/assets/landscapes/STEM-Teaching-Tool-30-Task-Formats-for-3D-Assessment-Design-v2.pdf

Donna L. Ross (*dlross@sdsu.edu*) (ORCID: 0009-0006-3433-5740) is an associate professor in the School of Teacher Education at San Diego State University and she is the associate director of the Center for Research in Mathematics and Science Education. She teaches science education at the credential, master's, and doctoral levels. She is a former elementary and high school science teacher. **Corinne Lardy** (*corinne.lardy@csus.edu*) (ORCID: 0000-0001-8516-8897) is an associate professor in the Department of Teaching Credentials at California State University Sacramento. She teaches science education courses for preservice and inservice teachers. She is a former middle and high school science teacher.