Four essential strategies for differentiating science lessons

BY CHESKA ROBINSON

If you spend enough time on an NSTA e-mail listserv, you will see there are certain topics that crop up time and time again. A perennial favorite is differentiating science lessons. If you type "differentiation" in the search bar of the unofficial NSTA E-mail Listserv Google Group (see Resources), you will find more than 600 examples!

Although most e-mails come from teachers seeking advice on how to differentiate science lessons for their lower level students, there are also others seeking help on how to keep their higher level students engaged without having to assign extra busywork. Others are looking for ideas on how to differentiate lessons for English language learners (ELLs). No matter the circumstances, finding a way to make science accessible for all students is an important and sometimes overwhelming task for teachers, as evidenced by these e-mails.

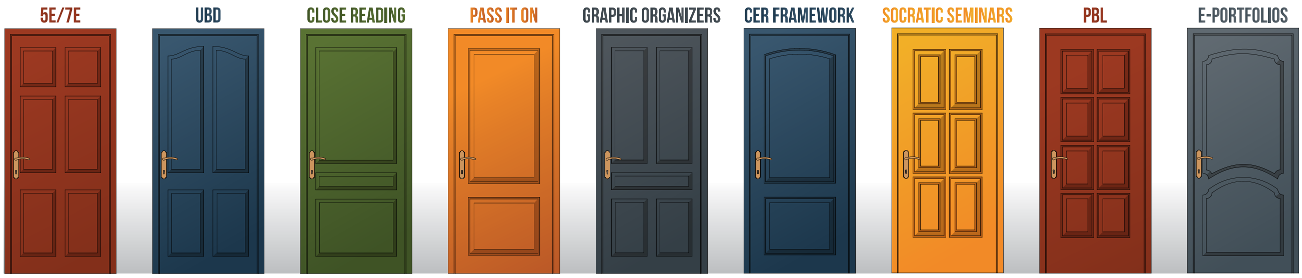
In this month's column, I focus on the general differentiation advice shared via the NSTA e-mail listservs. Of course, many wonderful lesson plans and links are shared daily by teachers, but they are subject-specific and I will not be able to cover them all. So, I have culled the responses and categorized them into the following four essential steps for differentiation.

1. Plan content backward

Most veteran teachers advocate the inquiry approach and the Biological Science Curriculum Study (BSCS) 5E Instructional Model (see Resources). The 5E model is based on the *constructivist* approach to learning, which builds on students' previous knowledge and experiences. Each of the five E's describe a phase of learning: Engage, Explore, Explain, Elaborate, and Evaluate.

Stacy H. explained that the flexibility of the 5E approach allows for differentiation and modeling instruction. She credited the improved scores of Title 1 students within her school district to this approach. Arthur E., author of "Expanding the 5E Model" in *The Science Teacher*, asked readers to also consider the 7E learning cycle. In the 7E learning cycle, the first phase is expanded into Engage and Elicit. It continues with Explore and Explain, and the Elaborate and Evaluate phases are expanded into Elaborate, Evaluate, and Extend. With the 7E learning cycle, more emphasis is placed on students' prior knowledge to generate more enthusiasm for the subject and focus on the transfer of new skills and knowledge to an unfamiliar context.

In some e-mail threads, teachers have mentioned that their schools have switched to Universal by Design (UbD) lesson planning (see "UbD in a Nutshell" in Resources). Developed by Grant Wiggins and Jay McTighe, UbD is a three-stage, backward-planning curriculum design process. The three stages are Desired Results, Evidence, and Learning Plan. With UbD, teachers focus on student understanding by starting with the desired results and transfer tasks. In the first stage, teachers unpack content standards and frame goals into long-term performance tasks, or *transfer tasks*. Transfer tasks ask students to demonstrate their knowledge,



understanding, and proficiency. It is important to emphasize big ideas and meanings at this stage so that students can make sense of their learning and transfer it to new situations. In the second stage, teachers develop appropriate assessments. In the third stage, teachers create their lesson plans. Essentially, with UbD, teachers plan the assessment *before* the instruction!

UbD is a curriculum design process that can be paired with the 5E or 7E learning cycle instructional models. Teachers can unpack the content standards, develop the performance tasks, and then move through the 5E or 7E learning cycle to collect evidence of student understanding through formative assessments during the Explore, Engage, Explain, and Elaborate phases, and through summative assessments during the Evaluate and Extend phases. Transfer tasks tie in nicely with the Evaluate and Extend phases, because students are asked to demonstrate their understanding by transferring what they have learned to new situations.

In my first years of teaching, I had the opportunity to learn about and use the UbD framework and the 5E instructional model with inner-city and suburban students. These approaches allowed me to focus on what is most important: the students. With the UbD framework, I had a clearer sense of direction in my planning and my lessons became more purposeful. I was able to avoid fluff activities and discern what would help strengthen my students' understanding of the major concepts.

The 5E model itself can be adapted for short-term lessons or long-term units; either way, it emphasizes students' understanding. It allows me to get to know my students through their ways of thinking and how their individual backgrounds help shape their thoughts. By understanding what my students already know and where they are, I become more adept at differentiating my own lessons. I continue to use UbD and the 5E model, especially as I grow as a teacher and develop more student-centered and student-driven instruction, performance tasks, and assessments.

No matter what framework or instructional model you choose to use, there is one key idea to remember: Don't get too caught up in the steps! When I first started using the 5E model, I thought I had to follow all the steps in sequence in a particular timeline. Over time, I realized that like all other templates, the 5E or 7E model should be used as a general guideline. If there are too few or too many steps in a template, do what is best for you. Take what works and customize it to meet your preferences and needs. The point, as made by Nanette F. and Bill R., is to take the time to plan purposefully and research the methods that work best for you and your students. Planning well is half the battle!

2. Reinforce reading, writing, and speaking

When the *Common Core State Standards* (*CCSS*; NGAC and CCSSO 2010) were released, they were greeted without fanfare as part of the announcements made during a professional development workshop. Our principal reminded us that all social studies and science teachers on staff were now responsible for helping the ELA teachers meet the *CCSS* requirements through increased reading and writing assignments in our classrooms. I think our principal expected loud groans from us, but in truth, my colleagues and I already viewed ourselves as literacy teachers. He wasn't assigning us yet one more thing to do because we were already doing it! In fact I start the school year by explaining to students that scientists do not just spend a majority of their time performing experiments in the laboratory. They also spend their time reading, writing, and speaking to other people about their work.

In one listserv e-mail, Cory C. asked for types of strategies teachers use for reading and writing in the science classroom. Trisha K. responded that first reviewing the learning objective and closely reading scientific texts and articles with students can help them stay on track when the class reads together. *Close reading* is a strategy that requires readers to determine the text's purpose and carefully notice text features so they can think about the details and why the author used them. In addition, Trisha shared that in her classroom, close reading is paired with annotations, which are in turn shared with peers through an online annotation tool (see Hypothes.is in Resources). Jennifer D. also posted a link to the NewsELA Close Reading Toolkit in response to an inquiry for resources for close reading (see Resources ID). David B. also shared a compilation of science resources for close reading texts. To see that list and get more resources on close reading, head over to the NSTA Pedagogy Listserv.

April B. posed a question on how to best use the science textbook in class. Most teachers in this thread agreed that science textbooks are hard to read and often are above the reading levels of their students. Some strategies, as shared by Teresa B., include assigning chunks of text and pairing it with flipped videos. Bianca B. and LeighAnn W. use outline worksheets and guided-note templates. Jacqueline C. previews text with her students and uses graphic organizers, such as before-and-after concept maps.

Graphic organizers are also helpful for lessons involving writing and scientific argumentation. Graphic organizers help guide students' thinking when analyzing public research papers or other technical writing. In addition, many teachers have amended their standard lab reports to include claim-evidence-reasoning (CER) responses. The CER framework scaffolds students as they use evidence to construct scientific explanations of their investigation results. As Laura H. once explained to me in a listserv e-mail, the CER framework helps students consider the context of the information and explain the "how" and "why" of phenomena. Evidence-based writing is what scientists do, and it also aligns with both the *CCSS* and *Next Generation Science Standards* (NGSS Lead States 2013).

Once students learn how to search for evidence in their readings and write scientific explanations, they must be able to communicate their findings and ideas with their peers through discussion. In an attempt to help her students improve their communication skills, Anne F. asked for strategies to model effective discourse in the science classroom. Listserv responses varied from a craft stick activity and think-pair-shares to round-robin journaling and sticky-note parking lots. Traditionally, the *sticky-note parking lot* is an instructional strategy during which students can "park" their off-topic or semi-related questions on a strategically placed poster for later resolution. Other teachers use chart paper divided into sections for other purposes, such as brainstorming ideas, responding to class questions, or creating a quick exit-ticket system. No matter what strategy is used, most teachers agreed that giving students time to write down their thoughts is a good way to start discussion. After all, if students write down answers first, they cannot shrug it off when called on!

Nancy R. shared a technique called "Pass It On," in which she asks other students if they agree or disagree with their peers' responses, and then asks participants to elaborate on their answers and provide evidence. In a similar way, Socratic seminars can be used in a more formal setting. Socratic seminars encourage students to understand ideas and issues in specific texts and hold them responsible for facilitating discussions around evidence instead of asserting opinions. They are a great way to bring together students' reading, writing, and speaking skills in the science classroom.

To help other teachers learn how to use Socratic seminars, Kristi V. H. posted a link to "Talk Science Primer" by Sarah Michaels and Cathy O'Connor (see Resources). Traci W. also posted links to "The Argumentation Toolkit" and a separate collection of free, open-source strategy guides created by the Learning Design Group at The Lawrence Hall of Science (see Resources). For students who require a bit more motivation, Jessica E. suggested using a game format. You can download and print a free game pack, "Socratic Smackdown," at the Institute of Play's website (see Resources).

3. Make lab experiences more meaningful to students

Veteran teachers tout the importance of inquiry-based learning for students. With inquiry-based learning, students are asked to be active learners and thinkers who create their own understanding of phenomena from their experiences, using evidence and logical thinking. Through inquiry, the 5E or 7E model, and the CER framework, students learn about how science actually works.

Tom A. pointed out, however, that some students resist inquiry learning because it requires them to do more thinking. He asked for ways to prepare students for more active roles so he could have more of an inquiry-based learning environment. Some suggestions on his e-mail thread include scaffolding inquiry into existing labs by allowing for more student choice and autonomy; using competition for activities and labs; and brainstorming testable questions, developing investigations using simple materials, and creating follow-up questions for open inquiry once or twice per semester.

Another suggestion is to consider project- or problem-based learning (PBL). *Project-based learning* asks students to develop a product, whereas *problem-based learning* asks students to solve a problem. Both are inquiry-based and student-centered. PBL is a teaching method where students explore real-world problems and challenges, and it inspires them to obtain a deeper knowledge of what they are learning. Because PBL involves students, they perceive the work as meaningful. PBL, as Matt B. pointed out, is also beneficial to lower-level and ELL students because it reinforces their reading, writing, and speaking skills. For more information on PBL, Timothy J. posted a link to the Buck Institute for Education (see Resources).

4. Incorporate education technology whenever possible

With tablets and laptops becoming increasingly available in classrooms, online simulations, live data websites, free data visualization tools, and citizen science programs are now easily accessible. Student assessment can also be completed online and graded more quickly than before. Some examples of free assessment tools shared from the listserv include Socrative, Padlet, and Plickers (see Resources).

However, it was not until this year, when I attended a technology conference, that I began to view technology use in the classroom from a different perspective. The keynote speaker, Jeffery Heil, spoke about his early teaching experiences creating videos with students. He learned how to give his students a voice by asking them to share their work with the global public. By asking students to publish their work, teachers do not just reward and celebrate their students' accomplishments; the bar is set higher, and students are asked to work harder and achieve more. Jodi G. asked the listservs for ideas on how to publish her students' science work. Christine H. responded that she publishes student work on a YouTube channel. Brandi D.H. suggested posting student portfolios on Wikispaces. Jeff U. provides his students with access to their own web pages on Google Sites. Jeremy M. had his students create digital science magazines, which were shared with parents. Podcasting and blogging were also brought up as other venues for publishing student work. Note that when publishing student work, you and your students should follow your school district's technology policies and review basic digital citizenship norms, search tips for public domain materials, and copyright rules.

Conclusion

Differentiating science lessons can be a challenge for many teachers. Classrooms of today have larger numbers of students with wider ranges of abilities and backgrounds. Effective science instruction goes beyond content knowledge, classroom management, and strategies. Although it sounds contrary, differentiation is really not about expanding or extending lessons; it is more about zooming in on the individual student. The four steps outlined in this article do exactly that.

UbD and the 5E or 7E instructional models allow teachers to get to know their students. Students are drawn into the planning and execution of their lessons through feedback. When teachers build lessons around inquiry or PBL, students begin to see their learning as meaningful because it involves them. Reinforcing reading, writing, and speaking skills in inquiry or PBL learning and adding technology to publish student work shows students that they have a voice in their learning and that *they* are meaningful. In the end, when a teacher sets out to create the best learning experience possible for all students, isn't that what differentiation is?

Don't forget to check NSTA's middle level Pinterest board (see Resources) to visit any websites mentioned in this month's article. If you are not part of a listserv yet, check out the NSTA Membership page to learn how to sign up (see Resources). Last but not least, many thanks to those wonderful teachers and NSTA e-mail listserv members who contributed their time, advice, and resources to the NSTA middle level professional learning community.

REFERENCES

National Governors Association Center for Best Practices and Council of Chief State School Officers (NGAC and CCSSO). 2010. *Common core state standards*. Washington, DC: NGAC and CCSSO.

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

RESOURCES

The Argumentation Toolkit—*www.argumentationtoolkit.org*
BSCS 5E Instructional Model—*http://bscs.org/bscs-5e-instructional-model*
Buck Institute for Education—*http://bie.org*
Cultivating a close reading toolkit—*http://bit.ly/2a4BXcR*
"Expanding the 5E Model" by Arthur Eisenkraft—*www.nsta.org/publications/news/story.aspx?id=48547*
Hypothes.is annotation tool—*https://hypothes.is*
Learning Design Group strategy guides—*http://bit.ly/2aeBOpR*
Middle level Pinterest board—*http://bit.ly/PinScopeNSTA*
NSTA Listserv signup—*www.nsta.org/membership/listserver.aspx*
Padlet—*www.padlet.com*
Plickers—*www.plickers.com*
Socratic Smackdown—*http://bit.ly/2a9uSbw*
Socrative—*www.socrative.com*
Talk Science Primer—*http://bit.ly/24Axp2K*
Unofficial NSTA listservs archive—*http://bit.ly/2awTZcx*
"UbD in a Nutshell" by Jay McTighe—*http://bit.ly/2bkn7Ek*

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