A common warning pervades today’s social media, entertainment news, and personal conversations: SPOILER ALERT! People use this phrase before revealing the latest plot development or surprise twist in a popular film franchise, television show, book series, videogame, or more.

 Spoilers can also infiltrate our classrooms. Science education “spoilers” are elements or behaviors that sabotage, short-circuit, and short-change the learning process and student creativity. “A rich science education has the potential to capture students’ sense of wonder about the world and to spark their desire to continue learning about science throughout their lives” (National Research Council [NRC] 2012, p. 28). Unfortunately, such frontloaded exposition can undermine the need for exploration and experimentation in science lessons.

 SPOILER ALERT! What motivation do students have to investigate phenomena and create solutions when objectives already give away the answer? Consider the language of your objectives and look for potential spoilers. Here are two examples to compare:

• **Objective A:** Students will identify rock minerals by testing for hardness, color streak, magnetism, and acid reactivity.

• **Objective B:** Students will design tests to investigate and identify rock minerals.

Both objectives address the same content. However, Objective B also emphasizes creativity and inquiry. Students will assuredly get to the various types of tests—hardness, magnetism, etc.—at the appropriate time in the lesson. Telling them ahead of time via Objective A takes away the opportunity for asking questions, planning investigations, analyzing data, and other Science and Engineering Practices in the Next Generation Science Standards (NGSS Lead States 2013).

The intent is not to hide information through vague objectives. Rather, the focus should be on key tasks and content without revealing particular results of students’ investigative efforts. Another approach is phrasing objectives in the form of questions. For the previous example, this might be “How can we test for different rock minerals?”

Teachers can also consider “essential questions” (McTighe and Wiggins 2013) as a way to frame lesson objectives. Although not typically limited to a single activity, essential questions (“EQ”) promote student creativity and inquiry in the classroom and beyond. Common EQ elements are open-
endedness, higher-order thinking, evidence-based justification, ongoing revisions, and additional questions—all of which remain spoiler-free.

**Spoiler #2: Terminology**

Numerous resources highlight the role of science in promoting literacy. This includes alignment of the NGSS and Common Core State Standards for English Language Arts (NRC 2014), and a multimodal approach in which students investigate, discuss, read, and write about science content (Pearson, Moje, and Greenleaf 2010). However, science teachers must be careful not to overemphasize terminology at the expense of authentic inquiry and creativity.

The word wall is a common classroom fixture that can spoil through terminology. Found on posters, chalkboards, or bulletin boards, these repositories typically feature key terms for a particular unit or topic. Word walls can be terrific tools to support students’ learning of spelling, vocabulary, even etymology. However, science teachers who use word walls must be purposeful in their assembly and timing. Like objectives, we must not spoil student creativity and inquiry by posting critical information before experience and experimentation. One effective approach to promote creativity and sense-making is an interactive word wall (Harmon et al. 2009). The teacher invites students to contribute terms, definitions, examples, and other important aspects in developing a shared learning resource.

Unchecked, terminology can spoil science learning in many other ways, sometimes barely noticeable. Look at titles of curriculum resources—handouts, worksheets, videos, and more. How many of these sabotage student creativity and science inquiry? Do any give away the answer?

Science teachers may be familiar with a lesson that involves dropping different types of game balls. Students collect data and compare differences between drop height and bounce height. They can also make predictions based on ball type. In a version I use, we apply multiple aspects of graphical analysis such as slope, intercepts, interpolation and extrapolation. However, the original title of the activity is Ball Bounce Lab. SPOILER ALERT! Not only can observant students use this title to guide their predictions, they also have an idea of what their final data should be, all before they even start the activity. Certainly bouncing is a key element, but not every ball bounces. I revised the lesson to call it Ball Drop Lab. It’s straightforward and spoiler-free.

I often use video clips to show demonstrations or discrepant events that are too expensive, dangerous, or otherwise not feasible in the classroom. However, these and other multimedia tools are rife with spoilers. Title screens or YouTube tags may give away the surprising results, stealing the “wow factor” with them. Preview your media and adjust screens or displays to hide any spoilers. At other times, a speaker in the video may divulge too much information before your students have the chance to reflect, debate, and develop hypotheses. In this case, use the pause and mute buttons wisely. Such changes may seem insignificant or even petty, but eliminating one or two words can often open the doors for wider inquiry and creativity.

**Spoiler #3: Cookbook labs**

Much has been written about “cookbook” or “cookie-cutter” labs in science classrooms (Clark, Clough, and Berg 2000; Everett and Moyer 2007; Shapiro 2019; Shiland 1997). Cookbook activities are hands-on, but also freely hand out spoilers. In essence, students follow a step-by-step script that tells them the question(s) to investigate, procedures to follow, data to collect, and—sometimes—what results they should find. SPOILER ALERT! Obviously, cookbook labs are prone to short-circuit students’ creativity and sense of discovery. Moreover, the entire ordeal inaccurately portrays the nature of science as a rote, uninspired endeavor.

Below is a compilation of strategies to promote science inquiry, student creativity, and spoiler-free learning when conducting lab work:

- Encourage students to determine questions and develop laboratory procedures.
- Ask students to make sense of their data.
• Cultivate a setting in which students share questions, designs, and data with peers.
• Provide opportunities to revisit questions and refine procedures for additional investigation.
• Have students decide how to clearly communicate and present results.
• Refrain from introducing vocabulary until after students have experiences from which they can construct meaning.
• Ask questions to foster discussion and reflection (and reduce frustration).

This is only a summary; teachers can find more tools and specific examples in the corresponding references provided. For example, the NSTA Reports article “Adding Inquiry to ‘Cookbook’ Labs” (Shapiro 2019) is available online (link in References) and provides several strategies from teachers, as well as additional insight related to classroom implementation, standards alignment, and support for students.

Naturally, there are labs and lessons in which students must learn appropriate procedures or verification methods. Due to time, safety, cost, or other considerations, teachers may need to opt for a more procedural lab activity on certain occasions. However, such instances should be the exception, while greater exposure to investigative and creative efforts should be the norm. Additionally, teachers concerned about time and maintaining a schedule should consider the emphasis in standards documents on exploring fewer scientific ideas with greater depth, as opposed to skimming across a breadth of trivia (NRC 2012, 2015).

**Spoiler #4: Teachers**

Admit it: All of us teachers are guilty of spoiling lessons from time to time. In the short term, it’s often just easier to lecture or give an answer instead of challenging students to think critically and creatively. But as alluded to previously, ease and speed are seldom conducive to authentic learning.

One of the biggest changes teachers can make is in their verbal interaction patterns. Similar to spoiler-free objectives, this transition begins by replacing statements with questions. Even in the midst of “direct instruction,” teachers can insert questions and prompts to invite student participation and discussion, as opposed to a stream of information. Rather than lectures, think of them as interactive presentations.

The type of question matters, too. Simple or closed-ended questions typically limit students’ level of thinking. Consider the following questions about the same topic—gas volume—and compare the amount of thought required and revealed by each prompt:

- Closed-ended question: “Did gas molecules expand to make the balloon bigger?”
- Open-ended question: “What do you think is happening inside the balloon?”

In this case, also notice how the closed-ended question can spoil scientific thinking, curiosity, and creativity in students’ responses.

To build a habit of effective questioning, preview each lesson and prewrite questions to foster discussion, guide student thinking, and draw out ideas. Another strategy is to refer to a “cheat sheet” or pocket guide with open-ended prompts: “How might . . . ?” “What if . . . ?” “For what reasons . . . ?” and more. Figure 1 includes general question stems teachers can use to facilitate dialogue about particular content. Notice that many of these encourage multiple responses and emphasize reflection, as opposed to merely recognizing or guessing a single correct answer. Use these prompts as springboards for moment-by-moment interactions focused on student thinking, inquiry, and creativity.

Equally important as initial questions are the ways teachers respond. When a student shares an idea or poses a question, the teacher’s response can either inspire or spoil future learning. Again, teachers will notice a significant difference when they respond with more questions than statements. Ask students to elaborate on their comments instead of doing it for them. Rather than answering a student’s query, respond with a different question that encourages further reflection. Moreover, refer student questions to the rest of the class to cultivate conversation and collaboration. In each of these responses, the teacher guides student thinking and checks for understanding without spoiling creativity or curiosity.
**Spoiler #5: Students**

Think of the last time you began a lesson or demonstration and a student interrupted you with “I’ve seen this before,” or “I know this already!” How do you stop a student from spoiling the rest of the class? Sometimes all it takes is a simple “Terrific! Please don’t spoil it for the rest of us. Thanks.” Encourage such students to pay attention and compare this present lesson with their previous experience. I reiterate to my classes that learning is not a “one-and-done” encounter, and they can still learn something new. Furthermore, students may recognize a particular topic but still possess limited comprehension of the concept. As summarized by Rule (2006), authentic learning involves real-world application, metacognition, collaborative discourse, and empowerment. All of these components require more than spoiled recitation or recall, providing educational experiences that feel fresh and unique.

**A final tease**

Science teaching is an amazing job, partly because we get to share our love of learning and discovery. In light of this enthusiasm, however, we must be careful to not spoil students’ own sense of wonder and creativity. A little restraint goes a long way. Moreover, we can direct our energy toward setting up revelatory experiences and interactions for our students.

According to the NGSS Framework, “An education in science should show that new scientific ideas are acts of imagination, commonly created these days through collaborative efforts of groups of scientists whose critiques and arguments are fundamental to establishing which ideas are worthy of pursuing further” (NRC 2012, p. 79). As science educators, we can collaborate with one another and with our students to foster learning through creativity and inquiry—all while avoiding spoilers to this process. To use another analogy from entertainment, we should enact and emphasize “teasers,” inviting and encouraging students to lifelong learning and imagination.

**FIGURE 1:** Open-ended question stems and prompts to engage, guide, and assess student thinking.

- What if . . .?
- How might . . .?
- For what reasons . . .?
- Explain how . . .
- How does that compare with . . .?
- Why might . . .?
- What do you think might happen if . . .?
- How could we . . .?
- Where else have we . . .?
- In what ways are . . .?
- To what extent . . .?
- Tell me more about . . .
- What sense can we make of . . .?
- Why do you suppose . . .?

Note: Use these prompts to replace simple questions that require yes/no or one-word responses [e.g., “Did anything . . .?” “Can you . . .?” “Is it . . .?”] and spoiler questions that reveal too much information and impede student thinking.
REFERENCES

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