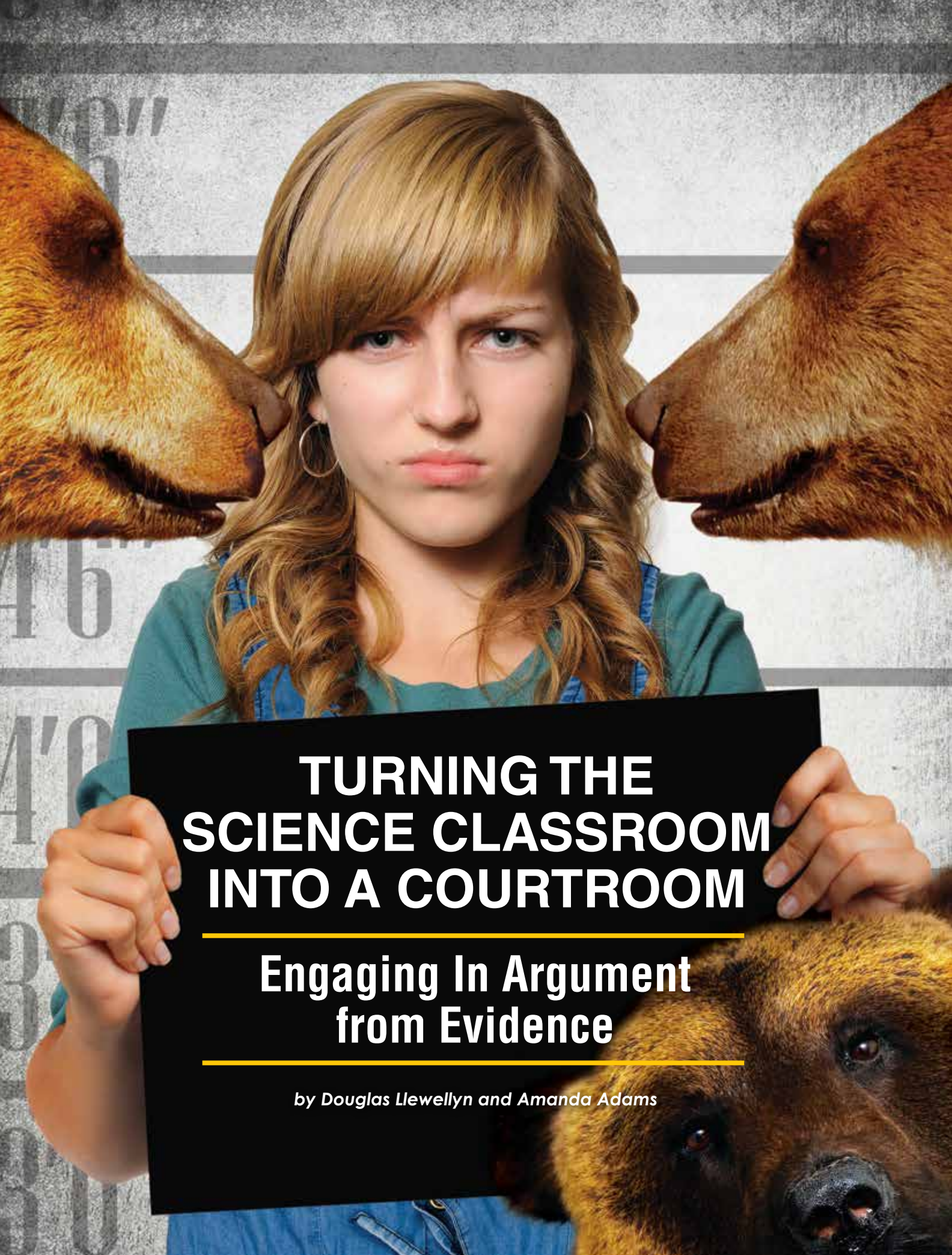


TURNING THE SCIENCE CLASSROOM INTO A COURTROOM

Engaging In Argument from Evidence

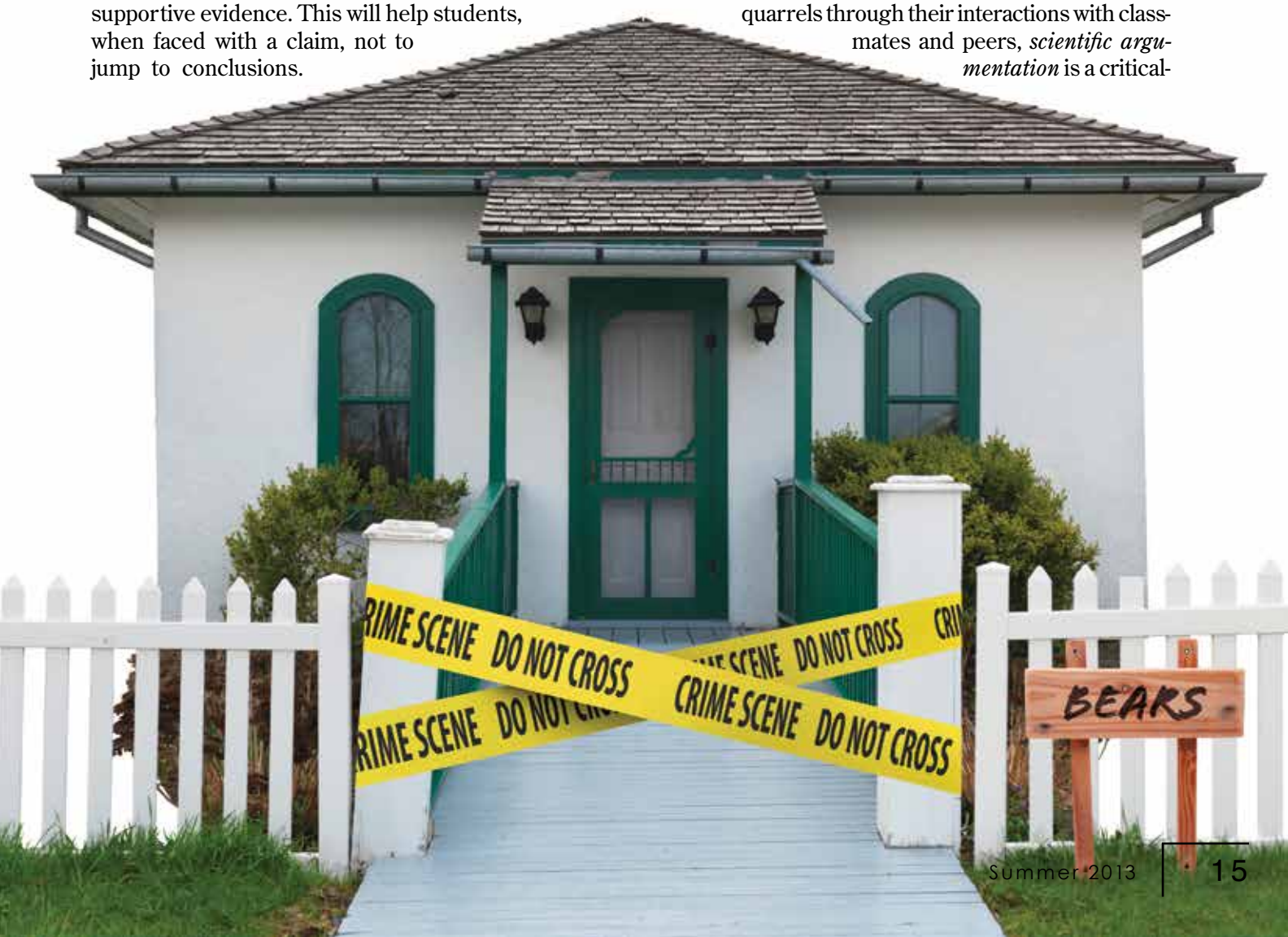
by Douglas Llewellyn and Amanda Adams

Every day, all of us, including middle-school-age youngsters, are besieged with unscrupulous claims backed by questionable evidence. Turn on the television, read the newspaper, or go online, and you can't avoid someone making a claim to adults about how to lose weight, how to stop smoking, how to increase your financial investments, or the benefits of herbal medicines. For kids, it may be a basketball sneaker company that claims it will make them into a top athlete, or an energy drink that is guaranteed to give them more pep. To prevent middle-level students from being bamboozled into making false assumptions, teachers need to provide lessons that (a) help students analyze assertions and scoff at claims that lack compelling and empirical evidence and (b) instill in their students the ability to discern a deceiving scientific argument from one grounded in substantial evidence. Effective teachers do this, in part, by giving students the experience of stating a claim, then defending and justifying it with supportive evidence. This will help students, when faced with a claim, not to jump to conclusions. Rather, they should first ask the following: Is the claim realistic? How reliable is the evidence? Is the evidence compelling?

This article proposes a way to scaffold students toward an understanding of scientific argumentation by answering three questions:

1. What are the basic parts of a scientific argument?
2. What do the *Common Core State Standards* and *A Framework for K–12 Science Education* say about argumentation?
3. How can teachers help introduce students to the concept of making and defending arguments by turning the science classroom into a courtroom?

First, teachers need to explain to students that everyday home and school-yard arguing is not the same as a scientific argument. Unlike conventional arguments, where middle-level students engage in quarrels through their interactions with classmates and peers, *scientific argumentation* is a critical-



thinking skill that students apply to propose, support, critique, refine, justify, and defend their positions about issues relating to science (Llewellyn 2013). As Ross, Fisher, and Frey (2009) put it, "Children are often good at arguing, but not at argumentation" (p. 28).

Although scientific arguments can vary in form and fashion, they often involve six essential elements:

1. The *question* emanates from an observed phenomenon that generates a scientific investigation or debate.
2. The *assumption* is an initial statement that uses prior knowledge to describe or explain an observed phenomenon. Sometimes the assumption helps build a model that constructs a possible answer to the question being studied. The assumption can also lead to a proposed hypothesis, a tentative answer, or a possible solution to a problem.
3. The *claim* is an assertion or conclusion that attempts to answer the original question or summarize the findings of a scientific inquiry.
4. The *evidence* is extracted from all the data collected in the form of observations and measurements. The evidence supports the legitimacy of the stated claim.
5. The *explanation* summarizes the claim and provides an interpretation of the newly acquired knowledge.
6. The *rebuttal* is a discussion, coming from the presenter's audience, that provides a counterclaim or new evidence to refute the original claim made.

These six elements play an important role in designing argument-based science investigations. Based on what scientists do and what we try to teach our students about scientific practices, argumentation is as inherent to scientific inquiry as it is to the nature of science.

Created by the National Governors Association and the Council of Chief State School Officers, the *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects* is a foundational document for crafting high-quality literacy standards for grades K–12. Many of the standards from the grade bands 3 to 5, 6 to 8, and 9 to 12 refer to the process of scientific argumentation. Thus, as teachers implement argument-based science investigations in their classrooms, they integrate language-arts literacy with scientific literacy (NGAC and CCSSO 2010).

Figure 1 is a sample of the reading, writing, and speaking and listening *Common Core* standards for the grade band 6 to 8 that align to scientific argumentation. As you scan down the lengthy list, notice how many standards include the terms *claim*, *evidence*, or *explanation*. Figure 1 illustrates that argumentation is a proficiency that intersects with many aspects of literacy. It tells us that by using the new benchmarks, classroom teachers can easily connect the standards of language arts and science to foster critical-thinking and problem-solving skills. Furthermore, argumentation is a 21st-century skill where students learn to (a) create and test their ideas, (b) design and conduct scientific inquiries, (c) collaborate with others throughout all phases of learning to argue and gather supporting evidence, (d) communicate clearly and articulately in presenting their findings and explanations, and (e) use information and media literacy to gather and use reliable sources to back their claims.

What does *A Framework for K–12 Science Education* say about argumentation?

The *Common Core State Standards* are not alone in citing argumentation as an important skill for students to acquire. In 2012, the National Research Council (NRC) produced the document *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. The *Framework* sets a vision for the future of science education and is built around three major dimensions: (1) scientific and engineering practices, (2) crosscutting concepts that unify science and engineering fields, and (3) core ideas in the physical sciences, life sciences, Earth and space sciences, and engineering and technology. As with the *Common Core*,

argumentation is one of the most essential features in the new Framework. The Framework makes a point of emphasizing "practices" as they relate to the authentic work of scientists and engineers. According to the NRC (2012), "the focus here is on important practices, such as modeling, developing explanations, and engaging in critique and evaluation (argumentation) that have too often been underemphasized in the context of science education" (p. 44). The Framework identifies eight essential practices to be integrated into the K–12 science curriculum that have a significant influence on inquiry and argumentation (NRC 2012, p. 42):

1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

FIGURE 1 Nanoscale measurements of various natural and human-made objects

Reading standards that apply to scientific argumentation

- Cite evidence that most strongly supports a point or analysis from the text.
- Distinguish between facts and opinions in a science-related article.
- Determine an author's point of view or purpose in a chapter and respond with counterevidence or an alternative viewpoint.
- Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient.
- Analyze a case in which two or more sources provide conflicting information on the same topic and identify where the sources disagree on matters of fact or interpretation.

Writing standards that apply to scientific argumentation

- Support a claim with logical reasoning and relevant, accurate evidence that demonstrate an understanding of a science topic.
- Use scientific words and phrases to clarify the reasoning and relationships among claims, counterclaims, and evidence.
- Provide a concluding statement or explanation that follows from and supports the argument presented.
- Write arguments focused on discipline-specific content to support claims with clear reasons and relevant evidence.
- Introduce a claim about a topic or issue, acknowledge and distinguish the claim from alternate or opposing claims, and organize the reasons and evidence logically.
- Write informative explanations generated from scientific procedures and investigations.

Speaking and listening standards that apply to scientific argumentation

- Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
- Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
- Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas.
- Acknowledge new information expressed by others and, when warranted, qualify or justify their own views in light of the evidence presented.
- Describe a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identify when irrelevant evidence is introduced.

You can see that Practices 6 and 7 apply directly to students' understanding of how explanation, argument, and communication are closely related. Thus, by implementing the eight Framework practices in the school curriculum, science teachers can seamlessly integrate inquiry- and argument-based instruction.

The classroom as a courtroom

As the Common Core and Framework demonstrate, the current trend in science education emphasizes literacy- and argument-based lessons. Science teachers in the middle-level grades may wonder how to incorporate argumentation into their instructional methods. Questions asked by some of these educators include "How do I attempt to implement the integration of literacy and argumentation in my classroom?" and "How can I help students make and defend arguments in my science classroom?" We will now explore one option—turning the science classroom into a courtroom—as a way to build student awareness of and interest in argumentation. This is an "opening hook" intended for use by teachers to introduce the concept of argumentation and begin to establish a mind-set for argumentation in their students rather than a step-by-step lesson plan for teaching argumentation mechanics.

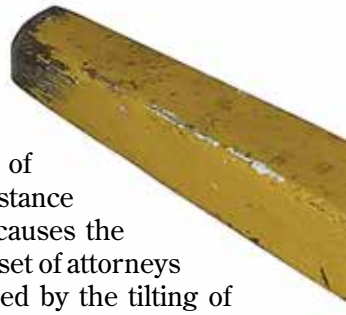
One way to introduce argumentation is by showing what argumentation looks like in familiar settings, such as a courtroom. Teachers can show video clips from movies and television series that illustrate what judicial argumentation looks like and plan follow-up discussions on the role of the judge, the prosecutor, the defense lawyer, and the jury. Students will begin to understand how people with different roles and viewpoints present evidence and testimony to prove a claim of guilt or innocence, while the jury renders a verdict based on the preponderance of the evidence.

Bringing the courtroom into the classroom allows teachers to explore the use of argumentation in courtroom proceedings and protocol as a means of building student interest in applying argumentation in the science classroom. As a first step in turning your classroom into a courtroom, consider using the excellent and motivating activity "In the Courtroom: Understanding the Players and the Action," which presents a trial of Goldilocks (see Resources). In this activity, students learn the workings of the legal system by acting out a criminal trial and assuming different courtroom roles. The website offers suggested courtroom diagrams, litigation vocabulary, and a trial script of the story characters. This activity connects students' prior knowledge (the story of "Goldilocks and the Three Bears") to something less familiar—using argumentation skills. It also serves as a means to enliven the introduction of argumentation to the science classroom.

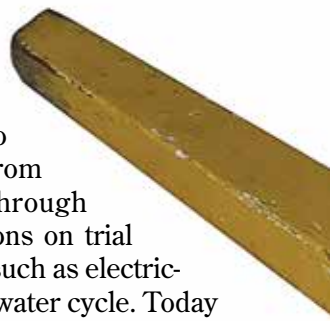
One set of "attorneys" can argue that the distance between the Earth and the Sun causes the different seasons, while the other set of attorneys argues that the seasons are caused by the tilting of the Earth's axis.

Misconceptions on trial

After showing students what argumentation looks like in the legal system, teachers can begin thinking about what topics to use to teach scientific argumentation. A good place to start is with topics that address misconceptions within science. Begin with misconceptions that are basic and will not generate distracting student emotions. For example, a familiar science misconception is that the distance between the Earth and the Sun causes the change of seasons. In this case, one set of "attorneys" can argue that the distance between the Earth and the Sun causes the different seasons, while the other set of attorneys argues that the seasons are caused by the tilting of the Earth's axis. Hearing both sides of this argument will enable students to see how empirical evidence helps to support a scientific concept. Once all testimony and arguments are concluded, the rest of the students, acting as the jury, will declare a verdict.



Science Court is a media resource for classroom use that examines common science misconceptions through argumentation. The animated cartoon series, which aired on television from 1997 to 2000, explores science questions from an argument-based perspective through a courtroom setting. Misconceptions on trial include timeless science concepts such as electricity, gravity, inertia, sound, and the water cycle. Today



teachers can use the *Science Court* DVDs and accompanying instructional materials as a way to assist their students in using argumentation to uncover science misconceptions (see Resources).

MythBusters is a current popular television series that offers yet another avenue for students to witness the application of the essential steps of argumentation to determine the veracity of common misconceptions, although not exclusively science misconceptions. In each episode, the series' hosts design a way to address different claims, myths, and misconceptions that are common in everyday life (see Resources).

Once students have practiced arguing science misconceptions, teachers can introduce more complex, current, and controversial topics that interest students. When the intensity of the discourse is scaffolded for students, they gradually become more proficient in their use of argumentation, even when the misconceptions are more complicated. This allows students to extend their understandings and eventually benefit from devising their own scientific arguments regarding misconceptions and topics of their own choosing.

Sample concepts and misconceptions to debate in the classroom, from simple to more complex, include the following:

- Earth-centric (Ptolemy) versus Sun-centric (Copernicus) universe
- Pluto: Planet or dwarf planet?
- A meteorite hitting the Earth caused the extinction of the dinosaurs.
- Euglena: Plant or animal?
- All magnets are made of iron.
- Cell phones can cause brain cancer.
- Tanning beds can cause skin cancer.
- Efficient sources of energy—oil versus solar power
- Global warming or the cycle of nature
- The expanding Earth or plate tectonics
- To frack or not to frack

Learning science through argumentation

Once students have gained basic argumentation skills from their courtroom-like experiences, they are better prepared to move on to designing and carrying out their own investigations, and using data to formulate claims with supportive evidence. At this point, middle-level students can be further encouraged to determine whether the data they collect are biased or flawed in any way and to communicate an explanation or model from the claim and evidence.

There is no doubt that possessing effective communication skills will be an essential aspect of scientific literacy in the 21st century. Scientific argumentation provides students with the opportunity to practice many useful critical-thinking and communication skills as they seek to create defendable arguments about different "sides" of scientific misconceptions. Through case studies, debates, and courtroom simulations, students learn to think about global issues based on empirical evidence. Argumentation also helps students formulate their points of view and opinions into justifiable claims based on supporting evidence and scientific reasoning. Students consider alternative viewpoints based on new evidence presented and foster respect for others' points of view. In addition, argument-based lessons help students to make choices based on empirical evidence (rather than individual opinions) and develop positive attributes such as self-efficacy and intellectual self-determination.

Carl Sagan, in *The Demon-Haunted World*, said, "Both skepticism and wonder are skills that need honing and practice. Their harmonious marriage within the mind of every schoolchild ought to be a principal goal of public education" (1996, p. 306). A smidgen of skepticism and the wonder of inquiry will go a long way in helping today's middle-level students separate authentic science from pseudoscience. For teachers, the transformation to scientific argumentation involves shedding "old skins" and altering our understanding of the dimensions of scientific literacy. For students, it means learning the true meaning of science. ■

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Resources

Further reading on scientific argumentation in middle-level grades

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Classroom tools

In the courtroom: Understanding the players and the action—*http://kidscourt.law.utah.edu/wp-content/uploads/2010/09/Lesson-Plan-5-In-the-Courtroom-final-pdf.pdf*

MythBusters—*http://dsc.discovery.com/tv-shows/mythbusters*

Science Court—*www.tomsnyder.com/products/product.asp?SKU=SCISCI*

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