USING ISSUES-BASED SCIENCE IN THE CLASSROOM

Challenging students to think critically about the role of science in society

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Every day we are confronted with issues of varying degrees of complexity and importance. Which bags are better for the environment—paper, plastic, or neither? What precautions should be taken to reduce the spread of the H1N1 virus? Are there risks involved in eating genetically modified fruits and vegetables? What impact will the use of alternative sources of energy have on global climate change? Questions such as these present unique opportunities to incorporate personal, societal, and global issues into the science classroom. Issues-based science not only helps increase student engagement, but also provides a context in which to learn and apply core science content. In addition, students evaluate scientific evidence, apply reasoning, examine positions, and weigh trade-offs.

For example, consider an Earth science class in which students are engaged in answering the hypothetical question, "Where should our town build a new high-rise?" Students conduct experiments such as testing the porosity of different soil types and investigating the relative strengths of rocks. They examine the geology of the area, research the history of earthquakes, and consider the various environmental effects of building in one location compared to another. Finally, students compose engineering reports that summarize their findings and conclude their exploration of the issue by acting as participants at a mock community meeting, in which they consider the evidence and trade-offs before voting on where the new high-rise should be built. These students are building a link between key science content and practical societal application.

In this example—and others like it that incorporate issues-based science—students learn the importance of communicating their findings clearly, so that others can understand and use the information to make important decisions. Incorporating issues supports a classroom environment that engages students in active and authentic ways (Figure 1). This article provides helpful resources for planning and using this type of instruction in the classroom.

FIGURE 1

Characteristics of issue-oriented science classrooms.

Less emphasis on...	More emphasis on...
Discussing science in isolation	Discussing science concepts and understanding in the context of personal and societal issues
Working alone	Collaborating with a group that simulates the work of a scientific community or represents authentic groups found in society
Acquiring scientific information	Acquiring conceptual understanding and applying information and conceptual understanding in making and evaluating personal, societal, and global decisions
Closed questions with one correct answer	Open-ended questions that require students to explain phenomena or take positions backed by evidence
Multiple-choice assessments	Authentic assessments

FIGURE 2

Examples of issues.

Personal issues	Societal issues	Global issues
What are the trade-offs of taking a new medicine?	How should society encourage energy efficiency?	Why might countries have different carbon emission guidelines?
Which is a better choice—bottled water or tap water?	Which forests in our area should be conserved?	Globally, which forests should be conserved?
Which car would you buy if safety were your primary concern?	Are there risks involved in using genetically modified animals as a source of food?	How can countries work together to sustain the world's oceans?
Which car would you buy if carbon dioxide emissions were your primary concern?	Where should the town or city build its new town hall?	How does the use of different renewable energy sources in one country affect Earth's global systems?
	Which energy source is most sustainable for our community?	

FIGURE 3

Tips for using issues in the science classroom.

- Introduce the issue using a newspaper article, headline, or other engaging way.
- Make it personal. Ask, "What would you do...?"
- Elicit students' ideas about the issue and the type of evidence that could inform and support their decisions.
- Draw on students' knowledge, understanding, and opinions to generate a list of questions about the issue and the science related to it. Post the list in the classroom, and record responses and new questions as you proceed through multiple activities.
- Whenever possible, connect the issue to current events and local concerns. Local newspapers, guest speakers, organizations, and businesses may provide additional information about local aspects of the issue.
- As students investigate the science related to the issue, regularly bring up the issue to discuss it in light of newly gathered evidence and students' new questions.
- Give students a chance to make a decision or recommendation about the issue.
- Be sure students explain how scientific principles and evidence helped them understand the options and reach a decision about the issue.
- Emphasize that science can often provide important information and explanations about an issue. People then use that information to make decisions based on varying viewpoints and priorities.

Addressing the Standards

The approach described in this article supports the National Science Education Standards for Science in Personal and Social Perspectives (NRC 1996, p. 193), which detail the important role of science in making societal decisions. The National Science Teachers Association (NSTA) position statement "Beyond 2000—Teachers of Science Speak Out" also supports using an issue-oriented approach to science learning, stating, "Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed" (NSTA 2000). When issues are used in the classroom, science understanding is paired with societal connections that make content relevant and help develop students' scientific literacy. Exposing students to situations where they use scientific evidence to make informed personal decisions and grapple with societal and global issues helps them develop the critical-thinking skills needed for success in the 21st century.

Selecting issues

The media provide an unending source of important societal and global issues, but selecting those issues most suitable for science instruction can be a challenge. The following questions are useful when evaluating an issue for use in the classroom:

- Does the issue require an understanding of important science concepts and application of scientific process skills?
- Will the issue lend itself to an application of evidence?
- Is the issue likely to be interesting and accessible to students?
- Is the issue likely to foster discussion and debate?
- Is the issue and associated content age and grade-level appropriate?

FIGURE 4

Inquiry continuum (NRC 2000).

Essential features of classroom inquiry and their variations.

	Essential feature	Variations			
1	Learner engages in scientifically oriented questions.	Learner poses a question.	Learner selects among questions, poses new questions.	Learner sharpens or clarifies question provided by teacher, materials, or other source.	Learner engages in question provided by teacher, materials, or other source.
2	Learner gives priority to evidence in responding to questions.	Learner determines what constitutes evidence and collects it.	Learner directed to collect certain data.	Learner given data and asked to analyze.	Learner given data and told how to analyze.
3	Learner formulates explanations from evidence.	Learner formulates explanation after summarizing evidence.	Learner guided in process of formulating explanations from evidence.	Learner given possible ways to use evidence to formulate explanation.	Learner provided with evidence.
4	Learner connects explanations to scientific knowledge.	Learner independently examines other resources and forms the links to explanations.	Learner directed toward areas and sources of scientific knowledge.	Learner given possible connections.	
5	Learner communicates and justifies explanations.	Learner forms reasonable and logical argument to communicate explanations.	Learner coached in development of communication.	Learner provided broad guidelines to sharpen communication.	Learner given steps and procedures for communication.

More <--------------- Amount of learner self-direction ---------------> Less

Less <----------- Amount of direction from teacher or material -----------> More

It is helpful to first distinguish between topics and issues. Topics are subjects; "global climate change," "genetically modified organisms," and "nuclear energy" are examples. Topics can be taught by focusing solely on the science content. Issues, in comparison, present a focused question or challenge; "Are genetically modified organisms a solution to world hunger?" is one example. When teaching topics through associated issues, the interplay between science and society is underscored.

For this reason, it is necessary to frame the issue through focus questions that elicit multiple perspectives and require personal or societal input. A good focus question should engage students as it introduces an issue. The best questions are ones that require students to do more than answer "yes" or "no." For example, "Which fuel should the town use to run its bus system in a more sustainable manner?" will generate richer discussion and create more opportunities for evidence-supported conclusions than "Can ethanol be a substitute for gasoline?" While both involve key concepts about the chemistry of fuels, the first is a more complex question. It forces students to examine positions, and support or refute these positions through the use of evidence. Figure 2 provides examples of questions that require students to both apply content understanding and evaluate evidence.

Planning issue-based instruction

Once an issue has been selected and the relevant science standards identified, it is best to focus attention on delineating

FIGURE 5

Evidence and trade-offs scoring guide.

What to look for:

- Response uses relevant evidence to compare multiple options in order to make a choice.
- Response takes a position supported by evidence and describes what is given up (traded off) for the chosen option.

Level 4 Above and beyond	Student accomplishes Level 3 and goes beyond in some significant way such as: ◆ including relevant evidence that was not studied in class; ◆ evaluating the source, quality, or quantity of evidence; ◆ proposing relevant experiments or research; or ◆ including a diagram or other visual aid to clarify his or her ideas.
Level 3 Complete and correct	Student compares options using accurate and relevant evidence, takes a position supported by the evidence, and describes trade-offs of his or her decision.
Level 2 Almost there	Student discusses one or more options using accurate and relevant evidence and takes a position supported by the evidence, but reasoning is incomplete or part of the evidence is missing.
Level 1 On your way	Student takes a position, but provides reasons that are subjective, inaccurate, or nonscientific.
Level 0	Student's response is missing, illegible, or irrelevant.
X	Student had no opportunity to respond.

the opportunities for assessment and feedback. Authentic assessment tasks are ideal for providing opportunities to assess both content and process, and at the same time, connect issue-based learning to real-world tasks. Such assessments should emphasize analysis, reasoning, and communication skills, and many can be embedded in the lessons themselves.

The final stage of planning is to develop a sequence of activities that helps students learn the concepts associated with the issue. A variety of learning activities, such as labs, investigations, readings, and research, can take students through a cycle of collecting and analyzing evidence, while building knowledge and making connections related to the initial challenge. The learning culminates in students applying what they have learned to address the original issue or problem. An excellent way to do this is to set up a social structure that follows the way that the issue might be discussed in society—this could be through simulations of a community meeting, a seminar or debate, or a town hall meeting, followed by an opportunity to vote on a proposal. Figure 3 (p. 26) provides tips that can be helpful when using issues in the classroom.

Incorporating issues into a science course naturally lends itself to various aspects of inquiry. The National Research Council's inquiry continuum (NRC 2000), shown in Figure 4 (p. 27), is a useful tool when determining how to design learning opportunities that productively engage all students in an issue-based classroom.

For example, when deciding what evidence students will use, the teacher may ask students to analyze a set of data that has been provided. Alternatively, the teacher may direct students to collect certain data, and in other situations, students may determine for themselves which data sets are needed and how they can be collected. In this way, instruction can be adjusted along the continuum to fit the developmental needs of students in any classroom.

Making evidence-based decisions

In an issue-oriented classroom, students encounter opportunities to make decisions that are supported by evidence and articulate the trade-offs associated with these decisions. For example, in a cell biology unit, a teacher may engage students in thinking about who should be quarantined during an outbreak of a disease by asking students to respond to the following scenario:

> There has been an outbreak of a flulike sickness at a school. A group of parents have demanded that the family members and close friends of all infected individuals, including students and teachers, stay home until everyone with symptoms gets better. Explain whether you agree with the parents' demand. Support your answer with evidence and identify the trade-offs of your decision.

In this example, students are evaluated on their selection and use of evidence to support their positions. They are not evaluated on whether they did or did not agree with the parents' demands. This type of evaluation can be accomplished through the use of scoring rubrics. An "Evidence and Trade-Offs" scoring guide, that can be used as the basis for developing such rubrics, has been developed by the Science Education for Public Understanding Program (SEPUP) in conjunction with the University of California, Berkeley's Graduate School of Education. This scoring guide, shown in Figure 5, outlines the criteria necessary for an evidence-based response. The guide can be adapted for use with any task in which students take a position supported by evidence. Sharing the scoring guide with students before they are asked to construct a response provides guidance as they learn the essential features of an evidence-based response.

Meeting challenges

It takes time, practice, and feedback for students to develop the reasoning skills and level of conceptual understanding necessary for crafting a solid argument to defend a position (Sadler, Chambers, and Zeidler 2002). For students to reap the true rewards from such instruction requires an investment of time in planning, designing, and conducting issue-oriented science lessons over prolonged periods throughout a science course. This can be accomplished by providing repeated opportunities for students to practice applying scientific reasoning and evidence-based decision making to societal issues throughout the school year (Sadler and Fowler 2006). The inclusion of issues might take time away from studying some science content, but there are powerful payoffs. Students' conceptual understanding is enhanced as they study content in depth and determine important relationships. In addition, the time spent on developing reasoning and argumentation skills can contribute significantly to the development of a student's scientific literacy.

As with most things new, students should be introduced to issues in a gradual way. For example, the complexity and scope of the issues studied can be developed as a course progresses. The amount of support provided to students can also be varied, in particular with planned gradual movement along the inquiry continuum, as shown in Figure 4 (p. 27). Sophisticated reasoning skills can also be broken down into more discrete subsets that students can work on over time.

Conclusion

Researchers and practitioners have found that incorporating societal issues into the science clasroom can help students think critically about the role of science in society and develop as scientifically literate young adults (Nuangcharlerm 2009; Tal and Kedmi 2006; Zohar and Nemet 2002; Patronis, Potari, and Spiliotopoulou 1999). Issue-based science challenges students of varying interests, abilities, and diverse backgrounds. Consequently, using issues is one method that not only helps to answer the question, "Why are we learning this?" but is truly an example of science for *all* students. ■

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