IT'S DEBATABLE!

USING SOCIOSCIENTIFIC ISSUES TO DEVELOP SCIENTIFIC LITERACY K–12

Dana L. Zeidler and Sami Kahn

NSTA press
National Science Teachers Association

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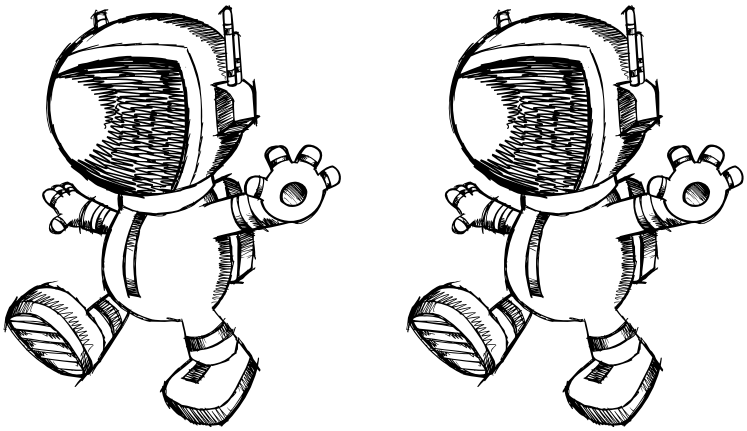

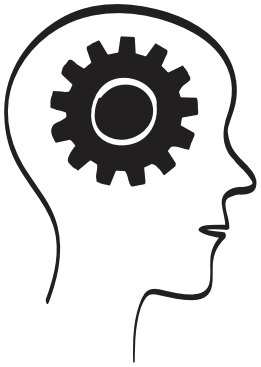

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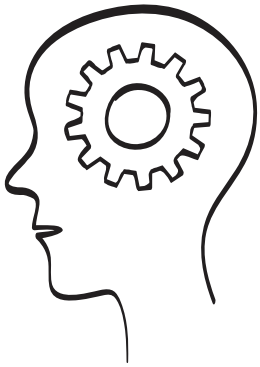

Dana L. Zeidler (first author) earned his PhD from Syracuse University. His research program incorporates aspects of socioscientific issues as a means to facilitate scientific literacy. His work has attracted international attention and is cited widely both within and external to the field of science education. His line of extensive research can be found in numerous journal articles, book chapters, keynote addresses and international conference proceedings. He works closely with doctoral students and other leaders in the science education community. He is a Professor and Program Coordinator of Science Education at the University of South Florida, Tampa Bay. Dana has long-standing ties to the science education community including working closely with other leaders, faculty, and graduate students. Some of his most recent honors include:

- President of National Association for Research in Science Teaching (NARST): A worldwide organization for improving science teaching and learning through research, 2010–2011
- Recipient for the Outstanding Mentor Award (2008), Association for Science Teacher Education (ASTE)
- Executive Board of Directors, NARST, 2006–2009
- At Large Board of Directors, ASTE (2008–2011)
- Series Editor for *Contemporary Trends and Issues in Science Education*, Springer: Dordrecht, The Netherlands (2008 to present)
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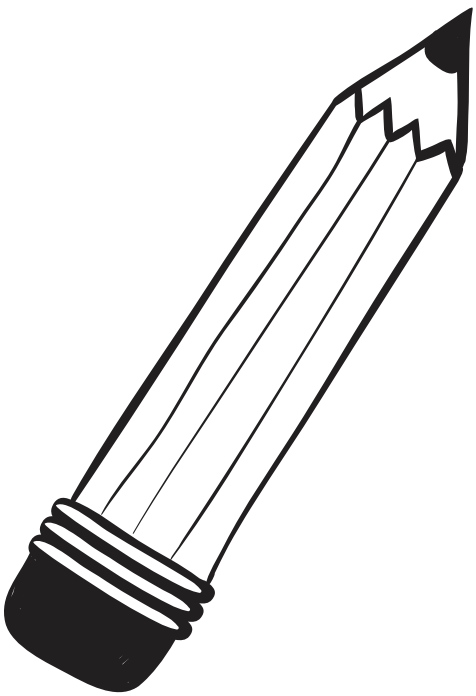
Sami Kahn (second author) is a 26-year veteran science educator with extensive experience in classroom teaching, professional development, and curriculum development. Currently serving as a Presidential Doctoral Fellow in Science Education at the University of South Florida, she has authored numerous journal articles, including several in *Science and Children*, and has coauthored three books on enhancing scientific inquiry experiences for children and adults. She has served as an invited and keynote speaker at several state and national conferences, and most recently at an international STEM conference in Thailand. She is particularly known for her work in ensuring quality science opportunities for all children, including those with disabilities. In that capacity, she has served as president of Science Education for Students with Disabilities (SESD), an NSTA Associated Group dedicated to inclusive science practices, chair of the National Science Teachers Association's Special Needs Advisory Board, and chair of the national awards committee for the Scadden Science Teaching Award. She also had the honor of serving as a delegate to the National Congress on Science Education, from which she was elected to represent the Congress as an NSTA national convention planning committee member. Ms. Kahn has successfully taught grades Kindergarten through college, as well as inservice professionals, and has won numerous awards for outstanding science teaching. She holds an MS in ecology and evolutionary biology and a JD with an emphasis in environmental law from Rutgers University. Prior to coming to University of South Florida, she most recently served as lower school science coordinator/teacher and K–12 science department chair at Collegiate School in New York City.



A Prelude

"Monday Morning"

Ms. C. left the school office in a hurry, hastily grabbing her mail before heading to her first period biology class. Mondays were always a challenge, but today seemed especially so. It wasn't even 8:00 and she had already been involved in a heated discussion of the new accountability measures being implemented in her school district; more tests, more requirements to meet Common Core, and more pressure to make sure her students made Adequate Yearly Progress or her performance evaluations would be on the line. "When did teaching become so stressful?" she thought. It was never an easy job, but the last few years felt especially weighty … less focused on the subject and students she loved, less creative, and definitely more stressful.

She took a deep breath as she entered her classroom. "Good morning!" she said with a somewhat forced smile. Almost immediately, she sensed something was different today… her ninth graders, usually sleepy on Monday mornings, were talkative and animated. The energy in the room was palpable.

"Hey, Ms. C, we were just arguing about the vaccine question from last week. I still think it's wrong to make teenagers take vaccines!" said Alex.

"But they protect us!" exclaimed Janelle.

"That's what the drug companies want you to think. What's your evidence?" asked Vincent.

Ms. C's ears pricked up as she was shocked to hear her students suddenly engaged in an impromptu discussion of … science!

"My group read an article about how the vaccine protects against cervical cancer, so it's a good thing!" Janelle retorted.

"Yeah, but what was the source? Did you evaluate the source?" pressed Vincent.

Ms. C. smiled in awe. She didn't know if the discussion on evaluating sources of evidence would sink in. It didn't sound like the most exciting topic when she read about it, and yet, the students really enjoyed evaluating different websites and articles using the rubric she had provided. Maybe this new curricular approach was working.

"But our group found an article that said that vaccines were bad for you. There are side effects … even death!" replied Alex.

"Yeah, that's the problem with science. There are always different reports. You never know what to trust!" added Crystal, in an exasperated tone.

"But that doesn't mean you can't trust it. Remember the whole nature of science thing? There's always new information," added Miguel.

Ms. C. felt a tingling feeling she hadn't felt in years: that combination of pride and excitement that comes with knowing you've impacted your students' lives.

"I don't think it matters whether the vaccine helps or not. No one has the right to make me take a vaccine if I don't want it. It's my body! And I talked about this with my parents this weekend and they agree!" exclaimed Karla.

Ms. C. couldn't believe her ears. She had never heard a peep from Karla, her quietest student. Yet today Karla was taking a stand, and she had clearly been talking (and thinking) about it over the weekend.

"Maybe this new SSI approach I'm trying is making a difference," Ms. C. thought. In fact, her friend Mr. Alvarez, a Language Arts teacher, did mention that he heard some of Ms. C's students discussing the vaccine argument in his class last Friday … science seemed to be spilling over into other parts of the day. And yet, Ms. C. really hadn't made a huge change in her teaching. She had just decided to tweak her already-existing curriculum to include a few extra lessons that put the science content into a personal context that really motivated and challenged her students … and her.

Ms. C hated to interrupt the students, who at this point were engaged in a full debate. "Let's take a look at what we've learned so far and see what we still need to discover!" she said.

It was going to be a good day … and a good year!

Unit 3

A Need for Speed?

Should speed limits be lowered to reduce traffic fatalities?

Unit Overview

During this unit, students will investigate physical science concepts related to forces and motion. They will then synthesize and apply their learning to grapple with the question of whether speed limits should be lowered to reduce traffic accidents. Through engagement in several hands-on activities, as well as the development of research-based arguments, students relate physical concepts to their everyday lives and to the functioning of society.

Key Science Concepts

Forces, Friction, Motion, Momentum, Mass, Gravity, Velocity

Ethical Issues

Personal Freedom, Government Regulation, Individual vs. Societal Interests

Science Skills

Predicting, Observing, Measuring, Analyzing Data, Understanding Cause and Effect, Communicating Results, Forming Arguments From Evidence.

Grade Levels

Upper Elementary and Middle School

3

Time Needed

The unit is comprised of four lessons over five class periods. Time can be adjusted depending on student content background.

Lesson Sequence

Lesson 1. Slippery When Wet (Momentum and Friction on the Slip 'n Slide)

Lesson 2. Data Driven (Analyzing and Interpreting Slip 'n Slide Data)

Lesson 3. Speed Kills? (Research on Speed and Automobile Safety: 2 periods)

Lesson 4. Town Hall Meeting: Should We Reduce Speed Limits?

Background on the Issue

Speed limits are part of everyday life in societies that rely on motor vehicles for transportation. Yet questions about whether speed limits really do save lives, and if so, what speeds are "ideal" remain controversial. Speed limits are generally imposed for safety reasons, but also have been used to reduce fuel consumption and reduce air and noise pollution. U.S. federal highway speeds have changed over the years, in response to research on road safety as well as fuel prices. Those who favor reduced speed limits generally cite research suggesting fewer road fatalities, improved fuel efficiency, and cleaner environments. Those who oppose speed limit reductions generally cite research suggesting that speed limits do not substantially improve safety or reduce air pollution, and that they are irrelevant since many people don't obey them anyway. Furthermore, opponents suggest that speed limits make commerce more difficult as they slow the movement of goods for businesses, yet create a large source of revenue for city, state, and local government through ticketing. In this unit, students will explore how velocity and mass affect momentum and will use their knowledge to analyze and interpret readings on speed limits and road safety. Students will then debate the proposed reduction of speed limits in a town hall meeting using evidence informed by their research.

Connecting to *NGSS*

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Accommodations for Students With Disabilities

Visual Impairments: Allow student to tactilely examine the Slip 'n Slide in advance of the lesson; have student count the number of paces back from the Slip 'n Slide so that she or he knows when to slide; allow student to feel the difference between one pound and one kilogram.

Hearing Impairments: Outdoor activities can be tricky as wind can increase "noise" for students who use hearing aids or cochlear implants; if possible, use an FM system or interpreter, or try to give directions either inside the school or in a wind-protected area if it happens to be windy; provide visual cues for vocabulary words such as *velocity*, *momentum*, and *mass*.

Learning Disabilities: Show students several examples of pound to kilogram conversions; separate the velocity and momentum portions of the data sheet into two pages to allow for greater white space on the page; use a T-chart to keep track of arguments for and against reduced speed limits.

Motor-Orthopedic Impairments: Accommodations will depend on the student's particular impairment and comfort level; speak with the student to discuss options for the Slip 'n Slide portion of the unit; the student could be seated on the Slip 'n Slide and have partners gently pull the student so that he or she can feel the difference in movement on a dry, wet, or soapy surface; if the student uses a wheelchair, the same calculations for velocity and momentum can be done using the wheelchair motion rather than the Slip 'n Slide; a whole-class alternative activity could consist of all students testing their speed using a spare wheelchair so that all students are using the same apparatus.

Emotional Disabilities: Assign numbers to students in advance of approaching the Slip 'n Slide to minimize arguments over the order of sliding; anticipate an outdoor "time out" spot that a student could move to if she or he requires a break from the excitement; if a student has difficulty listening or becomes disruptive during the debate, consider providing her or him with a Town Hall Meeting Participation Sheet and allow student to serve as an assistant to you; this may help student to focus on the conversation and provide a sense of autonomy.

3

Resources for Teachers

- The Physics Classroom on Momentum (*www.physicsclassroom.com/Class/momentum/u4l1a.cfm*)
- Insurance Institute for Highway Safety's Speed Limits Q&A Page: (*www.iihs.org/research/qanda/speed_limits.aspx*)

Note: This unit is based on a project submitted by Thomas Dolan.

An alternative to the "Slip 'n Slide" lesson that uses a skateboard can be found at:

Dolan, T. J., and D. L. Zeidler. 2009. Speed kills! (Or does it?). *Science and Children* 47 (3): 20–23.

3

Lesson 1

Slippery When Wet

To the Teacher

In this lesson, students will participate in a Slip 'n Slide activity to examine concepts of velocity, mass, momentum, and friction. They will record their time sliding on water with and without dish soap, calculate their momentum based on their weight, and examine the effects of a reduction of friction on their velocity.

Objective

Students will demonstrate their understanding of the impact of friction on velocity.

Time Needed

One class period

Materials

Slip 'n Slide, hose, stopwatch, bottle of dish soap, pencil, list (with the names of all students and 6 columns for each student), bathing suits, towels, goggles (1 pair per student).

Note: You may wish to have an extra adult on hand in order to assist with the data collection.

Procedure

1. In advance of the class, set up the Slip 'n Slide outdoors.
2. Bring students outside to the Slip 'n Slide and ask for a volunteer to slide down the track without water turned on. (Students will either refuse because they know they won't slide, or will sit on the Slip 'n Slide without moving.)

3

3. Probe students about friction. "Why can't we slide well on the dry Slip 'n Slide?" "What is friction?" "How can we reduce the friction on the track?"
4. Have students line up and spray them with the hose. Students will then line up and run a distance of 5 meters before proceeding headfirst down the Slip 'n Slide track. The Slip 'n Slide track is approximately 6.1 meters in length.
5. Have a parent or another adult time students on the track with a stopwatch and record student times on the data sheet.
6. Allow each student to slide three times with the water running.
7. After each child has gone three times, apply dish soap to the Slip 'n Slide. (This is used to further demonstrate the lessening of friction.) Have students wear goggles and allow them to take another three turns down the slide with the soap added. Record times.
8. After all students have gone a total of 6 times, students will rinse off and proceed to change back into their school clothes.

Slip ‘n Slide Time Sheet

Enter the number of seconds for each student’s trials
(trials 1–3 with plain water, trials 4–6 with soapy water)

Student	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6

3

Lesson 2

Data Driven

SCILINKS
THE WORLD'S A CLICK AWAY

Topic: Momentum
Go to: *www.scilinks.org*
Code: SSI005

To the Teacher

During this lesson, students analyze and interpret their results from the Slip 'n Slide activity to draw conclusions about the relationship between velocity and mass to momentum, as well as the impact of friction on velocity.

Objective

Students will demonstrate that both mass and velocity are related to momentum, and that friction reduces velocity.

Time Needed

One class period

Materials

Slip 'n Slide handout, timesheet (recorded from the previous day's activity for each student), pencil, paper, calculator.

Procedure

1. Begin by reviewing the events of the previous class. Can we slide on the Slip 'n Slide without water? (no, because too much friction) What is friction? (a force that slows things down) How did the water help us slide? (reduced friction). What effect do you think the soap had? (made it more slippery and reduced friction) Is it easier to stop with or without soap? (without)
2. Explain to students that in order to be certain about our results, we need to calculate our velocity, which is a function of time and distance. Have students examine their data sheets.

3. Students complete their data sheets by entering their mass (converted to kg as per the directions on the sheet) and then calculate their velocities both with and without soap. Students also calculate their momentum, which is a function of velocity and mass.

4. Have students compare and contrast the data in order to determine the effects of mass and velocity on momentum with regard to variances in friction due to the water and soap (soap decreases friction which then increases velocity; increased velocity increases momentum). Also note that velocity is inversely proportional to time for a given distance; in other words, it takes less time to get to a destination when traveling faster.

Closure

Pool the class data so students can compare their results with the class to look at the effect of mass on momentum (increased mass increases momentum). Students should observe that increasing both mass and velocity increase the momentum of an object. Note that an object with greater momentum takes longer to stop.

Assessment

Ask students to determine what factors would make a vehicle more or less likely to come to a quick stop, based on our results. (a fast, heavy vehicle will have more momentum than a slow, lighter vehicle, and will therefore stop more slowly; wet or oily roads reduce friction so velocity and momentum are increased)

Name: _____ Date: _____

Slip 'n Slide

Mass Conversion (Round answer to the nearest hundredths)

Your Weight (lbs.) × 0.454 = Your Mass (kg)

_____ × 0.454 = _____

Time Trials (Round time to the nearest tenth of a second)

Without Soap Trials

Trial	Time
1	
2	
3	

With Soap Trials

Trial	Time
1	
2	
3	

Velocity Calculation (Round answers to the nearest hundredths)

Trial	Distance (m) ÷	Time (sec) =	Velocity (m/sec)
1			
2			
3			
4			
5			
6			

Momentum Calculation (Round answers to the nearest hundredths)

Trial	Mass (kg) ×	Velocity (m/sec) =	Momentum (kg m/sec)
1			
2			
3			
4			
5			
6			

3

Lesson 3

Speed Kills?

To the Teacher

In this lesson, students will research various sources of data to grapple with the question of whether speed limits in the fictional city of Driversburg should be reduced in order to cut down on the number of vehicle fatalities.

SCILINKS® THE WORLD'S A CLICK AWAY

Topic: Speed Limits
Go to: *www.scilinks.org*
Code: SSI006

Objective

Students will analyze a series of articles to become familiar with statistics and information regarding speed and the effect it has on vehicular accidents.

Time Needed

Two class periods

Materials

Article packet (containing 4 articles), Article Evaluation Sheets, highlighters, pencils

Procedure

Day 1

1. After reviewing some of the major concepts from the prior lessons (momentum, velocity, mass), ask students whether they think that there should be speed limits on motor vehicles? (accept all answers) Ask, "If you think there should be limits, how can we decide what those limits should be? Should cars just go as slowly as they can?" (accept all answers)
2. Inform students that they are going to investigate research that has been done on vehicle safety to determine whether speed limits should be reduced.

3. In groups of four, have students read the articles and highlight important information within each article. After all students have finished reading the articles, each group will individually discuss the effects of lowering the speed limit and complete the Article Evaluation Sheets.

Day 2

1. Ask students to imagine that they are citizens of the city of Driversburg. After a series of recent fatal vehicular accidents, a law was proposed to reduce the speed limits on city streets by half. They have been charged with debating the law and ultimately, voting on its outcome.
2. Place students in new groups (different than their research groups) that represent various stakeholders on the issue of speed limit reduction. The new groups are: truck drivers, parents, business leaders, and police officers.
3. Challenge students to use the information in the articles and the knowledge gained in the hands-on experiments to formulate arguments for their particular stakeholder group. Allow students to access additional resources, if necessary, to enhance their arguments.

Closure

Inform students that they will be debating the issue in the next class period. "What are our ground rules for our debates?" (raising hands to speak, listening respectfully, no personal attacks or criticisms, using evidence to justify claims, and so on)

Assessment

Review student article summaries for accuracy and completeness.

Articles for Packets

Article 1: Witzenburg, G. (2003, January 23). Seven major myths of speed and speed enforcement. *Consumer Guide. www.motorists.org/ma/myths.html*

Article 2: U.S. Department of Transportation Research, Development, and Technology. 1992. Fact Sheet: Effects of raising and lowering speed limits. *www.fhwa.dot.gov/publications/research/safety/humanfac/rd97002.cfm*

Article 3: Nagourney, E. 2009. Safety: As speed limits rise, so do death tolls. *The New York Times*. July 20. *www.nytimes.com/2009/07/21/health/research/21safe.html?scp=3&sq=highway&st=cse&_r=0*

Article 4: Reinberg, S. 2009. Deaths, injuries increase with higher speed limits. *U.S. News and World Reports* (online version). July 16. *http://health.usnews.com/health-news/managing-your-healthcare/articles/2009/07/16/deaths-injuries-increase-with-higher-speed-limits*

Name: _____ Date: _____

Article 1

"Seven Major Myths of Speed and Speed Enforcement"

Summarize the main argument of the article:

_____

_____

_____

_____

Identify key points used in this article:

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

4. _____

_____

_____

5. _____

_____

_____

Name: _____ Date: _____

Article 2

"Fact Sheet: Effects of Raising and Lowering Speed Limits"

Summarize the main argument of the article:

_____

_____

_____

_____

Identify key points used in this article:

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

4. _____

_____

_____

5. _____

_____

_____

Name: _____ Date: _____

Article 3

"Safety: As Speed Limits Rise, So Do Death Tolls"

Summarize the main argument of the article:

_____

_____

_____

_____

Identify key points used in this article:

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

4. _____

_____

_____

5. _____

_____

_____

Name: _____ Date: _____

Article 4

"Deaths, Injuries Increase With Higher Speed Limits"

Summarize the main argument of the article:

_____

_____

_____

_____

Identify key points used in this article:

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

4. _____

_____

_____

5. _____

_____

_____

3

Lesson 4

Town Hall Meeting

Should We Reduce Speed Limits?

To the Teacher

In this lesson, students will use the evidence they have collected from their hands-on investigations and their article research to debate whether speed limits should be reduced in the fictitious city of Driversburg.

Objectives

Students will use evidence-based argumentation while engaging in respectful discourse on the controversial issue of whether speed limits should be lowered to reduce traffic accidents.

Time Needed

One class period

Materials

Completed article evaluation sheets and Slip 'n Slide data sheets from prior lessons, pencils.

Procedure

1. Organize students to participate in a town hall meeting to determine if the speed limit should be lowered to help reduce traffic fatalities in Driversburg. Truck drivers and business leaders will argue against the reduction in speed limit, while parents and police officers will argue in favor of the speed limit reduction. The final decision regarding the speed limit will be determined by a secret ballot at the conclusion of the debate.

2. Begin a semistructured debate whereby all groups make an opening statement comprised of one or two claims using evidence to persuade others of their viewpoint. After all four groups have made their statements, allow students to ask questions of other groups' evidence, refute their claims, or bolster their own claims with additional evidence. Students must raise their hands to participate.

3. At the end of the meeting, review your impressions with the students and clear up any misconceptions that may have surfaced during the discussion. Have students now assume the role of the governing body and vote using a secret ballot to determine whether the speed limit should be reduced in Driversburg. Students should vote what they believe, not their stakeholder positions (although these might be the same). Announce the results to the class.

Closure

Discuss the outcome with the students. "Were you surprised by the group's decision?" "Do you still have questions about the relationship between speed and vehicle safety?" "Could we have negotiated a different outcome?" "How does it feel to use evidence to inform decision making?" "Did you change your mind about this issue during the debate?

Assessment

Students write a letter to their town, county, or state department of transportation describing their research results and expressing their opinions on speed limits. Letters can contain additional research on local speed limits and speed-related accident statistics. Letters are assessed on accuracy of data, clarity of expression, persuasiveness of arguments, and format/grammar. Students can also be assessed on participation in all phases of Town Hall Meeting activities (See Town Hall Meeting Participation Sheet).

Name: _____ Date: _____

Town Hall Meeting Participation Sheet

(Place a check "√" in each box as task is completed.)

Student Names	Completed Article Research Sheets	Participated in Stakeholder Group Discussions	Made Evidence-Based Contribution to Town Hall Meeting	Developed a Thoughtful Letter to Department of Transportation	Total (4 "√" Max)
Truck Drivers					
Parents					
Business Leaders					

Name: _____ Date: _____

Student Names	Completed Article Research Sheets	Participated in Stakeholder Group Discussions	Made Evidence-Based Contribution to Town Hall Meeting	Developed a Thoughtful Letter to Department of Transportation	Total (4 "√" Max)
Police Officers					

3

Letter Scoring Rubric

Did the letter state the student's opinion on the issue of speed limits?	____ 5 pts.
Did the letter provide at least five specific facts and/or statistics learned from this unit?	____ 15 pts.
Was the letter accurate?	____ 5 pts.
Was the letter clear?	____ 5 pts.
Was the letter persuasive?	____ 5 pts.
Does the letter contain proper grammar and structure?	____ 5 pts.

Total Pts. ____/ 40

Index

*Page numbers printed in **boldface** type refer to tables or figures.*

IT'S DEBATABLE!

USING SOCIOSCIENTIFIC ISSUES TO DEVELOP SCIENTIFIC LITERACY K–12

This book encourages scientific literacy by showing you how to teach the understanding and thinking skills your students need to explore real-world questions like these:

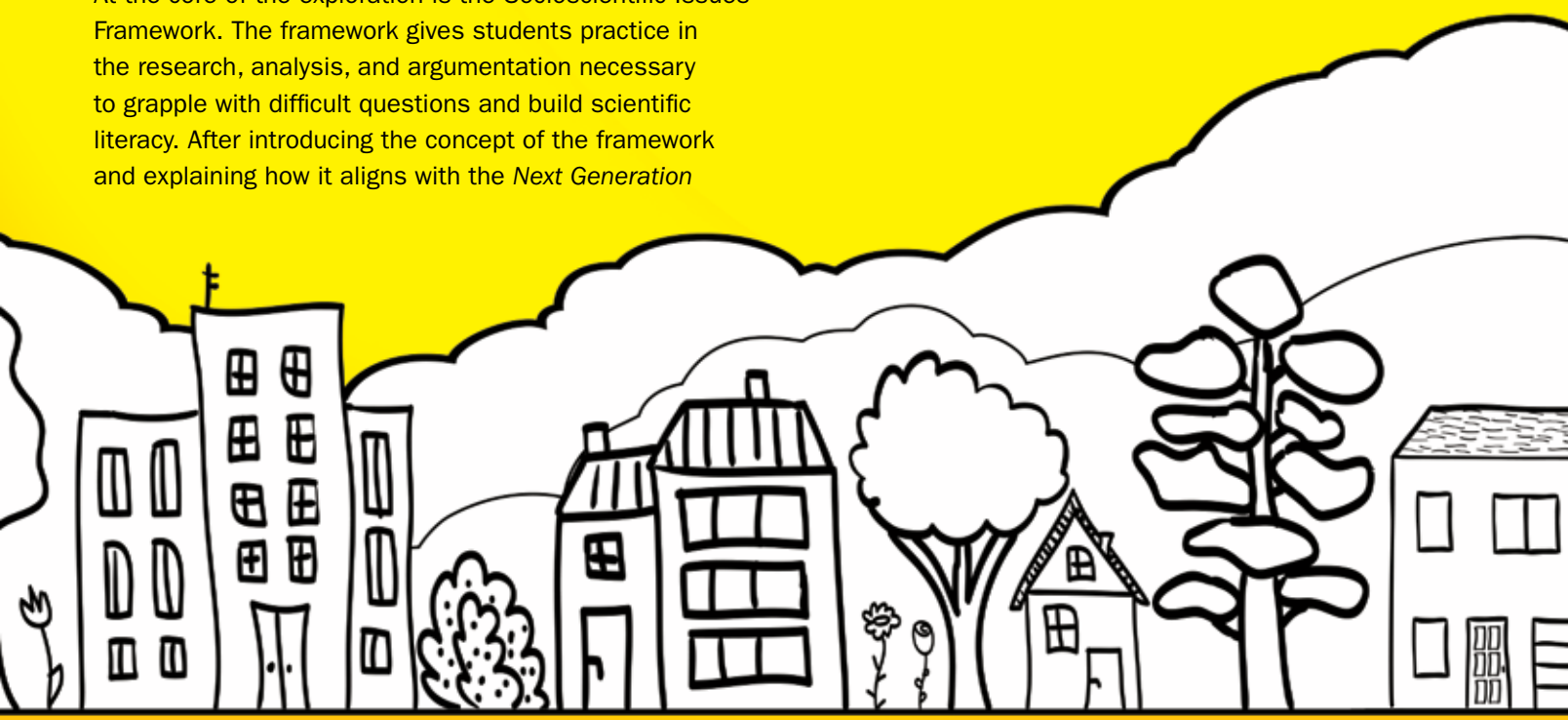
- Should schools charge a "fat tax" to discourage kids from eating unhealthy foods?
- Should local governments lower speed limits to reduce traffic fatalities?
- Should pharmaceutical companies be allowed to advertise prescription drugs directly to consumers?

At the core of the exploration is the Socioscientific Issues Framework. The framework gives students practice in the research, analysis, and argumentation necessary to grapple with difficult questions and build scientific literacy. After introducing the concept of the framework and explaining how it aligns with the *Next Generation Science Standards*, the book shows you how to implement it through seven units targeted to the elementary, middle, and high school levels. You even find out how to develop your own socioscientific issues curriculum.

"Functional scientific literacy requires an understanding of the nature of science and the skills necessary to think both scientifically and ethically about everyday issues."

—from the introduction to *It's Debatable!*

Both practical and content-rich, *It's Debatable!* doesn't shy away from controversy. Instead, the authors encourage you and your students to confront just how messy the questions raised by science (and pseudoscience) can be. After all, as the authors note, "The only way for our students to be prepared for participation in societal discourse is to have practice in their school years, and what better place than the science classroom?"



Grades K–12

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