Let’s Power Our Future: Integrating science and social and emotional learning improves collaborative discourse and science understanding.

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Published in August, 2019

Acknowledgement. The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A150272 to the University of Virginia (PI: Sara Rimm-Kaufman). The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education. The authors appreciate the important contributions of Tracy Harkins, Kristen Jones, Rebecca McGregor and the many teachers and students who have contributed to Connect Science. For questions, please contact Sara Rimm-Kaufman at serk@virginia.edu.

Rimm-Kaufman, S., & Merritt, E. (2019). Let's Power Our Future: Integrating science and social and emotional learning improves collaborative discourse and science understanding. *Science and Children*, *57*(1), 52-60.

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Citizens in the 21st century need to be able to solve energy problems that our world faces today. Trade-offs between human energy needs and conservation of natural resources are important for people of all ages to understand (U.S. Department of Energy 2014). Decisions about energy use are prime examples of "wicked problems" because they do not have a single, simple solution—each stakeholder has different ideas about the problem and best solutions (Rittel and Webber 1973).

As the United States faces energy problems at a national scale, our team has been working with teachers to help fourth-grade students learn and communicate about energy sources, consider the pros and cons of different sources, and make recommendations for future resource use. We trained fourth-grade teachers in Connect Science (2019), a new curriculum based on the KIDS as Planners Framework (Kids Involved Doing Service-Learning [KIDS] 2011). Connect Science is a comprehensive unit that includes lessons on science, social and emotional learning, and civic engagement. (See www.connectscience.org.) Teachers teach lessons about energy, electricity production, and renewable and non-renewable resources; provide instruction in social and emotional skills; and engage in an energy-related service-learning project (see Internet Resources).

In this article, we share a sequence of lessons that teachers thought were especially useful to produce effective science discourse and promote student understanding. The first lessons teach social and emotional skills. The later lessons teach about energy sources and systems, requiring students to apply their social and emotional skills to conversations about energy sources. Taken together, students learn about different energy sources, how these sources can be used to produce electricity, and the advantages and disadvantage of each source (ESS3.A and PS3). The lessons create the opportunity for students to Engage in Argument from Evidence (SEP 7) and Obtain, Evaluate, and Communicate Information (SEP 8). Here, we highlight a few main features of these lessons so science teachers can picture how they can work in their classrooms. The full lessons are available online (see NSTA Connection).

Why is Effective Science Discourse Important?

Talking about science helps students develop and construct their own understanding of scientific ideas (Hackling, Smith, and Murcia 2010). Effective collaborative discourse in science

requires more than just knowing science vocabulary words. Students need to use scientific language as they talk and reason about ideas (Lemke 1990). This can be challenging because it requires good tasks that lead to discussion about important ideas, strong communication skills among students, teacher facilitation and monitoring, and enough time for student discussion.

There are two main ideas to keep in mind when facilitating effective collaborative discourse (Mortimer and Scott 2003). One idea contrasts dialogic versus authoritative talk. Dialogic conversation values many ideas whereas authoritative values only one point of view. The second idea compares interactive versus non-interactive talk. Interactive conversation involves many voices whereas non-interactive conversation privileges a single voice, typically the teacher's voice. Conversations about energy sources can spark dialogic and interactive conversations because there is no one right answer and every energy source has advantages and disadvantages. The information can be made accessible so that fourth graders can voice an opinion based on evidence.

Effective collaborative discourse differs from the more common I-R-E discussions in which the teacher **i**nitiates with a question, the student **r**esponds with an answer, and then the teacher **e**valuates the response (Mehan 1979). I-R-E talk focuses on a single right answer and does not leave room for students to talk with each other. In contrast, ideal discussions about various energy sources are interactive and dialogic. The shift away from I-R-E and toward interactive, dialogic discussion requires teachers to facilitate students' exploration of concepts and discussion of ideas, even when students look to their teacher expecting one right answer.

One step toward breaking the I-R-E habit is to teach active listening, show students respectful ways to disagree, and prepare students for the idea that other students may bring ideas that are different from their own in science class. Then, students are ready to have conversations with each other about complicated topics like energy use. Disagreement is common as scientists and policy-makers address wicked problems. The same is true with fourth graders as they debate the pros and cons of different energy sources and make recommendations for energy sources they would like to see used in the future. The end goal of a productive science discussion is for students to be able to understand and talk about the scientific ideas, better understand others' perspectives, and come to an agreement and recommendation for action that takes everyone's ideas into account (Driver, Newton, and Osborn 2000). Social and emotional skills are essential to achieve this goal.

The teachers we worked with taught students social and emotional skills early in the year to provide a foundation for effective collaborative discourse in science. By the time the teachers taught the science lessons on energy sources, students had practiced their social and emotional skills and were ready to apply them. At the start of the science lessons, the teachers reminded students to use their newly-honed skills to produce effective collaborative discourse.

All students can benefit from learning social and emotional skills. For example, students with autism benefit when the strategies for social interactions are clear and concrete (White, Keonig, and Scahill 2007). Students with disabilities need extra rehearsal and practice of these skills (Elias 2004). Table 1 offers some ideas to keep in mind when teaching social and emotional skills. Below, we describe these lessons in action.

Lesson on Active Listening

In a lesson on active listening, one teacher modeled the behaviors that she wanted her students to show. She asked a student to tell her a short story about something that happened recently. She nodded, made eye contact and showed interest. Then, she asked the class, "What did you notice about my body as I listened to my friend's story?" Students responded, "I noticed that you were looking at your friend" and "I noticed that you were quiet while your friend was talking." She used a visual aid to show what her eyes, ears, mouth, brain, and heart were doing as she listened actively (Figure 1). Students partnered up with someone sitting next to them and practiced active listening so that they were really clear on the actual behaviors they needed to show as they listened carefully to others' ideas. The teacher assessed students' use of active listening by monitoring students while they worked in pairs and by noticing signs of active listening throughout the day and week.

Lesson on Respectful Communication

A few days later, the teacher taught a lesson on respectful communication. The goal was to teach students to show respect while arguing about evidence. The lesson began by introducing the notion that conflict is a normal and healthy part of science conversation. Then, the teacher used a short activity to teach students that disagreement is common when people really care about their ideas. She asked students to indicate agreement or disagreement with statements such as, "Group members always have to agree with each other" and "There is a respectful way to tell someone that you disagree with them." The teacher reflected on students' responses and mentioned the importance of having everyone talk about their ideas, not just the one or two

people who like to talk a lot. The teacher explained that when people work together, they need to show respect when they disagree.

The teacher introduced sentence stems to teach respectful communication. First, she asked the students to generate words that they use when they agree with an idea. She used the student ideas to generate sentence stems that she wrote on chart paper. Examples included: "I agree with …. and I think that …." And, "I thought about it in a similar way and I think …." The teacher modeled how she might use the sentence stem, "I agree with Maggie and I think that chocolate ice cream tastes better than vanilla." (She intentionally started with sentence stems that weren't about science so that the students could focus on using the sentence stems in the simplest possible way.) Then, the teacher followed the same procedures to generate and practice sentence stems to use when they disagreed or wanted to ask questions to understand another person's perspective. Figure 2 shows example sentence stems. Students practiced the sentence stems in pairs. With practice, the teacher noticed that the students adapted the sentence stems so they sounded like natural (yet respectful) fourth-grade language. The students became comfortable agreeing and disagreeing respectfully and this set the stage for effective science discourse. See Figure 3.

Lesson on Respecting Multiple Perspectives

The teacher read and discussed the book *The Sandwich Swap* (Queen Rania of Jordan & DiPucchio, 2010) during morning circle. The book is about two girls who had different opinions about sandwiches. It describes how the girls disagreed initially but then learned to respect each other's perspectives. After reading the book, the class reflected on situations they've experienced in their classroom when people disagreed or had different points of view. Some examples were general, such as "I am a vegetarian" and "I speak Spanish at home," and some were energy related, such as "My family takes the bus around town" and "When I am cold at home in winter, I put a sweater on instead of turning up the heat" (see Figures 4 and 5). Then, the class discussed what questions someone could ask to learn more about someone's perspective and what someone could say and do to show respect for someone else's opinion. The teacher linked back to the book and the class discussed the challenges that arise when you try to understand someone who has a perspective that differs from yours. Further, the teacher incorporated ELA Common Core Standards (SL 4.1, 4.3, 4.4) into this discussion (see Figure 4 and 5).

Lessons on Evaluating Different Sources of Energy

The teacher taught lessons on renewable and non-renewable resources earlier in the science unit using materials from the NEED Project and U.S. Energy Information Administration (see Internet Resources). Now, students were ready to debate and discuss energy sources and make recommendations for how we should power our country in the future. The teacher showed a video about energy sources (Student Energy 2015). After the video, the teacher reviewed new words from the video and introduced other terms related to energy sources (i.e., *renewable resources, non-renewable resources, solar, wind energy, hydropower, biomass, coal, natural gas, petroleum, nuclear*). The students wrote their own definitions and drew a sketch for each word to reinforce conceptual understanding. Some students needed scaffolds such as key words to use in their definitions. For English learners, the teacher asked students to generate pictures of the concepts with a few words to represent the idea and demonstrate their emerging understanding. The student-constructed definitions served as formative assessments of student understanding. As students constructed their own definitions, naïve conceptions that needed to be addressed became clear. Teachers revisited vocabulary, as needed, and encouraged students to use the words in context in later lessons.

In the next lesson, each student received a set of flash cards that described and illustrated common sources of energy, which provided another opportunity to apply and work with concepts (Figure 5). First, students sorted the energy source cards into two groups: renewable and nonrenewable. This task required students to synthesize previously learned ideas about each source and served as another formative assessment to help the teacher see whether students understood which energy sources were renewable.

The next day, students were ready to build upon their understanding using both higher order thinking and social and emotional skills. Students were given a table that outlined pros and cons for each energy source (Figure 6). The teacher prepared them for differences in opinions, as described below.

Teacher: “You’re going to talk with your neighbor about your top two choices for energy use in the future. I want you to talk about why you chose them. Now, if Avery and Maria choose different energy sources, how should they speak to each other about those energy sources?

Student: “I respectfully disagree with whatever…”

Teacher (nodding): So respectful communication is important. Maybe Avery thought long and hard about her choice and so Maria needs to be respectful of her. Can you listen and care about what someone says, even if you disagree with it?

Class: “uh-huh” “yes.”

T: Great, I want to hear respectful conversations happening in the next few minutes.

Students worked in small groups to analyze and discuss pros and cons of each energy source. As they read about each energy source, they ranked which sources they think should be used more in the future (50 years from now; see Figure 7.) The teacher anticipated that students might turn to her, expecting that she would tell them the correct answer. She told students that there were no right or wrong answers, but that they should be ready to explain the evidence they used to make decisions.

In each group, the students talked and listened to each other about which energy sources they thought were best and why. The teacher reminded the students to use active listening and respectful communication as they discussed and debated about their favorite energy source for the future. (This exercise can be adjusted for English Learners by giving students just four or five energy options instead of eight.)

Here is a sample conversation among four students about their *least* favorite energy source:

Student 1: Okay, well, I think the one we should use the least is coal.

Student 2: I think we should use less coal because it takes so many years to have the coal.

Student 3: It says right here that there is a lot of coal in the ground in the United States.

Student 2: Yes, but a lot of people get hurt mining it and….

Student 4: It takes a lot of plants a long time to get more coal.

Student 2: Coal wouldn’t be so bad if it wasn’t so dangerous to get.

This conversation shows science understanding, back-and-forth conversation among students, use of the evidence, understanding of pros and cons of coal, and differences in opinion in what matters most to them in their decisions.

At the end of the lesson, the teacher gathered the whole class together and shared a graphic that showed current energy sources used in the United States (Figure 8). She asked the students to discuss the chart with one another and tell whether the sources they liked best are being used much in our country. As the teacher listened to students’ responses, she reminded students that there is

more than one right answer and that each energy source has trade-offs. The teacher stated, "I noticed some ties on what you think is the most important energy source to use. And, that's okay, too, because as a country, we don't just use one energy source. We use lots of different sources."

Students noticed that the current U.S. energy sources did not match up with what they hoped to see in the future and realized that the U.S. uses a lot more non-renewable than renewable energy sources. One student observed that most of the energy that we use is non-renewable. Another student commented on how little solar energy we use in the U.S. This raised new questions as students began thinking about how our energy sources affect the environment, as described in the example below:

> Student 1: At first I said petroleum, but then I changed to hydropower.
>
> Teacher: So why did you change from petroleum to hydropower?
>
> Student 1: Because it says on the card that the oil spills can impact the ecosystem so if oil gets in the animals it can get into our food.
>
> Teacher: Yes, oil spills can endanger our food supply.

The students had different opinions about energy sources, which mirrored diverse opinions in society today. Some disagreements occurred because energy sources have trade-offs and there are no clear or simple answers. At the end of the lesson, the teacher gave students an open-ended question about energy sources that students answered in writing as part of the summative assessment for the unit. Students were asked, "Which renewable energy source do you think we should use more in the future? Why?" Students shared many different ideas about which renewable energy sources should be used more in the future and why. See example student responses in Figure 9. The teacher evaluated the student explanations based on students' use of evidence and the accuracy of the explanation.

Benefits of Integrating Social and Emotional Learning and Science to Improve Collaborative Discourse

By fourth grade, students can advance new ideas, compare and refine arguments, give and receive critique on each other's ideas, and debate the merit of various solutions (National Research Council 2012; NGSS Lead States 2013). Discussing energy solutions lends itself to effective science discourse that is both dialogic and interactive. Ideally, we want students to argue about scientific ideas and form their opinions based on evidence while also listening carefully to other's explanations and showing caring, kindness, and respect for one another. Most

fourth graders do not come to science with the social and emotional skills to engage in effective science discourse. So, it's helpful to teach and cultivate these skills before asking students to use them in class discussions.

Students love opportunities to discuss ideas with other students in their classrooms, but too often their lack of social and emotional skills interfere with collaborative learning. *A Framework for K–12 Science Education* reminds us that "science is fundamentally a social enterprise, and scientific knowledge advances through collaboration and in the context of a social system with well-developed norms" (NRC 2012, p. 27). Explicit lessons in active listening, respectful communication, and understanding multiple perspectives can create a foundation for high quality science discourse and productive science learning. Science teachers can try out these lessons that give students practice engaging in collaborative scientific discourse about controversial issues. With practice, students will be ready to tackle the complex problems that they encounter in the future.

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NSTA Connection

Download a complete lesson plan at *www.nsta.org/SC0819*.

Internet Resources

Connect Science

www.connectscience.org

NEED Project

www.need.org

Renewable Energy

www.youtube.com/watch?v=T4xKThjcKaE

U.S. Energy Information Administration
www.eia.gov/kids

References

Harkins, T., Merritt, E. G., Rimm-Kaufman, S. E., Hunt, A. & Bowers, N. (2019). *Connect Science Energy Manual.* Unpublished Manual: The University of Virginia, Arizona State University and Harkins Consulting.

de Jong, T. 2010. Cognitive load theory, educational research, and instructional design: Some food for thought. *Instructional Science* 38 (2): 105–134. doi:10.1007/s11251-009-9110-0

Queen Rania of Jordan & DiPucchio, K. *The Sandwich Swap.* New York: Disney Publishing Worldwide.

Driver, R., P. Newton, and J. Osborne. 2000. Establishing the norms of scientific argumentation in classrooms. *Science Education* 84 (3): 287–312.

Elias, M.J. 2004. The connection between social-emotional learning and learning disabilities: Implications for Intervention. *Learning Disability Quarterly* 27 (1): 53–63.

Hackling, M., P. Smith, and K. Murcia. 2010. Talking science: Developing a discourse of inquiry. *Teaching Science: The Journal of the Australian Science Teachers Association* 56 (1): 17–22.

KIDS Consortium 2011. *KIDS as Planners.* Lewiston, ME: Harkins Consulting.

Lemke, J.L. 1990. *Talking science: Language, learning, and values*. Norwood, NJ; Ablex Publishing Corporation.

Mehan, H. 1979. 'What time is it, Denise?": Asking known information questions in classroom discourse. *Theory into Practice* 18 (4): 285–294.

Mortimer, E., and P. Scott. 2003. *Meaning Making in Secondary Science Classrooms.* Berkshire, England: McGraw-Hill Education.

National Research Council (NRC). 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, D.C.: National Academies Press.

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By State*s. Washington, DC: National Academies Press.

Rittel, H.W., and M.M. Webber. 1973. Dilemmas in a general theory of planning. *Policy Sciences* 4 (2): 155–169.

U.S. Department of Energy. 2014. Energy literacy: Essential principles and fundamental concepts for energy education. Washington, DC: U.S. Department of Energy.

White, S.W., K. Keonig, and L. Scahill. 2007. Social skills development in children with autism spectrum disorders: A review of the intervention research. *Journal of Autism and Developmental Disorders* 37 (10): 1858–1868.

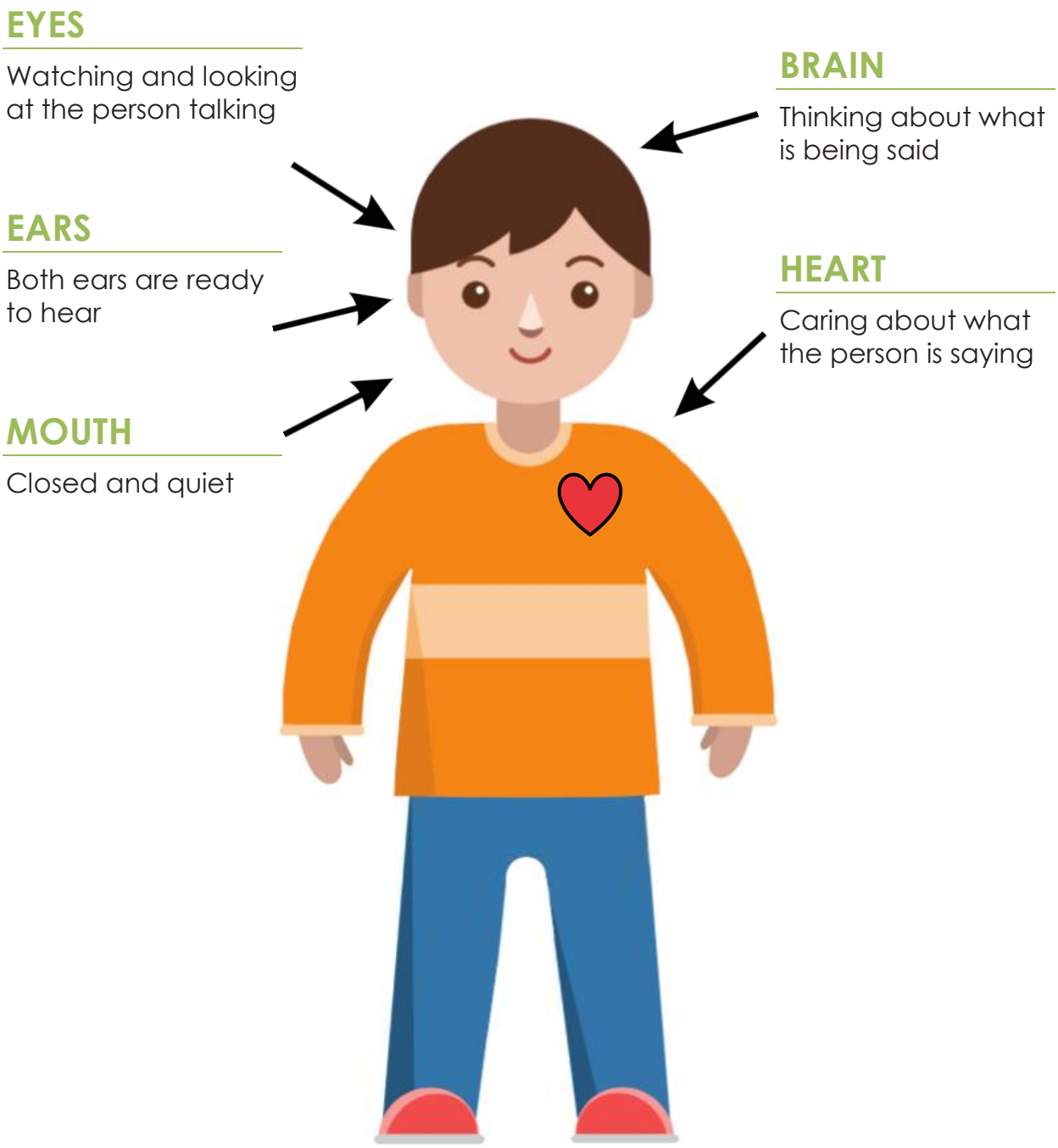


Figure 1. Visual aid to introduce active listening.

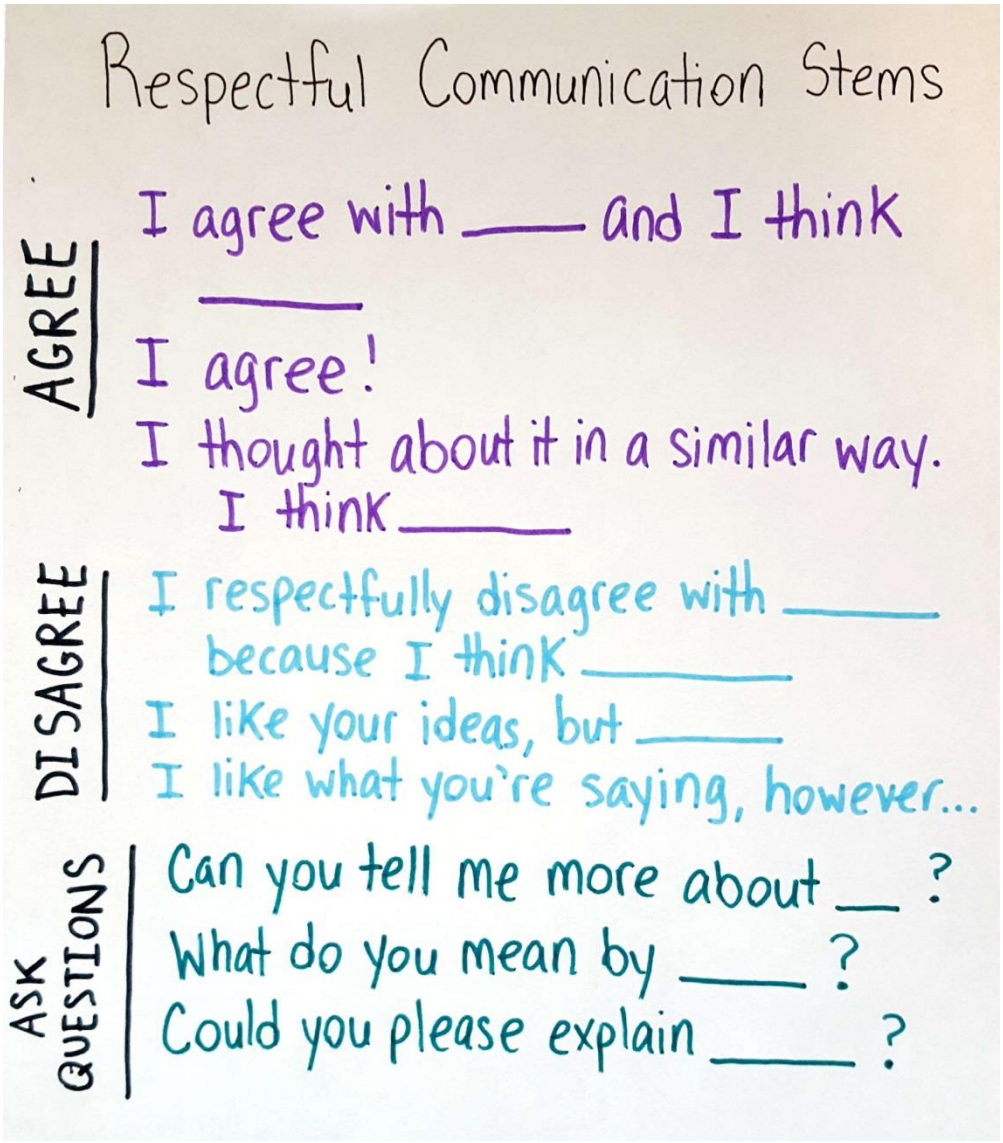
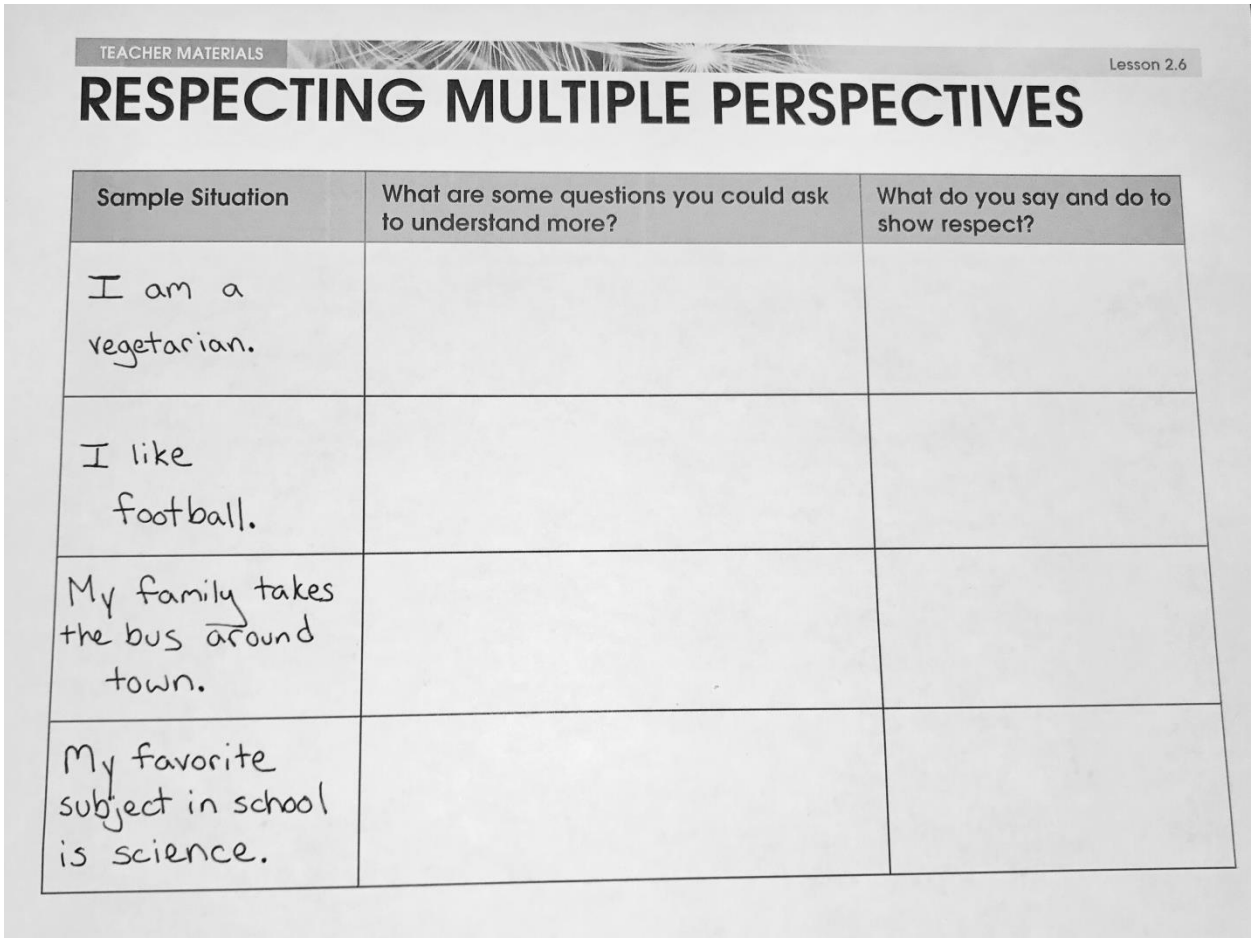


Figure 2. Example sentence stems for "agreeing" and "disagreeing" in a fourth grade classroom.

Figure 3. Example of teacher teaching students social skills *prior* to expecting students to use and apply these skills to science instruction.



TEACHER MATERIALS

Lesson 2.6

RESPECTING MULTIPLE PERSPECTIVES

Sample Situation	What are some questions you could ask to understand more?	What do you say and do to show respect?
I am a vegetarian.		
I like football.		
My family takes the bus around town.		
My favorite subject in school is science.		

Figure 4. Example of a Respecting Multiple Perspectives chart.

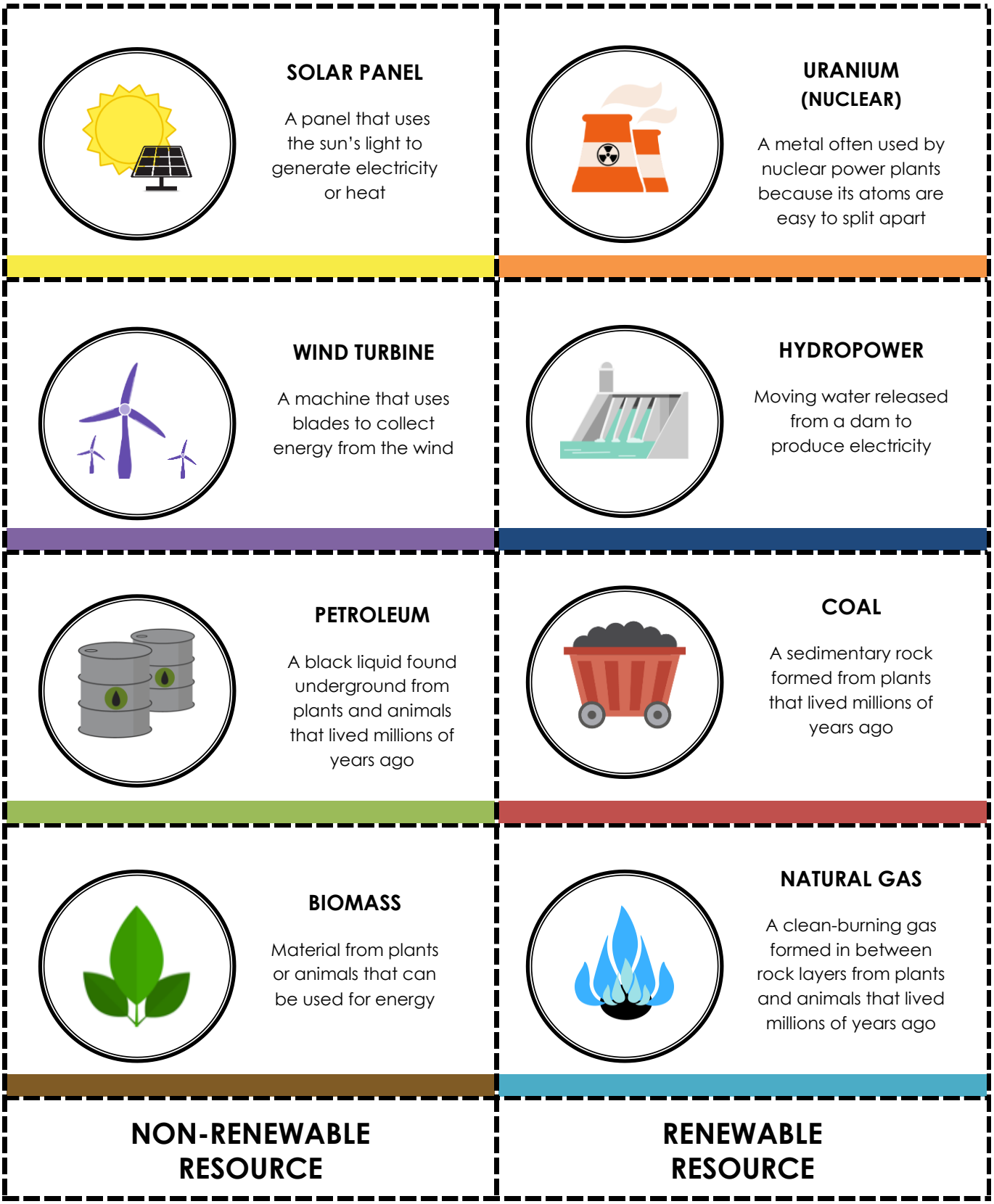


Figure 5. Flash cards that describe and illustrate common sources of energy.

	PROS	CONS
BIOMASS	• Renewable • Reuses materials like manure, leftover wood and crops that might not be used for other things	• Releases carbon dioxide when burned • Leftover ash after burning needs to be treated carefully so that it does not pollute water
COAL	• Inexpensive • There is a lot of coal underground in the United States • Many coal power plants are already built	• Non-renewable • Releases carbon dioxide when burned • Leftover ash after burning needs to be treated carefully so that it does not pollute water
HYDROPOWER	• Renewable • No air pollution or carbon dioxide emissions	• Dams flood large areas of land and change river ecosystems • Fish cannot migrate unless fish ladders are built
NATURAL GAS	• Inexpensive • Pollutes the air less than coal • There is a lot of natural gas underground in the United States	• Non-renewable • Releases carbon dioxide when burned • Releases another gas called methane into the air when it leaks from wells and pipelines
PETROLEUM (OIL AND GASOLINE)	• Can be used for transportation • Most cars, trucks and that we use today need oil and gasoline • Is used to make other things, like plastics	• Non-renewable • Releases carbon dioxide when burned • Oil spills can damage ecosystems
SOLAR PANELS	• Solar panels do not pollute air or water • The sun is free and shines everywhere	• Sometimes the sun does not shine • Batteries to store solar power are expensive and use minerals that are hard to find
URANIUM (NUCLEAR)	• No air pollution or carbon dioxide released into the air • The supply of uranium will last for a long time	• Non-renewable • Used fuel rods are harmful to people and animals, so they need to be stored carefully underground for a long time
WIND TURBINE	• Renewable • No air pollution or carbon dioxide emissions	• When wind is not blowing, other energy sources must be used, or electricity must be stored in expensive batteries • Birds or bats may be injured by blades

Figure 6. Student handout describing the pros and cons of different energy sources.

Figure 7. Fourth graders using the flashcards to sort energy sources.

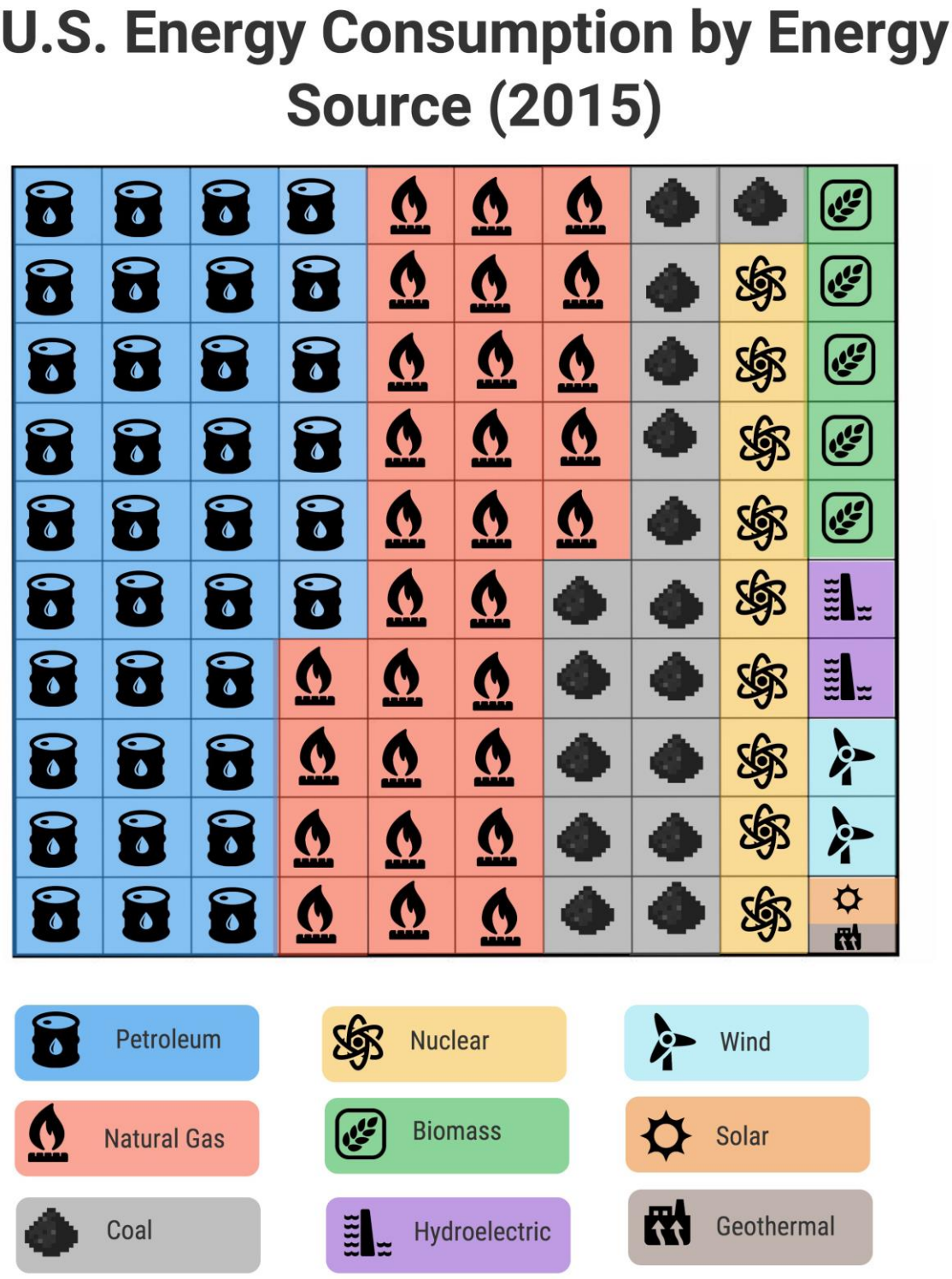
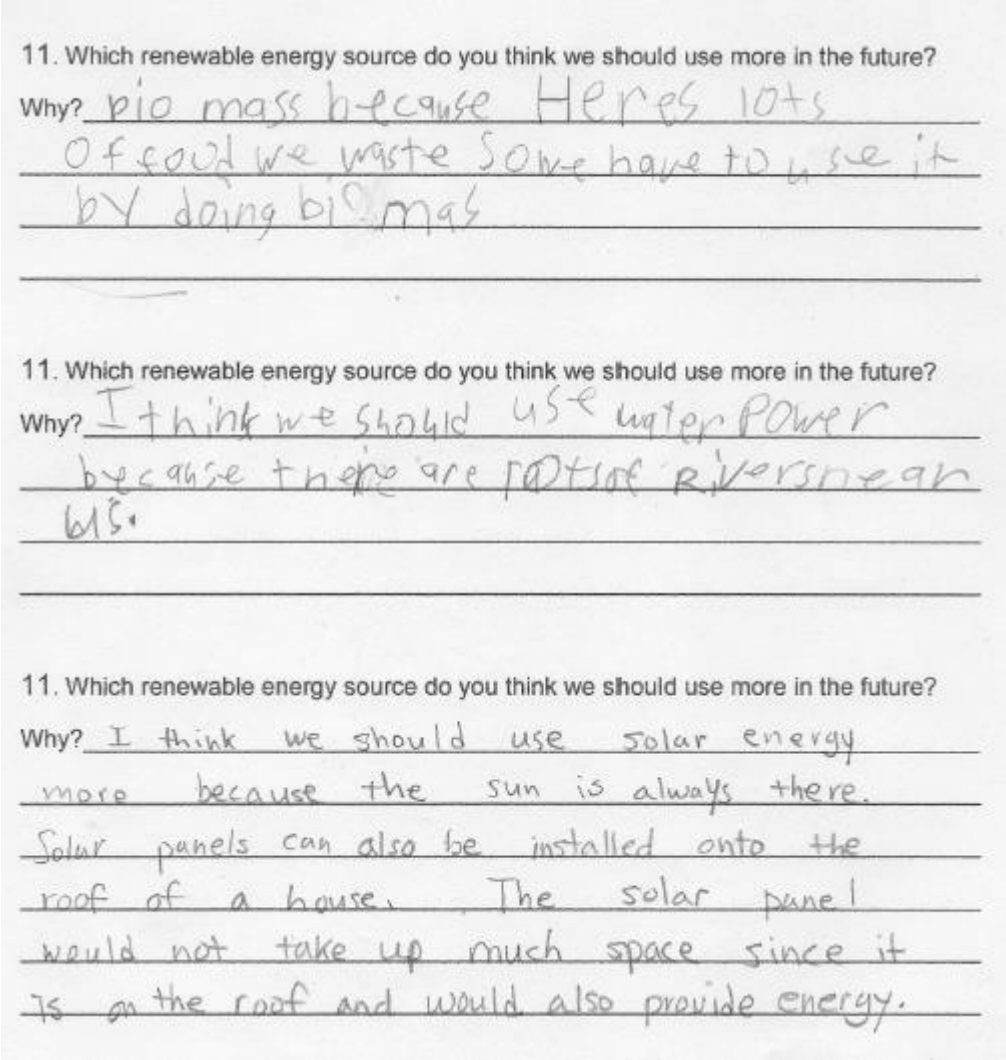


Figure 8. Hundreds chart showing energy sources in the U.S. using data from the U.S. Energy Information Administration.


11. Which renewable energy source do you think we should use more in the future?

Why? bio mass because Heres lots of food we waste Some have to use it by doing bio mas

11. Which renewable energy source do you think we should use more in the future?

Why? I think we should use water power because there are lots of Rivers near us.

11. Which renewable energy source do you think we should use more in the future?

Why? I think we should use solar energy more because the sun is always there. Solar panels can also be installed onto the roof of a house. The solar panel would not take up much space since it is on the roof and would also provide energy.

Figure 9. Students' explanation for choice of hydropower and solar energy.

Table 1. Connections to the *Next Generation Science Standards* (NGSS Lead States 2013):

4-ESS3-1 Earth Systems *http://www.nextgenscience.org/pe/4-ess3-1-earth-and-human-activity* *The materials/lessons/activities outlined in this article are just one step toward reaching the Performance Expectations listed below. Additional supporting materials, lessons and activities will be required.*	
Performance Expectation	**Connections to Classroom Activity** *Students:*
4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment	• read non-fiction text about renewable and non-renewable energy sources, and how the use of each source affects the environment
Science and Engineering Practices	
Engaging in Argument from Evidence	• students construct and support an argument about the need for a specific energy source with evidence
Obtaining, Evaluating and Communicating Information	• exercise relationship skills and social awareness by listening and communicating respectfully, even when people have different views • combine information in written text with information contained in corresponding charts when thinking critically about effective energy sources • communicate scientific information orally when explaining ideas about future energy sources

Disciplinary Core Idea	
ESS3.A: Natural Resources • All materials, energy, and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.	• evaluate the advantages and disadvantage of various sources of energy, considering environmental and social impacts
Crosscutting Concepts	
Energy and matter: Flows, cycles and conservation Systems and system models	• students evaluate various energy sources that function as inputs to power plant systems

Connections to the Common Core State Standards (CCSSO 2010):

SL 4.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 4 topics and texts*, building on others' ideas and expressing their own clearly.

SL 4.3 Identify the reasons and evidence a speaker provides to support particular points.

SL 4.4 Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

Table 2. Important guidelines for teaching social and emotional skills.

1. Establish a positive social climate prior to teaching social skills. Ask students how they would like their classroom to look, sound and feel, and then generate norms or rules with the class that help create a positive classroom climate.
2. Teach social and emotional skills early in the year with follow-up and support throughout the year. Time spent orienting students to these skills early means that they will become integrated into their routine behavior with only occasional reminders from teachers.
3. Break learning social skills into small steps. Learning a new behavior like respectful communication using sentence stems requires students' cognitive resources (e.g., working memory). That means it is best to start with practices on simple examples that do not carry a lot of emotion with them and may not relate to science. Then, get more complex over time (de Jong, 2010). So, for instance, when you are teaching students to use sentence stems to disagree, use noncontroversial content. For instance, it would be better to ask students to use their disagreement sentence stem to discuss, "Which taste better—apples or oranges?" instead of something very complex such as, "Which is a better energy source, coal or wind energy?" or something that may elicit strong opinions, "Which is a better baseball team, the White Sox or Cubs?"