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Multimodal Text Sets to Use Literature and Engage All Learners in the Science Classroom

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To make a prairie (1779)

To make a prairie it takes a clover and one bee,

One clover, and a bee.

And revery.

The revery alone will do,

If bees are few.

(Dickinson, 2000)

Though written over 200 years ago, Emily Dickinson's nature poems, especially about bees, offer not just beautiful language, but also an invitation to pause and wonder about the scientific understanding from her observations. We know that bees are, in fact, needed not just to make prairies but so much more. *Revery* (daydreaming, meditating) may not make a prairie, but perhaps Dickinson is getting at the importance of taking time to pause, look, listen, and think. This revery may help connect literature and science in our classrooms. A

larger question is, what can a poet, novelist, or essayist provide for students' sense-making processes to understand phenomena, or, in other words, "doing science" (Rhodes & Feder, 2014, p. 77).

Reading and writing can help all learners to engage in the science classroom and develop scientific knowledge (Norris & Phillips, 2003). Multimodal text sets are collections of resources from different genres, media, and levels of complexity that are strategically sequenced to build vocabulary, background knowledge, and interest around a particular science topic. The text sets provide scaffolds to support learners in accessing and comprehending complex text in order to meet the expectations of the NGSS (Next Generation Science Standards) and the CCSS-ELA (Common Core State Standards – English Language Arts) or state equivalents. We have found that as teachers implemented multimodal text sets, their learners developed critical thinking, confidence, and engagement (Juergensen et al., 2020). Students also showed statistically significant growth in their ability to develop arguments and support those arguments with evidence and reasoning (Juergensen et al., 2020). Importantly, all learners, including students who may find scientific texts a challenge, students who need support with reading and writing, and students who may need specific instructional supports are able to use instructional scaffolds and content scaffolds to build stamina and background to understand more complex texts.

As teachers, we should provide opportunities for students to learn disciplinary content and develop the skills needed to read texts independently (Buehl, 2011; Schoenbach et al., 2012; Shanahan, 2012). We can better reach all learners by providing instruction using a range of reading materials, including literature along with informational texts.

In the January 2020 *Science Scope* editorial, "Scientific Literacy in the Post-truth Era," Dr. Patty McGinnis encouraged the collaboration of science and English language arts teachers to address the need for students to obtain, evaluate, and communicate information as promoted in the NGSS (McGinnis, 2020). In this world of social media communication, McGinnis stresses the importance of developing students' literacy and critical thinking skills through reading multigenre texts and assessing text credibility and accuracy. Learners should be introduced to appropriate and diverse texts to read, explain, analyze and judge these texts. Multimodal and multigenre text sets support reading complex scientific texts and provide opportunities for students to work with information in a variety of modalities. In the [name of program], we incorporated literary texts into science units on pollination, heat stress, and vaping, thus creating text set models that could then be adapted for other topics within the science curriculum. Such disciplinary integration works well when educators can collaborate, such as in this program that includes English language arts, science, and special education teachers (Juergensen et al., 2020).

Working with a Complex Text: Multimodal Text Sets

Text complexity has gained attention over the years since the Common Core State Standards were developed. While conceptualizations of text complexity vary (Amendum, Conradi, & Hiebert, 2017), we distinguish between *text complexity* and *text difficulty* where text complexity refers to the properties of a text alone, but text difficulty refers to how hard or

easy a text is for a reader (Mesmer, Cunningham, & Hiebert, 2012). We use the criteria set forth in the Common Core State Standards (Council of Chief State School Officers, 2017) to identify and analyze appropriately complex texts for middle grades (see Figure 1). Three main criteria for analyzing the complexity of a text (both *complexity* and *difficulty*) are used: (1) Quantitative analysis in which the text is analyzed to determine the reading level (e.g., grade or age) of the material; (2) Qualitative analysis in which the “demands” of the text are identified for vocabulary, background knowledge, meaning or purpose, and text structure; and (3) Reader and Task Considerations such as the unique backgrounds, interests, motivations, and needs of a reader. And, each text provides unique purposes, audience expectations, and context.

Analyzing text complexity and difficulty through these criteria can guide the teacher in making appropriate instructional decisions based on student needs. Multimodal text sets from different genres, media, and levels of reading difficulty, strategically sequenced to build vocabulary and knowledge, become tools to help students meet the expectations of the standards. There are many ways of organizing multimodal text sets. For the [insert name] program, the topic of a text set is determined by the **anchor text**. The anchor text is the focus of a close reading with instructional support. The number of subsidiary texts, materials and resources, what we call **scaffolds**, can vary depending on the dimensions (the science or engineering practice, the disciplinary core idea, and the crosscutting concept) for a given topic (see Figure 2). Each anchor text that has been developed includes connections to the various Science, Technology, Engineering, and Mathematics (STEM) disciplines.

What is important is that all the scaffolds in the set are connected meaningfully to each other to support students in building vocabulary and knowledge to deeply understand the anchor text. In a sense, the texts and materials *talk to one another* so that in reading the set, students build a coherent body of knowledge around a topic. For instance, a poem may introduce a topic as teachers implement instructional scaffolds to start building background knowledge and engage students in forming questions. Students may read a range of articles, content scaffolds, that span a variety of grade levels but that are carefully selected to continue building background knowledge. During the reading of these, students are guided to locate and analyze key vocabulary and concepts, to find evidence presented in articles, and to analyze text features in scientific articles. See Figure 3 for further information as to the features of a strong text set.

As Figure 3 describes, a strong text set includes a range of text types such as literary and informational text. In the next section we provide literary text examples from three different text sets, each based on a unique anchor text and topic. For each of these three topics and anchor texts, we describe it and provide example scaffolds (text set and inquiry experiences) used to help address complex demands of the text with all learners in mind (see Figure 4 for an overview). As they are developed, the anchor texts and text sets are available at the program website: (include program link or place in references only).

“Flight of the Bumblebee” Multimodal Text Set

The anchor text for one of our multimodal text sets, “Flight of the Bumblebee” (FOTB), was adapted from a peer-reviewed scientific article (Miller-Struttman et al., 2017)¹. This middle grade-level complex anchor text has a Lexile of 1020 (range 900–1105; 6th-8th grade) and, when analyzed qualitatively, involves various demands including: subject matter knowledge, (i.e., pollination, acoustic monitoring), academic language (i.e., correlate, hypothesize), sentence structure (i.e., “While we are accustomed to using sound waves to carry messages – with the radio and our cell phones, for instance, sound waves also are used to gather information about organisms”), and graphs. Given the complexity of the text, many readers may struggle to engage in the text and understand the content.

As an introduction to the anchor text, teachers may use two scaffolds in the FOTB text set, Figure 4: the poem “To Make a Prairie” by Emily Dickinson (2000) and an instrumental orchestral interlude *Flight of the Bumblebee* by Nikolai Rimsky-Korsakov (2004). After reading the poem, listening to the interlude, and displaying images of bees, students write in their journal and share based on the following prompts:

- How do hearing and seeing help you understand and describe the sounds made by bees?
- What is Emily Dickinson saying about bees and what bees do? How necessary are bees?

Finally, students draw a wave model of the sounds of bees, label and describe the key features, and share with a partner how these features reflect what they hear and imagine. These scaffolds allow students to question, build awareness, and gain some background knowledge with multimodal texts (audio and written text) at the start of a learning cycle, and before the anchor text is read.

Another scaffold in the text set is a picture book titled *Flowers are Calling* by Rita Grey. Prior to reading, the teacher shares the book cover and title with the students and asks what they think the title means. The following questions are posed before reading the book, and the students are asked to jot down any notes while the book is being read aloud:

- What is the author’s purpose?
- What is something new you learned from this book?
- How does this book add to what you already learned?
- What new questions does it raise?

After reading, students share their notes with each other. Not only does utilizing a literary text allow students to experience a different genre to build their vocabulary and background knowledge, but they also love participating in a read aloud! Figure 5 provides one teacher’s adaptation of these literary texts as shown in one lesson that was part of her FOTB unit.

¹Adapted from “Flight of the Bumble Bee: Buzzes Predict Pollination Services,” by N. E. Struttman, D. Heise, J. Schul, J. C. Geib, & C. Galen, 2017, *PLoS One*, 12(6), e0179273. Adapted with permission.

Flight of the Bumblebee Lesson: The Flowers are Calling

Connecting to the Next Generation Science Standards (NGSS Lead States 2013)

Figure 6 connects the examples provided in the *Flight of the Bumblebee* text set with the NGSS, within a unit on Ecosystems, 8th grade Life Science.

“Earth and Human Body Systems” Multimodal Text Set

The anchor text for this text set was developed from a peer-reviewed published paper (Steinweg & Gutowski, 2015)² and addresses the concerns of increased temperatures leading to more heat stress on the human body. It was adapted for middle school learners (grades 6–8) taking into consideration NGSS standards, state Science and Language Arts Learning Standards (MLS), and CCSS-ELA.RST. The Lexile of the anchor text is 1060 (6th-8th grade). Based on the qualitative analysis, the text is rich with knowledge requirements including: scientific terms related to subject matter knowledge, (i.e., climate, climate models, heat stress, sickle cell anemia), academic language (i.e., projections, determine, hypotheses), sentence structure (i.e., “To study the daily and monthly weather, properties of the atmosphere such as the temperature, humidity, precipitation [rain or snow], wind speed and air pressure are measured”), and figures and graphs. One of the scaffolds is the poem, “Heat,” by Hilda Doolittle (1915), which uses imagery and simple language to illustrate the impact of heat. The poet creates the sense of the severe heat when the air feels thick, and the poet is calling out to the wind for help:

“O wind, rend open the heat, cut apart the heat, rend it to tatters.”

Though many students may already have experiences with severe heat, the poem helps to personify “Heat” and can engage students in the topic before they start reading other informational texts, leading to the anchor text.

Another text example is a biography of a scientist who studied Sickle Cell anemia: *Doris Wethers Oral History*. In the biography, Dr. Wethers, an African American scientist, narrates her clinical and research experience to Joseph Dancis, a doctor at New York University. Students create a timeline to trace the discovery of sickle cell anemia, including the National Sickle Cell Anemia Control Act in 1972 and establishment of government clinics to screen and counsel patients. The students identify the importance of research in this area, address the shocking statistics about its effects (i.e., 50% of children with sickle cell anemia died before they were 20 years old), and show how this evidence led to policy changes. Furthermore, this biography highlights pioneering scientists, such as Dr. Doris Wethers.

Fiction and literary texts enrich students’ background knowledge about weather and climate change by providing different perspectives. In the short story from India, “Horegallu,” by Sudha Murty, students identify ways people in other parts of the world handle heat.

²Adapted from “Projected Changes in Greater St. Louis Summer Heat Stress in NARCCAP Simulations,” by C. Steinweg and W. J. Gutowski, Jr., 2015, *American Meteorological Society*, 7, p. 159–168 (I159DOI: [10.1175/WCAS-D-14-00041.1](https://doi.org/10.1175/WCAS-D-14-00041.1)). Adapted with permission.

Horegallu is an Indian word which means a big stone that bears weight, and it is usually under trees. The story elaborates how the horegallu offers rest in the shade for the Indian travelers and the villagers during heatwaves. Similarly, *Same Sun Here*, a novel by Neela Vaswani and Silas House, provides another window for adolescent learners to view climate issues. In this novel, Meena, an Indian immigrant girl living in New York City’s Chinatown, and River, a Kentucky coal miner’s son, are pen pals who share their thoughts and experiences about life, including environmental and social stresses. As students read the short story or novel, they write to the following questions:

- What is the environmental challenge addressed in the text?
- How are humans and the environment affected?
- What questions do you have as you think of these environmental challenges?

From these texts, students connect the more regional issues presented in the anchor text to a wider perspective about the impact of climate on earth and human systems.

“Vaping: Not for the Young at Heart!” Multimodal Text Set

The anchor text, “Not for the Young at Heart!”, is derived from two peer reviewed articles (Moheimani, et al, 2017; Middlekauff, 2019)³ that were adapted for middle school learners. The text describes a study examining the effects of electronic cigarettes (with/without nicotine) on the cardiovascular system. The anchor text addresses the NGSS (or state equivalent) standards and practices relating to the structures and functions of organisms and the ELA/literacy Common Core State Standards. This grade-level complex text has a Lexile range of 1010–1400 (6th–8th grade) and when analyzed qualitatively, involves various demands including: subject matter knowledge, (i.e., parasympathetic and sympathetic nerves, cardiovascular system, heart rate), academic language (i.e., randomized, significance), a scientific study structure (i.e., summary, introduction, methods, results), and graphs.

One scaffold, *Beneath a Meth Moon* written by Jacqueline Woodson, depicts the addiction journey of a teenage girl. The author illustrates the phases of addiction: the experiences leading to addiction, the life of an addict, and the rehabilitation. While reading the novel, students compare and contrast the protagonist’s physical health, mental health, and relationships throughout the phases of addiction. In their journals and follow-up discussions, students are asked the following:

- What physical changes occur to the protagonist during her addiction?
- What mental health changes occur to the protagonist during her addiction?
- Describe the protagonist’s relationships before, during, and after her addiction.

³Adapted from “Cardiovascular Impact of Electronic-cigarette use,” by H. R. Middlekauff, 2019, *Trends in Cardiovascular Medicine* (doi: [10.1016/j.tcm.2019.04.006](https://doi.org/10.1016/j.tcm.2019.04.006)) and from “Increased Cardiac Sympathetic Activity and Oxidative Stress in Habitual Electronic Cigarette Users: Implications for Cardiovascular Risk,” by R. S. Moheimani, M. Bhetraratana, F. Yin, et al., 2016, *JAMACardiology*, 2(3), p. 278–284 (doi: <https://doi.org/10.1001/jamacardio.2016.5303>). Adapted with permission.

- What environmental factors affected the protagonist’s addiction journey? These questions require students to examine the changes one experiences within addiction and substance abuse.

After reading the novel, students explore the impact of substance abuse on organisms. This inquiry activity facilitates the formation of connections between the protagonist’s story and the biological effects of substance abuse. To study this phenomenon, students observe the immediate effects when they administer nicotine to planaria (flatworms) and observe the negative reaction to the substance. Additionally, over a period of time, students compare the growth of a planaria receiving nicotine to a planaria not receiving nicotine. These scaffolds enable students to witness the journey of addiction, while expanding their knowledge of the effects of substance abuse on the human body systems. This planaria study is an example of connecting the reading of literature (a fictional account of meth addiction) and using science to understand the phenomena.

Additional texts help scaffold the content of this unit. The novel *Because of Winn Dixie* is about a child dealing with a mother’s alcoholism. This novel could be a companion to *Beneath a Meth Moon* by broadening the range of addictions to be considered and how addictions impact human body systems and families in multiple ways. Two instructional and content scaffolds can support students to contextualize the biological and social effects of addiction in society. One activity requires students to write a letter to policy makers addressing addiction policy recommendations and supporting claims with evidence and reasoning from the texts and inquiry activity. Another activity requires students to design their own messages, such as illustrated poems or letters, to communicate a better understanding of the effects of addiction on the human body systems and supporting those who are facing various addictions.

Conclusion

Students’ engagement and learning can be aided by using text sets that include multiple types of texts which “expand students’ opportunities to read about and understand important content” (Schoenbach et al., 2012, p. 11). As an example, we return to Emily Dickinson for how literary text helps to develop the obtaining, evaluating and communicating students need to do in science. In an excerpt of Dickinson’s poem “The Bee,” we see her careful observation of nature:

“His feet are shod with gauze,
His helmet is of gold;
His breast, a single onyx
With chrysoprase, inlaid.
His labor is a chant,
His idleness a tune;
Oh, for a bee’s experience
Of clovers and of noon!”

[Glossary:

Chivalry –courageous, helpful

Shod – fit with a shoe

Onyx – stone of different colors

Chrysoptase (krisəpr z/) is an apple-green to dark green colored gem]

Dickinson aptly describes the texture, color, shape, and sounds of bees. Students then evaluate these observations against what they are learning as they examine the anatomy and details of various bees. With carefully chosen anchor texts and accompanying resources and scaffolds, learners with diverse interests and skills are able to read complex texts and engage with content for deeper understanding. The use of varied literature -- poetry, short stories, novels, and other literary texts -- engages students who may find literature a more welcoming path to science.

Literature and literary texts help us connect with humanity. By reading narratives, poems, and memoirs, students gain a deeper understanding of the relevance of scientific phenomena. A novel, memoir, essay or short story can provide students with new perspectives. In text-based experiences, students record their own observations of what they are reading, write their evaluations, and practice how to communicate by drawing on a wealth of language and literature, knowledge and vocabulary. Through multimodal text sets literature can engage all learners in doing science.

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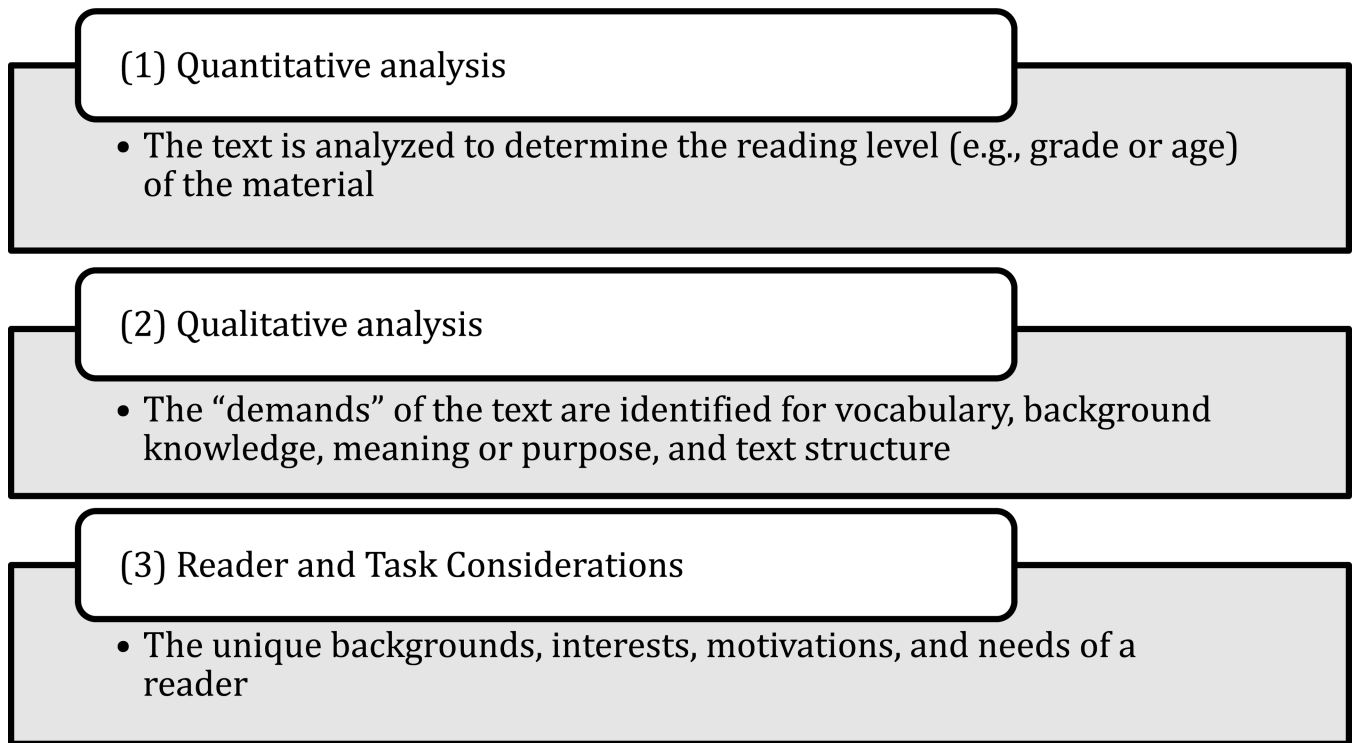


Figure 1.
Criteria for analyzing the complexity of a text.

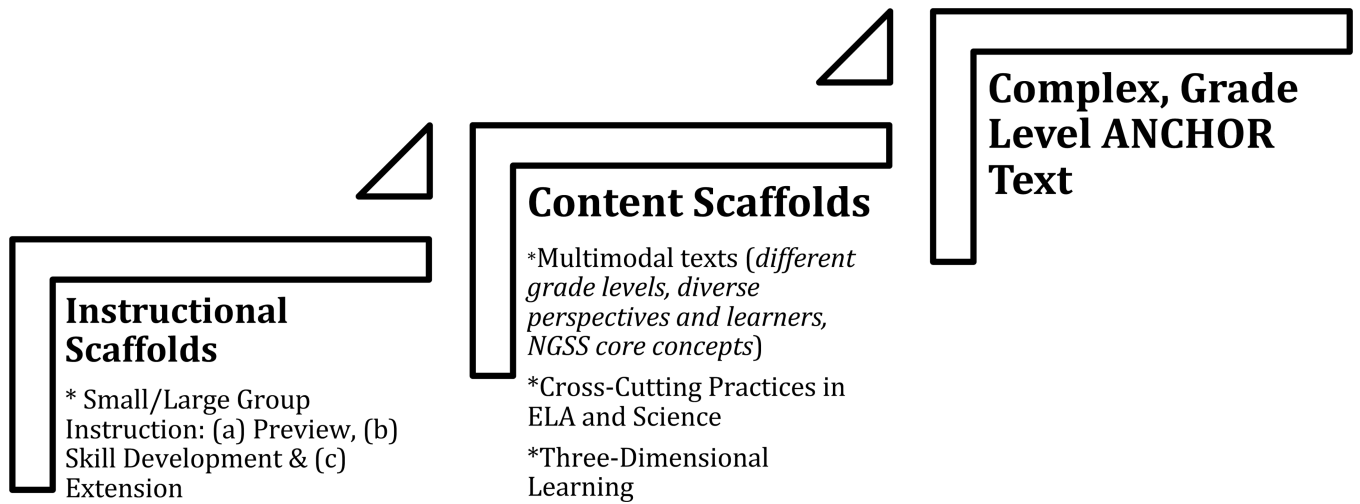


Figure 2.
Organization of a multimodal text set.

Strong sets	Weak sets
<i>Build student knowledge about a topic; meaningfully connect to the anchor text</i>	<i>Resources are not related or connected</i>
<i>Resources are authentic, rich, varied and worthy of student attention</i>	<i>Have limited variety and many textbook passages</i>
<i>Range of text types (literary and informational) and other formats and related resources (such as inquiry)</i>	<i>Focused exclusively on one genre or format (unless the set is a genre study)</i>
<p><i>Text complexity levels support student achievement of the grade-level complexity demands for reading.</i></p> <p><i>Note: *Resources in a set may start below the quantitative demands of the grade band in an effort to build towards the anchor text; concurrently, some resources may be placed above the band to provide an opportunity for advanced engagement with the content, after students have built vocabulary and background knowledge in the anchor text.</i></p>	<i>Text complexity levels are erratic and do not support the staircase of text complexity called for by the grade level.</i>

Figure 3.
General Features of Strong and Weak Text Sets, adapted from the Guide to Creating Text Sets, 2013.

Anchor text	Literary Scaffolds	Genre
Flight of the Bumblebee	“To Make a Prairie” by Emily Dickinson	Poem
	<i>Flight of the Bumblebee</i> by Nikolai Rimsky-Korsakov	Orchestra
Earth and Human Activity	“Heat” by Hilda Doolittle	Poem
	<i>Doris Wethers Oral History</i> by Joseph Dancis	Biography
	<i>Horegallu</i> by Sudha Murty	Indian short story
	<i>Same Sun Here</i> by Neela Vaswani and Silas House	Novel
Vaping	<i>Beneath a Meth Moon</i> by Jacqueline Woodson	Novel
	<i>Because of Winn-Dixie</i> by Kate DiCamillo	Novel

Figure 4.
Sampling of literary texts per each unit.

Duration: 1 Class period (45-60 minutes)**Learning Standards (CCSS.ELA-LITERACY):****Key Ideas and Details:**[CCSS.ELA-LITERACY.RI.7.1](#)

Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

[CCSS.ELA-LITERACY.RI.7.2](#)

Determine two or more central ideas in a text and analyze their development over the course of the text; provide an objective summary of the text.

Craft and Structure:[CCSS.ELA-LITERACY.RI.7.4](#)

Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of a specific word choice on meaning and tone.

Integration of Knowledge and Ideas:[CCSS.ELA-LITERACY.RI.7.7](#)

Compare and contrast a text to an audio, video, or multimedia version of the text, analyzing each medium's portrayal of the subject (e.g., how the delivery of a speech affects the impact of the words).

[CCSS.ELA-LITERACY.RI.7.8](#)

Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.

Range of Writing:[CCSS.ELA-LITERACY.WHST.6-8.10](#)

Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Comprehension and Collaboration:[CCSS.ELA-LITERACY.SL.8.1](#)

Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Objectives:

Students will identify and explain the central/main-ideas in informational text.

Students will cite textual evidence used to support central/main ideas in informational text.

Students will identify and explain how evidence in informational text supports the central/main idea.

Students will infer meaning and author's purpose in informational text.

Resources:

Picture book <i>The Flowers are Calling</i> with pages displayed; copies of the final page for students to highlight.
<p>Engage: Begin the class with a journal prompt in response to the Emily Dickinson poem, “To Make a Prairie”: Based on the poem, what did Dickinson understand about bees? What do you think this poem means and why?</p>
<p>Explore: Introduce the picture book by showing the cover and reading the title (students may want to sit on the floor near the teacher in order to see the pictures). Ask: “What is confusing about this title?” (Flowers don’t make sounds, do they?).</p> <p>As you read the book aloud, pause to show the images, insert discussion questions as appropriate: What do you notice about the genre/style/language? What do you think is the message purpose of the book? What claims does the author make and what evidence is used to support them?</p>
<p>Explain: Provide students with a journal page to write down new information. They could do this individually or with a shoulder partner. (See supplemental resources for Rolling Journal). After a few minutes of writing, share with shoulder partner or others in a small group. Then give another minute or two to add to the journal page. Students can first share with a partner, and then partners can combine into groups of 4. During group share time, provide clear directions that each person shares by reading out loud one line (or more) of text. Group members then say “thank you” and may ask questions. The goal is for students to hear one another and to give each student the chance to read out loud one line from their journal. A variety of group formations can help all students learn together.</p>
<p>Elaborate: Display or provide copies of the last page of the book. Explain that this page is different from the rest of the book and ask, “How is this page different?” “How does it support/fit the rest of the book?”</p> <p>With shoulder partners or small groups, use highlighters to identify claims, evidence, and reasoning. (If possible, use a different color highlighter for claim, evidence, and reasoning.)</p>
<p>Evaluate: Ask students to respond to the following questions in their journal:</p> <ol style="list-style-type: none"> 1) “How do the claims and evidence you just found on this page support the rest of the book?” 2) “What claim can you make about the author’s intent in writing this book? Use evidence to support your claim and explain your reasoning.” <p>Students’ responses to these questions and the writing in their journals throughout the lesson become important formative assessments of their understanding of the content and of the lesson’s objectives. Because this is a formative assessment, a quick check of their understanding and marks on the journal, such as a \checkmark or $\checkmark+$, with brief comments, can inform the teacher and the student regarding the development of ideas so far in the lesson.</p>
<p>Extend: Show/display the following:</p>

<https://www.npr.org/sections/thetwo-way/2016/05/30/479804121/bumblebees-little-hairs-can-sense-flowers-electric-fields>

Ask: Would you use this information in the book if you were the author? Why/Why not? Explain.

Assessment:

Determine student understanding of claim/evidence/reasoning identification through the highlighting done on text from the last page.

Determine student understanding of claim/evidence/reasoning through the students' writing in response to the above questions. See Rubric in Supplemental Resources.

Figure 5.
Sample 5E Lesson Plan for Flight of the Bumblebee.

MS-LS2-2: Ecosystems: construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems	
MS-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.	
Dimension	Classroom Connections
<p><i>Science and Engineering Practice:</i></p> <p>Constructing Explanation and Designing Solutions</p> <p>Engaging in argument from evidence</p>	<p>Students construct explanations supported by multiple sources using notes from the texts (see Rolling Journal in Supplemental Resources).</p> <p>Students analyze and interpret data from inquiry projects in which plants are grown with and without access to pollinators.</p>
<p><i>Disciplinary Core Idea:</i></p> <p>LS2-A: Interdependent Relationships in Ecosystems</p> <p>LS2-C: Ecosystem Dynamics, Functioning, and Resilience</p>	<p>Students discover the role of pollination within food production and how the foods they eat are impacted by loss of pollinators.</p>
<p><i>Crosscutting Concept:</i></p> <p>Stability and Change</p>	<p>Students discover the human impact on pollinators and ways scientists are tracking pollinators/bees.</p>

Figure 6.
Connections to the Common Core State Standards and three dimensions of NGSS.