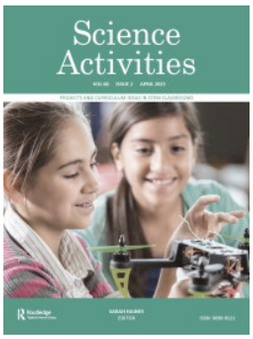

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Anchoring phenomena and summary writing working together to improve student learning

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ABSTRACT

Abstract concepts, such as gravity, may provide the perfect opportunity to bring phenomena into the classroom. As a knowledge generation strategy, summarizing can foster that opportunity. Using phenomena and summary writing together might help student learning since it requires making connections between their ideas and words to explain the natural phenomena. This article describes how anchoring phenomena and summary writing were integrated into a cohesive unit by using five generative activities that include different language and epistemic practices. Five activities include 1) Asking, 2) Designing, 3) Negotiating, 4) Explaining, and 5) Summarizing. A series of lessons, aligning with the Common Core State Standards for English Language Arts and the NGSS, were designed with the Science Writing Heuristic (SWH) approach. After these lessons, students were asked to write a letter to their younger peers about what they learned related to the phenomenon. The teacher mentioned that class discussions and summary writing practice helped her to see connections in students' ideas and how those connections changed throughout the unit. Many of the students also mentioned that they preferred completing a summary writing rather than a paper-pencil test because they were able to explain themselves in a more comfortable way.

KEYWORDS

K3-5; anchor phenomena; summary writing; forces and interactions; NGSS

Introduction

Helping elementary-age children understand big ideas in science can be a challenge, especially when the ideas are intangible and difficult to be visualized. Abstract science concepts such as gravity describe natural phenomena that are the consequences of a series of events, and hence the explanation of those concepts requires the ability to understand logical relationships between the events and to connect the words and ideas that represent the relationships. This ability may not be naturally developed by simply using phenomena, or "observable events that occur in the universe and that we can use our science knowledge to explain or predict" (Achieve 2016, 1) in science lessons. Although integrating phenomena can make learning science more a tangible and engaging experience for students, it may not be enough for conceptual understanding and meaning making. It is essential to provide students with opportunities to generate their own knowledge so they can make connections between the ideas related to the phenomena and words in their minds.

Fiorella and Mayer (2016) proposed eight strategies that include different cognitive and language practices to promote knowledge generation: mapping, drawing, imagining, summarizing, self-explaining, teaching, self-testing, and enacting. Summarizing as a knowledge generation strategy requires students to interact with others by translating their understandings into new forms of language and generating a comprehensive explanation that makes sense to the audience (Hand, Chen, and Suh 2020). Indeed, integrating summary writing into a phenomena-based science lesson or unit is a powerful method that enables both students and teachers to see how students connect their ideas with science concepts related to the phenomena.

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To integrate anchoring phenomena and summary writing into a cohesive unit, we used the Science Writing Heuristic (SWH) approach. The SWH is a knowledge generation approach that creates immersive and language-rich classrooms. It requires students to read, write, listen, and talk to generate and justify a science argument as they engage in scientific inquiry (Cavagnetto, Hand, and Norton-Meier 2010; Hand, Chen, and Suh 2020). We propose five essential generative activities that include different language and epistemic practices. Five activities include: 1) Asking, 2) Designing, 3) Negotiating, 4) Explaining, and 5) Summarizing (Figure 1). This article describes how a series of generative activities was designed and utilized around the gravity phenomenon in a fifth-grade classroom to promote student learning and teacher assessment. A series of lessons were designed and described, aligning with the Common Core State Standards for English Language Arts and the Next Generation Science Standards (NGSS Lead States 2013).

Materials

During the investigation phase, each group selects two objects to drop to investigate whether a heavier object fall faster or slower than a lighter object. Some groups can test the same item in different forms, such as crumpled piece of paper vs. a flat piece of paper. Others can compare different size rocks. During the explanation phase, students complete the text-to-self connections handout (Table 1). They use different resources, including videos or children's book on gravity (see the Appendix for the list of resources), so they can connect what they had discovered to relevant scientific vocabulary terms and concepts. At the summary phase, students will write letters to a Kindergarten student to explain what they learned about gravity. Students will need papers and pencils for this activity, or they can write on their computers.

Standards

Next Generation Science Standards (NGSS 2013)

Performance Expectation: 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.

Science and Engineering Practices: Engaging in argument from evidence. Students critique the scientific explanations or solutions proposed by

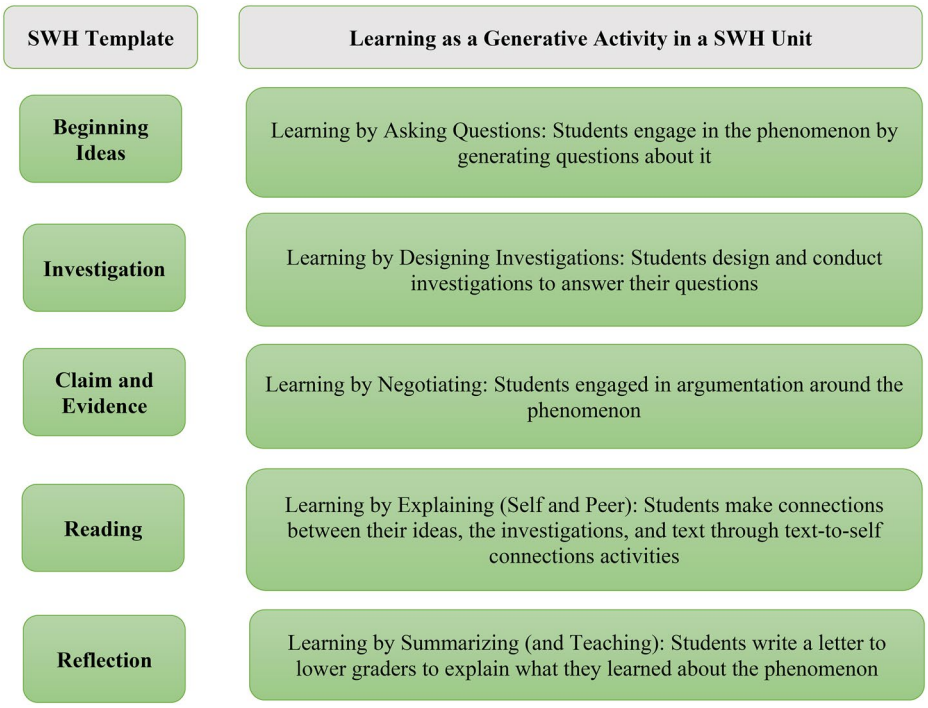


Figure 1. Outline of the Unit.

Table 1. Text-to-self connections.

Text to Self
Text to Text
Text to Media
Text to World

peers by citing relevant evidence about the natural and designed world(s).

Disciplinary Core Ideas: Types of Interactions. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)

Crosscutting Concepts: Cause and Effect. Cause and effect relationships are routinely identified and used to explain change.

Common Core State Standards (NGAC and CCSSO 2010)

CCSS.ELA-Literacy.RI.5.9: Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

CCSS.ELA-Literacy.W.5.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

CCSS.ELA-Literacy.W.5.4: Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

Procedures

We here describe the procedure of our series of generative activities. Students work in groups during all the activities except summary writing. Students can work in the same group throughout activities, or you can change group members for each activity.

Learning by asking questions

When it comes to teaching concepts, such as gravity to upper elementary students, teachers know that most of the time their students may bring common prior knowledge, such as it (gravity) holds us down on the ground. However, there are misconceptions that go along with the prior knowledge. The use of phenomena is a great way to assess students' prior knowledge and level of understanding, as it allows time to reflect on what is being seen in the phenomena.

When thinking of our big idea or unit focus, which was that Earth's gravitational pull affects the speed of falling objects, Mrs. Richards used a natural phenomenon as the introduction. She selected a video (on the website, The Wonder of Science) of Felix Baumgartner's 2012 space jump, in which he completed a four-minute free fall.

Before watching the video, Mrs. Richards had the class share what they knew about gravity. As she anticipated, students presented similar ideas such as, "It is a force that holds us on the ground." and "Outer space has gravity, just lower levels". While students watched the phenomenon video, they were asked to write down questions that they had regarding gravity, free fall, and space. After the video, she and her students talked and wrote together to generate a list of questions that would later drive their lessons. Some examples of questions asked included, "Does he (Felix) have extra weights that make him go down?" and "Would a lighter object float and not be pulled down by gravity?".

Learning by designing investigations

From here, Mrs. Richards and her students decided as a class to begin with an investigation on gravity. The students then developed a focus question as a group: "Would a heavier object fall faster or slower than a lighter object?". The students, with some assistance, created a plan for the investigation. Each group would choose two objects to drop, while one student would time the fall of those objects. All groups agreed that they would drop their objects from the same height to have fewer variables within the investigation. Some groups chose to test items such as a crumpled piece of paper vs. a flat piece of paper. Others chose to compare different size rocks. By allowing the students the opportunity to test different objects, the students were able to make their own connections and develop their own understandings.

Learning by negotiating

After all students had a chance to complete the investigation, groups were given a few minutes to discuss their findings. Then, they shared their

results as a class. By allowing time for student-led discussion, both in small groups and the whole group, the students were able to generate and share their claims and evidence. Throughout the discussions, it was evident that they had started developing an understanding of how gravity works. As the dialogue continued, the students were able to make connections between their own findings and what was seen in the phenomenon video, which led to developing more questions and planning our next investigation, an engineering design activity in which students worked to design a parachute that could be used to slow down the fall of a small plastic toy.

Learning by explaining (self and peer)

To help students connect their ideas from discussions and investigations, Mrs. Richards used text-to-self connections. This activity also prepared students for the next step of the instruction, which is summary writing.

In order for the students to make connections with their thinking and investigations, Mrs. Richards and her students first viewed the video titled "Danger! Falling Objects: Crash Course Kids #32.1" as well as read different pieces of literature. This was a time for students to assess their own thinking and relate what they had discovered to relevant scientific vocabulary terms and concepts. As they read the books such as *Gravity* by Jason Chin, they as a class completed a text connections handout (see Table 1).

During this time, she began by modeling the connections that she was able to make with the text and the phenomenon, the investigations, and the Crash Course Kids video. The students quickly jumped in as she continued to read, sharing their own connections, such as "It reminds me of when I jump on my trampoline." Afterward, the students worked with a partner to read additional books and complete the Text-to-Self Connections handout (Figure 2).

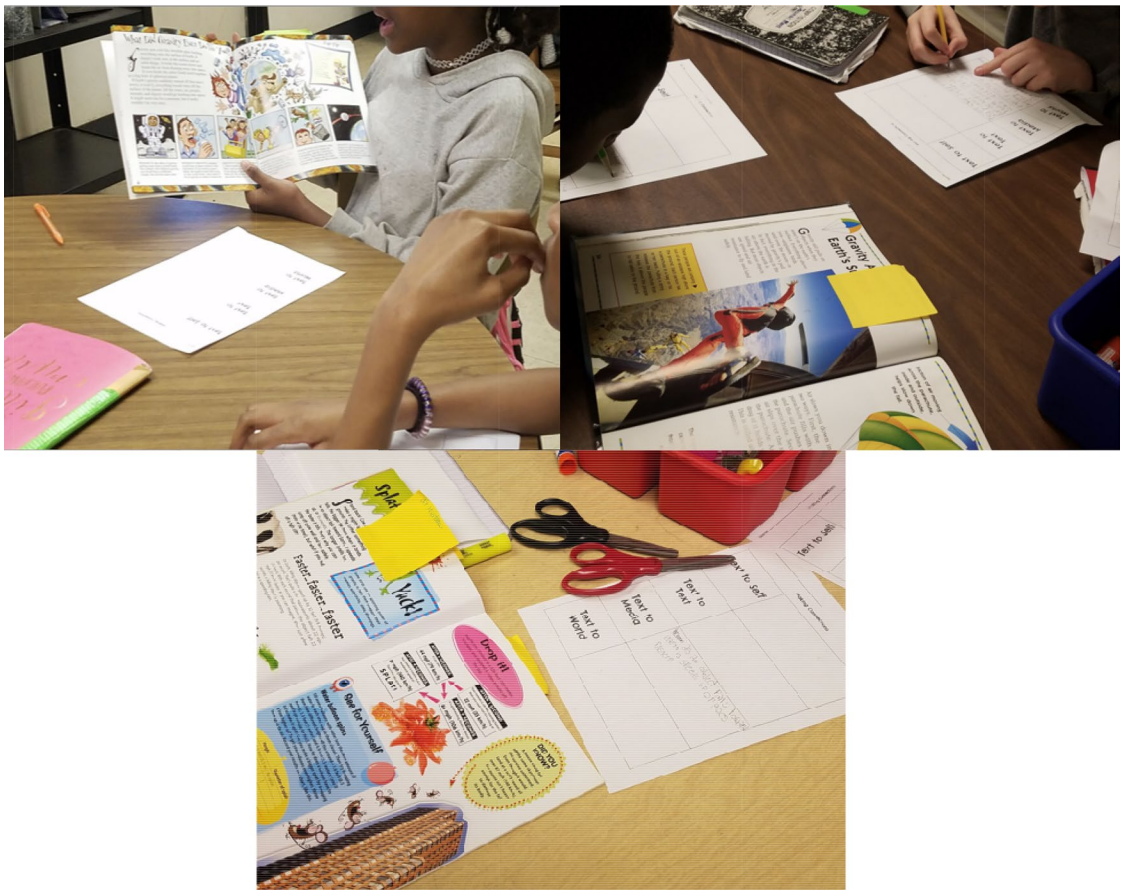


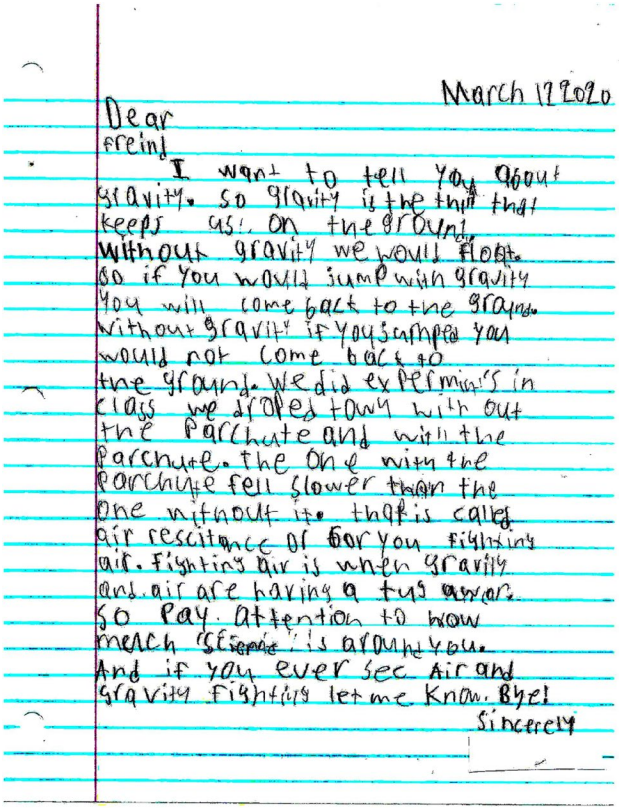
Figure 2. Students are working on text-to-self connections.

The students were to record any connections they were able to make between the text being read and the phenomenon, class discussions, and investigations. As the students worked, it became clear through their conversations that they were able to connect the concepts and terms presented in the texts with the class discussions and investigations. For example, one student wrote in her journal, "The word force makes me think of all the gravity projects, like in class when we dropped the crumpled paper vs. a rock and the flat paper vs. a rock." By using the Making Connections handout, students were able to begin moving their everyday language to a more scientific language, develop their own understanding, and take ownership of what they were learning instead of the teacher simply telling them what to know. This understanding could later be seen in the students' summary writing.

Learning by summarizing (and teaching)

Summary writing provides the perfect opportunity for a teacher to assess students' understanding of a big idea. The use of summary writing creates an environment that provides a time and space for students who are not comfortable with speaking out in class to share their thinking. There are many ways that summary writing can be conducted. Some examples are writing a short summary of what was learned in the day's lesson in two or three sentences, creating a cartoon using illustrations and words to summarize or to explain a concept, or writing a letter to an adult or student within your school. The levels and length of the writing assignment can be altered depending on the individual student's capabilities and ages. ESL and Exceptional Education students may need additional support through guided writing. For example, teachers may need to provide sentence starters for some students or allow the use of illustrations in addition to or instead of writing.

After making further connections through additional investigations, texts, and media, the students completed a more formal and purposeful summary writing activity. For this activity, the students wrote a letter to a Kindergarten student summarizing what they had learned


March 17 2020

Dear
freind
I want to tell you about gravity. So gravity is the thing that keeps us on the ground. Without gravity we would float. So if you would jump with gravity you will come back to the ground. Without gravity if you jumped you would not come back to the ground. We did experiments in class we dropped toys with out the parchute and with the parchute. the one with the parchute fell slower than the one without it. that is called air rescitance or for you fighting air. Fighting air is when gravity and air are having a tug awar. So pay attention to how much science is around you. And if you ever see air and gravity fighting let me know. Bye!
Sincerely

Figure 3. Student letters.

about gravity and also how air resistance can slow down a falling object (see Figure 3). This particular writing assignment allowed the students to become the "teacher" and clearly showed that the students had more ownership of their learning (Learning by Teaching). This final summary writing allowed Mrs. Richards to assess all of her students' understanding of the scientific concept discussed in class. Even though the students were writing to the same audience, the letters were different because the students had developed their own understanding of the concept and not just memorized information. By having the students write to a younger grade level, they had to make sure that they explained the concepts in a way that could be understood by a five- or six-year-old and not just tell them words and definitions. The audience of the summary writing could easily be altered to meet your needs.

Assessing summary writing

As with other types of writing, the easiest way to assess a student's understanding is through the

Table 2. Rubric for the assessment of a summary letter on a phenomenon.

	Effective (4)	Adequate (3)	Limited (2)	Minimal (1)
Main Ideas	Thoroughly explains what the phenomenon is, and main ideas related to it.	Adequately explains what the phenomenon is, and main ideas related to it.	Missing some of the necessary information needed to explain what the phenomenon is, and main ideas related to it.	Does not include all the necessary information to explain what the phenomenon is, and main ideas related to it.
Evidence	Provides different evidence and clearly makes connections between all evidence and the phenomenon	Provides evidence and clearly makes some connections between the evidence and the phenomenon.	Provides evidence but does not clearly indicate how evidence explains the phenomenon.	Does not provide any evidence to explain the phenomenon.
Word Choice	Word choices are clearly appropriate for the intended audience.	Word choices are generally appropriate for the intended audience.	Word choices are generally inappropriate for the intended audience.	Word choices are totally inappropriate for the intended audience.
Mechanics	Two or few errors are present in sentence formation, grammar, spelling, capitalization, and/or punctuation.	Three to four errors are present in sentence formation, grammar, spelling, capitalization, and/or punctuation.	Five to six errors are present in sentence formation, grammar, spelling, capitalization, and/or punctuation.	Seven or more errors are present in sentence formation, grammar, spelling, capitalization, and/or punctuation.

use of a rubric. By providing students with a copy of the rubric ahead of time, the students will know the expectations for the assignment, but it is their actual writing that will let you know if the student has made true connections with the phenomenon, investigations, and/or texts, or if they simply learned terms and definitions. The provided rubric (Table 2) can be used for any phenomenon and unit of study but could also be modified to fit your specific lesson or students. The main focus of assessment in summary writing should be the main idea and evidence. By focusing on these two areas, you can see the students' understanding and connections that were made throughout your lesson(s).

Observations and discussions

Anchoring phenomena and summary writing into a cohesive unit by using the SWH approach allowed students to engage in phenomena through reading, writing, and dialogue. Engaging in different learning tasks, including watching videos, taking notes, writing a summary letter, reading, and engaging in discussions, allowed students to show their learning in different ways. Writing activities helped students process new information in their phase and reflect on their learning. Students were able to individually connect their prior knowledge to the phenomenon, which led to their own inquiries and investigations. In return, the students were able to develop a deeper understanding of gravity instead of just memorizing the vocabulary words and definitions. Other studies conducted thus far have also shown that SWH helps to improve students' conceptual understanding of different science concepts (e.g., Hand, Chen, and Suh 2020; Kingir, Geban, and Gunel 2013). As a teacher, Mrs. Richards said she was able to see what the students learned because of the conversations and writing that took place in class. By using summary writing as her assessment piece, she was able to see the connections and learning that were made throughout the unit. After our final writing assignment, many of her students expressed that they preferred completing a summary writing rather than a paper-pencil test because they were able to explain themselves.

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Kingir, S., O. Geban, and M. Gunel. 2013. Using the science writing heuristic approach to enhance student understanding in chemical change and mixture. *Research in Science Education* 43 (4):1645–63. doi: 10.1007/s11165-012-9326-x.

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Appendix

Books used during class discussions:

Branley, F.M. *(2007). Gravity is a Mystery*. New York, NY: HarperCollins.

Chin, J. 2014. *Gravity.* New York, NY: Roaring Brook Press.

Claybourne, A. (2013). *Gut-Wrenching Gravity and other fatal forces*. New York, NY: Crabtree Publishing Company.

Kurzius, A. (2019). *Physical Science Gravity*. Children's Press.

Maloney, R.P. (2016). *The Day Gravity Goes Loco*. CreateSpace Independent Publishing Platform.

Prasad, K.S. (2004). *Why Can't I Jump Very High? A Book about Gravity*. Santa Rosa, CA: Science Square Publishing.

Rooney, A. (2016). *You Wouldn't Want to Live without Gravity.* Franklin Watts.

Stille, D. (2004). *Motion: Push and Pull, Fast and Slow*. Picture Window Books.

Stringer, J. (2000). *The Science of Gravity.* Heinemann Library.

Internet resources

Danger! Falling Objects: Crash Course Kids #32.1
https://www.youtube.com/watch?v=dxcx35x5L9Y

Felix Baumgartner Space Jump World Record
https://thewonderofscience.com/phenomenon/2018/7/7/felix-baumgartner-space-jump-world-record