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Broadening Conceptions of Writing in the Science Classroom

AAPT eMentoring Webinar

8:00 EST (5:00pm PST)

tinyurl.com/aapt110915

#AAPTK12

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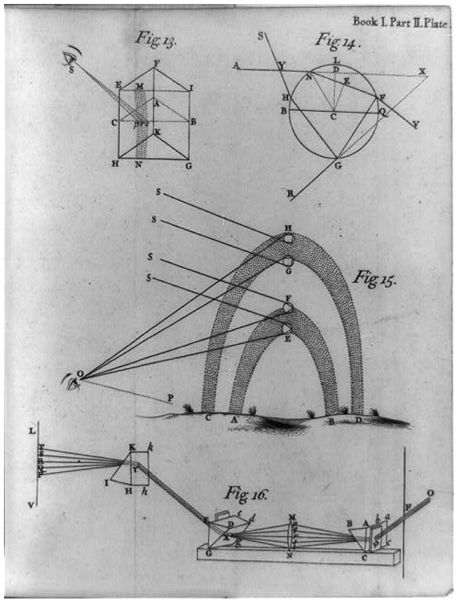
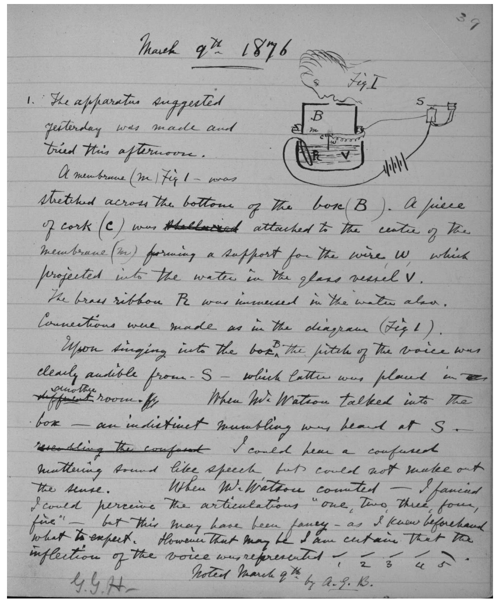
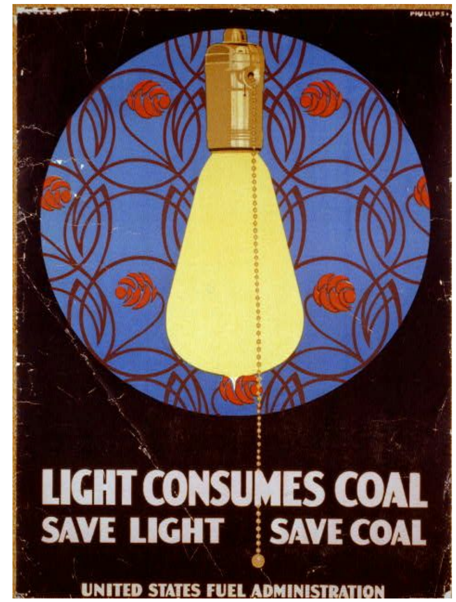
Webinar Overview

Join this one-hour webinar about writing and literacy in science classrooms. Teachers will discuss ways in which writing can be used to support development of conceptual understanding of core disciplinary ideas in science, to engage students in the practices of doing science, and to provide opportunities for students to use science knowledge and practices as members of classroom, local, and global communities. This webinar will also include a brief overview of the Common Core State Standards for ELA Reading and Writing in the Sciences and Technical Subjects.

ENGAGE

Take a look at the documents and links below.

What do these documents have in common? What's different about them?

	 March 9th 1876 Fig I 1. The apparatus suggested yesterday was made and tried this afternoon. A membrane (m) Fig 1 – was stretched across the bottom of the box (B). A piece of cork (C) was ~~[illegible]~~ attached to the centre of the membrane (m) forming a support for the wire W which projected into the water in the glass vessel V. The brass ribbon R was immersed in the water also. Connections were made as in the diagram (Fig 1). Upon singing into the box B the pitch of the voice was clearly audible from S – which latter was placed in ~~[illegible]~~ ~~different~~ another room. When Mr. Watson talked into the box – an indistinct mumbling was heard at S – ~~resembling the confused~~ I could hear a confused muttering sound like speech but could not make out the sense. When Mr. Watson counted – I fancied I could perceive the articulations "one, two, three, four, five" – but this may have been fancy – as I knew beforehand what to expect. However that may be I am certain that the inflection of the voice was represented 1 2 3 4 5. Noted March 9th by A. G. B. G. G. H.	
Diagrams of optical phenomena, including the rainbow, the double Icelandic spar, and prism refraction, Isaac Newton, 1704	Image 21 of Notebook by Alexander Graham Bell, from 1875 to 1876	Light consumes coal - Save light, save coal, United States Fuel Administration, 1917

EXPLORE

Think about your own classroom…

Q1 **What** are students writing?	Q2 **Who** is the intended audience?	Q3 **Why** are students writing? (purpose)	Q4 **When** are students writing?	Q5 **Where** and **how** is the writing shared?
Answers, questions, observations, thoughts, ideas, rebuttals.	Instructor, classmates, themselves.	To explain, to justify, to flesh out their ideas and findings. To record their questions, and answers received.	During and after lab experiments; on assignments; during boarding.	In class during boarding discussions.
labs, explanations, answers to conceptual questions, procedures for labs	teacher, AP readers (AP Physics 1 Test has lots of Writing!)	To show an understanding of scientific concepts	for labs and on tests	labs are shared in report form or on tests
definitions, diagrams, abstracts, lab notebooks, whiteboards	their peers (and me)	mostly: to figure out their own ideas; somewhat: to share and vet those ideas; somewhat: to critique others' ideas	always - in their lab notebooks, whiteboards, homework	usually in class. sometimes in a google doc with their peers. rarely outside of the class.
lab reports, research papers	Teacher, classmates	To express their understanding of concepts; to argue their opinion	Assessment, after labs	Labs are sometimes collaborative with Google Docs
lab reports; justification on tests; quizzes; thinking problems at the	peers and teacher and self	To share data and think about what graphs from labs tell us; to	In class; Homework; on tests/quizzes; to communicate with	whiteboard info is shared with everyone in a circle; tests/quizzes

beginning of class (predictions); writing on the board; whiteboarding lab data and problem sets; taking notes		communicate with me for a grade; to clarify ideas and apply concepts to other situations	themselves for reviewing class work	on papers handed in to me; sharing problem solving with peers in class
Lab reports; Cornell notes; real life examples	self; teacher; peers	to make connections; to apply concepts; to demonstrate understanding	Introduction (brainstorming); synthesis; tests; after lab	only with teachers and perhaps with peers
explanations of experiments	peers, teacher	to help clarify understanding demonstrate understanding of principles	during class for homework tests	on whiteboards, in notebooks
Free response questions, experimental conclusions	Teacher, AP readers (eventually), classmates	to justify their conclusions/claims	frequently...during labs, and quizzes/tests	Not shared (except for with me), unless it's through whiteboarding sessions...which typically isn't a lot of *writing* - it's more *speaking.*
Lab reports; lab summaries; paragraph questions; graphic organizers	Students; teachers	conceptual understanding; new AP Physics test has more writing	In class; at home	Google docs, peer editing; pass around; in science journals, on whiteboards
Summaries and QCERRs - Question, Claim, Evidence,	The teacher, team members, and other class members	Important to be able to communicate clearly in science and this format	One to two times a week.	Self reflection, Team reflection, Peer Reflection and Teacher

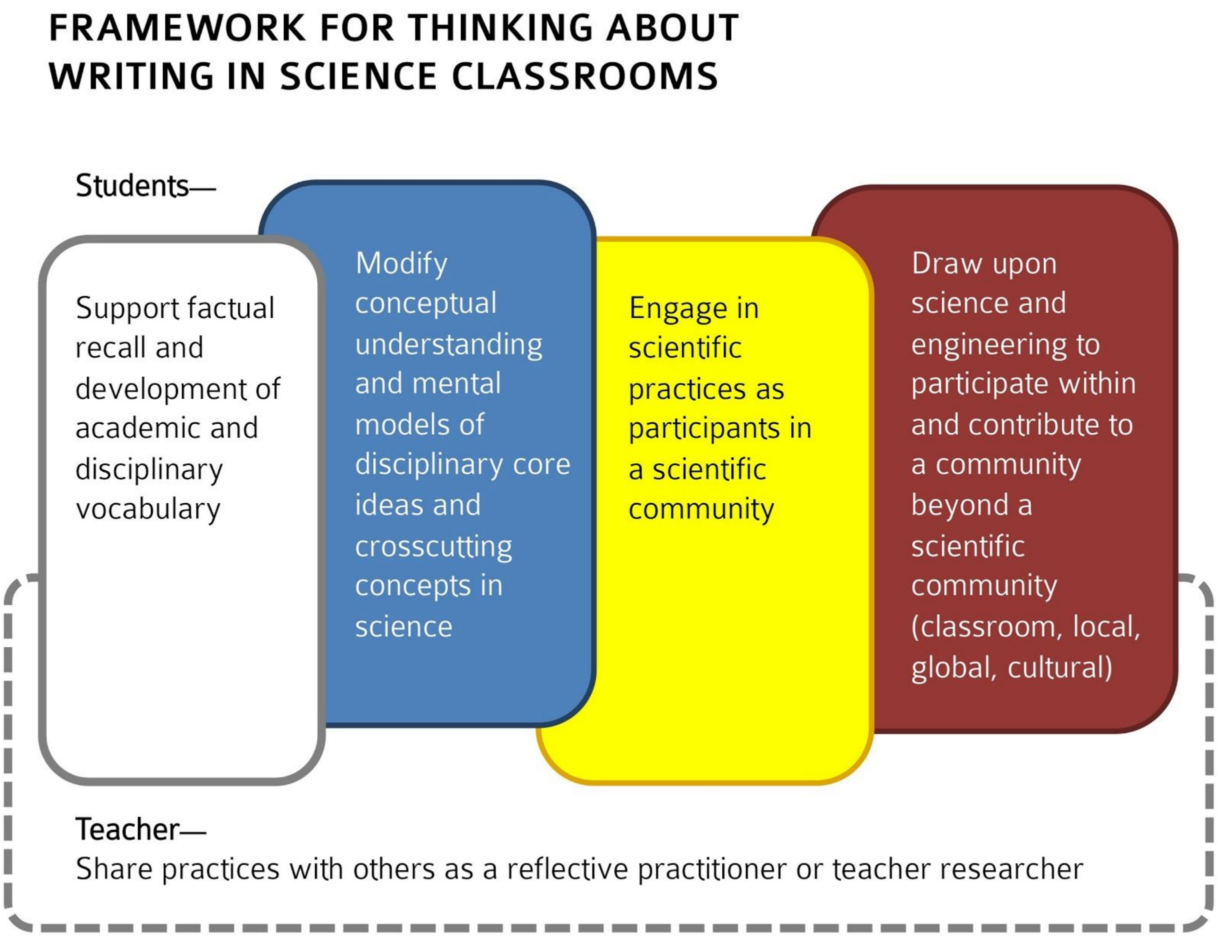
Reasoning & Rebuttals		supports the goal.		Reflection
answers to lab question	for the teacher			

What do you notice? Are there patterns?

- Lots of writing for people in the room… and AP readers, but maybe not for others outside the classroom.
- A lot of writing around labs, but not in other areas - problem solving, exams, etc.
- Some people have said “write to figure out what they know” some people have said “write to show what they know” how are those two writing experiences similar or different?
- Lots of whiteboarding!!! Yay!
- Writing for the teacher
- writing for tests and labs

FRAMEWORK FOR THINKING ABOUT WRITING IN SCIENCE CLASSROOMS

Here are some ways we've been thinking about writing in the science classroom:



Related considerations:

- When is writing scientific? When is it not? And when might non-scientific writing be appropriate in a science classroom?
- What are the expectations for students in the Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS)?
- How might this framework relate to teaching a diverse range of students?
- Both CCSS and NGSS push students to make arguments from evidence. How does this fit with the framework?
- What role does educational technology play?

TYPE V

Support factual recall and development of academic and disciplinary vocabulary

What? Who? Why? When? Where and how?
(Think: mode, genre, audience, purpose, medium)

★ Classroom
★ Student and teachers

Examples:

- Semantic feature analysis charts
  - Examples from middle school science: States of matter, classification, cells, precipitation
- Frayer model
  - Teacher blog post: Frayer models for science (To the Square Inch)
- Other examples? (*comment here*)

CCSS Literacy in Science and Technical Subjects:

➔ CCSS.ELA-LITERACY.RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

Allen, J. (2007). *Inside words: Tools for teaching academic vocabulary, grades 4-12*. Portland, ME: Stenhouse. (preview)

TYPE 1 **Modify conceptual understanding and mental models of disciplinary core ideas and crosscutting concepts in science** What? Who? Why? When? Where and how? (Think: mode, genre, audience, purpose, medium) ★ To express their understanding of concepts ★ To help clarify understanding ★ demonstrate understanding of principles ★ Located mainly in the classroom ★ Created for others in the classroom and the teacher Examples: ● Inquiry-based learning and discrepant events as a starting point for writing and making visible mental models ○ Video: Physics: The Cartesian Diver (Teaching Channel) ○ Video: Good Thinking! Conceptual Change: How New Ideas Take Root (Smithsonian Institute) ○ Video: Good Thinking! Fired Up About Energy (Smithsonian Institute) ● Open-ended responses, constructed responses, and formative assessment ○ Example student and teacher page: Just Rolling Along (NSTA) ● Other examples? (*from participants*) ○ NTIPERS ○ Elicitation Questions (a la Diagnoser Tools) CCSS Literacy in Science and Technical Subjects: ➔ CCSS.ELA-LITERACY.RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.	Carey, S. (2000). Science education as conceptual change. *Journal of Applied Developmental Psychology*, 21(1), 13-19. Georghiades, P. (2000). Beyond conceptual change learning in science education: Focusing on transfer, durability and metacognition. *Educational Research, 42*(2), 119-139. Erekson, T. (2004, March). Assessing student understanding. *The Science Teacher, 71*(3), 36-38. Keeley, P., & Harrington, R. (2010). *Uncovering student ideas in physical science, volume 1: 45 new formative assessment probes*. Arlington, VA: NSTA Press. (preview) Konicek-Moran, R., & Kelley, P. (2015). *Teaching for conceptual understanding in science*. Arlington, VA: NSTA Press. (preview) O'Brien, T. (2010). *Brain-powered science: Teaching and learning with discrepant events*. Arlington, VA: NSTA Press. (preview) McDermott, M. (2010, January). More than writing-to-learn. *The Science Teacher, 77*(1), 32-36. National Governors Association Center for Best Practices. Council of Chief State School Officers. (2012). *Common Core State Standards for English language arts and literacy in history/social studies, science, and technical subjects*. Washington D.C. (available online)

TYPE 2

Engage in scientific practices as participants in a scientific community

What? Who? Why? When? Where and how?
(Think: mode, genre, audience, purpose, medium)

Examples:

- Inquiry-based learning, labs, lab reports, and lab notebooks
- Model-based learning
- Science fair
- Reading, summarizing, analyzing, and reflecting on scientific writing
    - Jigsaw activity
    - Whiteboarding summaries
    - Argument Driven Inquiry style lab reports.

NGSS Performance Expectations: Physical Science:

- ➔ HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
- ➔ HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

CCSS Literacy in Science and Technical Subjects:

- ➔ CCSS.ELA-LITERACY.RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- ➔ CCSS.ELA-LITERACY.RST.9-10.9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Gilbert, S. W. (2011). *Models-based science teaching*. Arlington, VA: NSTA. (preview)

Goldbort, R. (2006). Chapter 2: Laboratory notes. In *Writing for science* (pp. 56-80). New Haven, CT: Yale University Press.

Kotelman, M., Saccani, T., & Gilbert, J. (2006). Chapter 6: Writing to learn: Science notebooks, a valuable tool to support nonfiction modes/genres of writing. In R. Douglas, M. P. Klentschy, K. Worth, and W. Binder (Eds.), *Linking science and literacy in the K-8 classroom* (pp. 149- 161). Arlington, VA: NSTA Press.

Krajcik, J. (2015, November). Three-dimensional instruction: Using a new type of teaching in the science classroom. *The Science Teacher, 82*(8), 50-52. (available online)

National Research Council. (2012). Chapter 9: Integrating the three dimensions. In *A Framework for K-12 science education: Practices, crosscutting concepts, and core ideas* (pp. 217-240). Washington, DC: National Academies Press. (available online)

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. (available online)

Porter, R., Guarienti, K., Brydon, B., Robb, J., Royston, A., Painter, H., & Smith, M. H. (2010, January). Writing better lab reports. *The Science Teacher, 77*(1), 43-48.

TYPE 3 **Draw upon science and engineering to participate within and contribute to a community beyond the scientific community (classroom, local, global, cultural)** What? Who? Why? When? Where and how? (Think: mode, genre, audience, purpose, medium) ★ Purposes outside of the discipline of science (for art, policy, business) ★ Enter into debates and discussions ★ Working toward social justice Examples: ● STEAM, STREAM, STR^{2}EAM, STEM-C ○ Making movies about science concepts ■ Making Molecular Movies (NSTA) ■ The Special Theory of Relativity (Breakthrough Junior Challenge) ● Making, fab labs, and makerspaces ○ 13 Year old invents braille printer with legos ● Place, project-, and problem-based learning (P^{3}BL) ○ How I teach kids to love science (TED Talk) ○ Wearables: Teaching Physics with Felt (Edutopia) ○ Designing a better wheelchair (Tufts University) ● Interdisciplinary units with colleagues in other disciplines ● Career and Technical Education (CTE) integration CCSS Literacy in Science and Technical Subjects: ➔ CCSS.ELA-LITERACY.RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.	Allen, D. E., Duch, B. J., & Groh, S. E. (1996). The power of problem-based learning in teaching introductory science courses. *New Directions for Teaching and Learning, 68*, 43-52. Calabrese Barton, A. (2003). *Teaching science for social justice*. New York: Teachers College Press. Grow, P. L., & Plucker, J. A. (2003, December). Good problems to have: Implementing problem-based learning without redesigning a curriculum. *The Science Teacher, 70*(9), 31-35. McCormack, S. (2015, March) Policy, energy, and literacy. *The Science Teacher, 82*(3), 30-34. O'Brien, W. (2015, April). Making molecular movies. *The Science Teacher, 82*(4), 29-34. (Available online.) Sadler, T. D. (2004). Moral and ethical dimensions of socioscientific decision-making as integral components of scientific literacy. *Science Educator, 13*(1), 39-48. Savery, J. R. (2005, May). Overview of problem-based learning: Definition and distinctions. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 9-20. (Available online.) Style, E. (1996). Curriculum as window and mirror. *Social Science Record, 33*(2), 35-38. Tofel-Grehl, C., & Fields, D. (2015, November). Sewing up science: A craft-based approach to teaching electricity and circuits. *The Science Teacher*, *82*(8), 45-49.

TYPE R

Share practices with others as a reflective practitioner or teacher researcher

What? Who? Why? When? Where and how?
(Think: mode, genre, audience, purpose, medium)

Examples:

- Blogging and publishing online
  - Primary Sources in Science Classrooms (Library of Congress)
  - Making the Most of Mitosis (Philadelphia Writing Project)
  - Quantum Progress
  - Physics! Blog!
  - Newton's Minions
- Writing for periodicals and books
- Presenting at conferences

Cochran-Smith, M., & Lytle, S. L. (2009.) *Inquiry as stance: Practitioner research for the next generation*. New York: Teachers College Press.

Mohr, M. M., Sanford, B., MacLean, M. S., Rogers, C., & Clawson, S. (2004). *Teacher research for better schools*. New York: Teachers College Press. (preview)

Osborne, R., & Freyberg, P. (1985). Chapter 8: Roles for the science teacher (pp. 91-99) In *Learning in science: The implications of children's science*. Heinemann.

TESTING THE FRAMEWORK

Let's consider the framework in light of some concerns related to teaching and learning science?

Q6 How might this framework--and the uses of different genres of writing--affect diverse ranges of learners? ● Video: Why aren't girls taking physics? (Teaching Channel) ● Video: Full interview on how language, identity, and cognition impact students' learning (Stanford University) ● Chapter 8: Students with Disabilities and the *Next Generation Science Standards* (NSTA)	Lee, O., Miller, E., & Januszyk, R. (Eds.) (2015). *NGSS for All Students*. Arlington, VA: NSTA Press. (preview) NGSS Lead States. (2013). Appendix D: "All standards, all students": Making the Next Generation Science Standards accessible to all students. In *Next Generation Science Standards, Vol. 2: Appendixes* (25-39). Washington, DC: National Academies Press. (available online) Wright, K., Eslami, Z., McTigue, E., & Reynolds, D. (2015, April). Picture perfect. *The Science Teacher, 82*(4), 41-46.
Q7 In what ways are arguments and evidence (an emphasis in NGSS and CCSS) used in the writing students do? In what ways are arguments different in science compared to other disciplines? ● Compare (A) analyzing data to understand thermodynamics with (B) analyzing data to advocate for a specific energy policy. ● Key idea: argumentation is different in different disciplines; science classrooms should teach students about scientific argumentation but may also choose to engage students in different kinds of argumentation that would be appropriate in other disciplines and non-science settings → However, students should learn the differences and should be able to argue in science	McNeill, K. L., & Krajcik, J. (2008). Chapter 11: Inquiry and scientific explanations: Helping students use evidence and reasoning. In *Science as inquiry in the secondary setting* (pp. 121-134). Arlington, VA: NSTA Press. Llewellyn, D. (2012). *Teaching high school science through inquiry and argumentation*. Thousand Oaks, CA: Corwin Press. Osborne, J. F. (2010). An argument for arguments in science classes. *Phi Delta Kappan, 91*(4), 62-65. Sampson, V., & Grooms, J. (2010, July). Generate an argument: An instructional model. *The Science Teacher, 77*(5), 32-37.

Q8 How might educational technology support the 3 types of writing outlined in the framework? ● Google docs support access and collaboration (*Digital Is*, National Writing Project)	Bell, R. L., & Garofalo, J. (Eds.). (2005). Chapter 1: Guidelines for integrating technology in science instruction. In *National Educational Technology Standards (NETS) for students curriculum series: Science units for grades 9-12* (pp. 9-14). Washington, DC: International Society for Technology in Education.
Q9 In what ways does this framework fit with other frameworks for designing classroom learning? ● Connected Learning Framework (Digital Media & Learning Research Hub) ● Rigor and Relevance Framework (International Center for Leadership in Education) ● 4MAT (About Learning) ● Partnership for 21st Century Learning	
Q10 How does framework help us make sense of example lessons? ● History of Atomic Theory Social Media Project	
Q11 Is one type of writing described in the framework **better** than the other types? Should I incorporate all three types into every lesson? Can Type 1 be taught without Type 2? ● All three types have the potential to engage different kinds of learners in different ways. ● NGSS primarily addresses a combination of Type 1 and Type 2 writing (in combination called 3-dimensional learning that simultaneously engages disciplinary core ideas, crosscutting concepts, and science and engineering practices). ● CCSS leaves room to engage with Types 1, 2, and 3.	

USING THE FRAMEWORK TO DESIGN LEARNING EXPERIENCES

How might the infusion of writing extend / improve / deepen this assignment?

Speakers from Paper Plates (Museum of Science, Boston)
Video: Rockin' Paper Plate Speaker

TYPE 1 **Modifying conceptual understanding and mental models of disciplinary core ideas and crosscutting concepts in science**	TYPE 2 **Engaging in scientific practices as participants in a scientific community**	TYPE 3 **Drawing upon science and engineering to participate within and contribute to a community beyond the scientific community (classroom, local, global, cultural)**
Explain how/why the cone modifies sound. How do the physics concepts help explain how it works? Draw a diagram and explain the energy transformations	Engineering notebooks: Keeping track. What works? What doesn't? Experimental procedures - description of process after collaboration with classmates. PREDICT what happens if you make your cone narrower or wider? Test it. Describe what happened.	Explain the PURPOSE. IF you were stuck on an island Create an advertisement to sell your speaker while explaining why it is superior to others