Science, Literacy and Language Development Through Hands-on Science

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Science, Literacy and Language Development Through Hands-on Science

• What are the “best teaching/learning practices” for enhancing student success with the NGSS (science standards) as well as the language/literacy standards (CCSS ELA)?  - Interdisciplinarity

• What is the ST²REAM model of learning and why is it more effective than the traditional approach of education (delivering “siloed” academic content)?

• How do I start off the school year as an unknown to my students and end up as an unforgettable?

...a visual and conceptual tour...
• Knowing *who* you teach (a child with 100B neurons capable of making an infinite number of learning **connections** for a lifetime) is just as important as *what* you teach (disciplinary content).

• “I teach science.” No, you teach **students** whose brains prefer to learn by actively making elaborate **connections**.
Experience the World

Brain Science: Making Connections

24/7 we translate our interactions with the world into the chemical language of the brain, and create circuits that represent what we have experienced.
Neuron sending an e-message down the axon

Ensemble of neurons
Prior to learning what a “yellow tennis ball” is, the excitatory neurons (brain cells) that are most prone to responding to each of these single elements already exist and they are anxiously awaiting activation (to “fire”). They only need an experience that will link them together.
Experience → builds the representative network
Distributed Networks: Making Connections

The “Use it or lose it” principle.
Developing Early Literacy through Active Learning

Schema theory: “mental file folders” of categorical information (animals, furniture, needles, etc.) → inside each folder → categorical contents (similar to “slips of paper”) – a.k.a. semantic features (anything that would/should fall into the category.)

Adding new information or “knowledge” = adding more “slips of paper” into that flexible schema folder → “slot filling,” which is how vocab. dev./cognitive growth occur.

Connect the new word with a term/word/concept that the student already knows by “labeling” the new information (“Instead of the word rain, we will now try to use the word precipitation) -- AL
The **Association Cortices** Make up 37% of the Human Cerebral Cortex
ST²REAM

Science

Technology (and Thematic trans-disciplinary instruction to extend student learning)

Reading and Language Arts

Engineering ("Design and Engineering")

Art

Mathematics

(Maximizing connections and sensory experiences)
Standards from Which Discipline: **Math** or **Science**?

1. Asking questions and defining problems (**NGSS**)
2. Obtaining, evaluating, and communicating information (**NGSS**)
3. Look for and make use of structure (**M**)
4. Planning and carrying out investigations (**NGSS**)
5. Attend to precision (**M**)
6. Analyzing and interpreting data (**NGSS**)
7. Model with mathematics (**M**)
8. Using mathematics and computational thinking (**NGSS**)
9. Constructing explanations and designing solutions (**NGSS**)
10. Make sense of problems and persevere in solving them (**M**)
11. Reason abstractly and quantitatively (**M**)
12. Construct viable arguments and critique the reasoning of others. (**M**)
13. Developing and using models (**NGSS**)
14. Engaging in argument from evidence (**NGSS**)
15. Use appropriate tools strategically (**M**)
16. Look for and express regularity in repeated reasoning (**M**)
<table>
<thead>
<tr>
<th>Math</th>
<th>Science</th>
<th>English Language Arts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M1.</strong> Make sense of problems and persevering in solving them.</td>
<td><strong>S1.</strong> Asking questions (for science) and defining problems (for engineering).</td>
<td><strong>E1.</strong> They demonstrate independence.</td>
</tr>
<tr>
<td><strong>M2.</strong> Reason abstractly and quantitatively.</td>
<td><strong>S2.</strong> Developing and using models.</td>
<td><strong>E2.</strong> They build strong content knowledge.</td>
</tr>
<tr>
<td><strong>M3.</strong> Construct viable arguments and critique the reasoning of others.</td>
<td><strong>S3.</strong> Planning and carrying out investigations.</td>
<td><strong>E3.</strong> They respond to the varying demands of audience, task, purpose, and discipline.</td>
</tr>
<tr>
<td><strong>M4.</strong> Model with mathematics.</td>
<td><strong>S4.</strong> Analyzing and interpreting data.</td>
<td><strong>E4.</strong> They comprehend as well as critique.</td>
</tr>
<tr>
<td><strong>M5.</strong> Use appropriate tools strategically.</td>
<td><strong>S5.</strong> Using mathematics, information and computer technology, and computational thinking.</td>
<td><strong>E5.</strong> They value evidence.</td>
</tr>
<tr>
<td><strong>M6.</strong> Attend to precision.</td>
<td><strong>S6.</strong> Constructing explanations (for science) and designing solutions (for engineering).</td>
<td><strong>E6.</strong> They use technology and digital media strategically and capably.</td>
</tr>
<tr>
<td><strong>M7.</strong> Look for and make use of structure.</td>
<td><strong>S7.</strong> Engaging in argument from evidence.</td>
<td><strong>E7.</strong> They come to understanding other perspectives and cultures.</td>
</tr>
<tr>
<td><strong>M8.</strong> Look for and express regularity in repeated reasoning.</td>
<td><strong>S8.</strong> Obtaining, evaluating, and communicating information.</td>
<td></td>
</tr>
</tbody>
</table>

*The Common Core English Language Arts uses the term “student capacities” rather than the term “practices” used in Common Core Mathematics and the Next Generation Science Standards.*
Taught in the domain of Science or ELA?

<table>
<thead>
<tr>
<th>Text Structure</th>
<th>Signal Questions &amp; Signal Words</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause and Effect</strong></td>
<td><strong>Compare and Contrast</strong></td>
</tr>
<tr>
<td><img src="image" alt="dominoes" /></td>
<td><img src="image" alt="circles" /></td>
</tr>
</tbody>
</table>

### Signal Words

| **So**<br>Because<br>Since<br>Therefore<br>If...then<br>This led to<br>Reason why<br>As a result<br>May be due to<br>Effect of<br>Consequently<br>For this reason | **Same as<br>Similar<br>Alike<br>As well as<br>Not only...but also<br>Both<br>Instead of<br>Either...or<br>On the other hand<br>Different from<br>As opposed to** | **First<br>Second<br>Next<br>Then<br>Before<br>After<br>Finally<br>Following<br>Not long after<br>Now<br>Soon** | **Question is...<br>Dilemma is...<br>The puzzle is...<br>To solve this...<br>One answer is...<br>One reason for the problem is...** | **For instance<br>Such as...<br>To begin with<br>An example<br>To illustrate<br>Characteristics<br>Look for the topic word (or a synonym or pronoun) to be repeated** |
**Similar Concepts, Discipline-specific Terminology**

<table>
<thead>
<tr>
<th>Reading</th>
<th>Mathematics</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Listening, speaking, reading/researching, writing</strong></td>
<td><strong>Listening, speaking, reading, writing</strong></td>
<td><strong>Listening, speaking, reading/researching, writing</strong></td>
</tr>
<tr>
<td><strong>Predict</strong></td>
<td><strong>Estimate</strong></td>
<td><strong>Hypothesize, predict</strong></td>
</tr>
<tr>
<td><strong>Identify</strong></td>
<td><strong>Find the…</strong></td>
<td><strong>Observe, investigate</strong></td>
</tr>
<tr>
<td><strong>Compare and contrast</strong></td>
<td><strong>Difference, sorting, quantifying</strong></td>
<td><strong>Classify → sense-making</strong></td>
</tr>
<tr>
<td><strong>Sequence (chronology)</strong></td>
<td><strong>Order and magnitude</strong></td>
<td><strong>Organize and categorize</strong></td>
</tr>
<tr>
<td><strong>What is the main idea?</strong></td>
<td><strong>Solve for…</strong></td>
<td><strong>What is the key concept?</strong></td>
</tr>
<tr>
<td><strong>List the…</strong></td>
<td><strong>Chart/graph the</strong></td>
<td><strong>Record and interpret the data</strong></td>
</tr>
<tr>
<td><strong>Summarize the</strong></td>
<td><strong>What is the…?</strong></td>
<td><strong>What conclusion can you draw?</strong></td>
</tr>
<tr>
<td><strong>List your reasons for</strong></td>
<td><strong>Show your work</strong></td>
<td><strong>What evidence supports your claim?</strong></td>
</tr>
<tr>
<td><strong>Cause and effect</strong></td>
<td><strong>Ratios and relationships</strong></td>
<td><strong>Cause and effect, cycles, systems</strong></td>
</tr>
<tr>
<td><strong>Sense-making, reasoning</strong></td>
<td><strong>Number sense</strong></td>
<td><strong>Claims and evidence, reasoning</strong></td>
</tr>
<tr>
<td><strong>Argumentation</strong></td>
<td><strong>Proofs</strong></td>
<td><strong>Arguments and evidence</strong></td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td><strong>Problems</strong></td>
<td><strong>Investigations (and Inquiry)</strong></td>
</tr>
<tr>
<td><strong>Proposition-answer</strong></td>
<td><strong>Problem-solution</strong></td>
<td><strong>Question-experiment</strong></td>
</tr>
<tr>
<td><strong>Descriptive skills dev.</strong></td>
<td><strong>Quantitative skills dev.</strong></td>
<td><strong>Thinking skills dev.; applications</strong></td>
</tr>
<tr>
<td><strong>Content focus</strong></td>
<td><strong>Focus on Problem-solving</strong></td>
<td><strong>Focus on answering questions</strong></td>
</tr>
<tr>
<td><strong>Words for expression</strong></td>
<td><strong>Words, numbers, symbolic Expressions</strong></td>
<td><strong>Written, visual, numerical, symbolic Expression and applications</strong></td>
</tr>
<tr>
<td><strong>Critical thinking</strong></td>
<td><strong>Quantitative and logical thinking</strong></td>
<td><strong>Creative thinking</strong></td>
</tr>
</tbody>
</table>
Commonalities in CCSS & NGSS

**ELA Features**

- Reading for **Literature** (10 standards)
- **Reading** for **Informational Text** (10 standards)
- **Foundation** (4 standards – K-5 only)
- **Writing** (10 standards)
- **Language** (6 standards)
- **Speaking and Listening** (6 standards)

Balance between informational text and literature

Writing in response to texts (events, experiences, etc.)

Conducting and reporting on research

Cross-content literacy (transdisciplinary)
Common Core (E/LA and Math), ELD, STEM, and the new Science Standards (NGSS):

Standards correlations → overlapping

- standards
- content
- concepts
- student learning objectives
- language goals and vocabulary
One of the great ironies of formal education is that we expect students to put the various pieces of the curriculum together into something we call real-world knowledge that can be applied after they graduate, although we make no claim that we ever showed them how during the first thirteen years.
You will be planning, designing, and making each of the objects, structures or products listed below. Which of them require the skills that are developed in the STEM/STREAM subjects?

<table>
<thead>
<tr>
<th>Object</th>
<th>Science</th>
<th>Technology</th>
<th>Reading (ELA)</th>
<th>Engineering</th>
<th>Art/Design</th>
<th>Math</th>
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</thead>
<tbody>
<tr>
<td>Running shoes</td>
<td>⬤</td>
<td>⬤</td>
<td></td>
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<tr>
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<td></td>
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<tr>
<td>Non-tipping kayak</td>
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<tr>
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<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>New i-Pod</td>
<td>⬤</td>
<td>⬤</td>
<td></td>
<td>⬤</td>
<td></td>
<td>⬤</td>
</tr>
<tr>
<td>Amusement park</td>
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<td>⬤</td>
<td></td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Amusement park rides</td>
<td>⬤</td>
<td>⬤</td>
<td></td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Racing bike</td>
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<td>⬤</td>
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<td>⬤</td>
<td>⬤</td>
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<tr>
<td>Sunglasses</td>
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<tr>
<td>Electronic game</td>
<td>⬤</td>
<td>⬤</td>
<td></td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
</tbody>
</table>
S.T².R.E.A.M.

Science
Technology
Engineering
Mathematics

Reading/Language Arts (Standards)
Reading, writing, discourse, argumentation, vocabulary development, comprehension, journals, note-booking, lab reports, summaries, oral presentations, recording interpreting and critiquing data and information

Visual Literacy
Drawing/diagramming, visual spatial thinking, imagery, inferential thinking, 2/3-dimensional modeling, symbolic models, interpreting visual evidence, visual representations - illustrations, charts, etc.

Art

Convergent/Integrative STEM T’ & L’
The last day of the school year I always have mixed feelings. I'm excited about summer starting, but it's also report card day.

The problem is, nothing in school is like it is in the outside world.

S.T².R.E.A.M.
THE LAST DAY OF THE SCHOOL YEAR I ALWAYS HAVE MIXED FEELINGS. I'M EXCITED ABOUT SUMMER STARTING, BUT IT'S ALSO REPORT CARD DAY.

SCHOOL IS MOSTLY TRUE-FALSE AND MULTIPLE CHOICE...

...BUT REAL LIFE IS ALL ESSAY QUESTIONS.
Schools vs. the Real-world
(“Interdisciplinarity is like real life”)

“…school learning is abstract, theoretical and organized by disciplines, while work in the real world is concrete, specific to the task, and organized by problems/projects…” not by disciplines.

1. Knowledge in one discipline
2. Application within one discipline
3. Application across disciplines
4. Application to real-world predictable situations
5. Application to real-world unpredictable and/or creative situations where the focus is on applications of knowledge ("improvisational intelligence")

"Nothing is more dangerous than an idea, when it’s the only one you have."
If they don't learn the way you teach, then

why not teach the way they learn?
1. People learn and remember best through real-world first-hand experiences, not memorization.

2. Children are born investigators.

3. Understanding builds over time (knowledge is cumulative and occurs over extended periods of time – “distributed learning”)

4. We attempt to “make sense” of all incoming stimuli through the senses, visualization, and through formal language (AL).

5. Science and Engineering require both content knowledge and knowledge of effective practices (SEPs: thinking, knowing and doing - applications)
The real cause of failure in formal education is essentially the fact that one begins with *language*, instead of beginning with *real and material action*. (Piaget, 1976)
The brain moves best from *meaning-to-print*, rather than from *print-to-meaning*.

1\textsuperscript{st} hand

CONCRETE

cognitive *rehearsals* →

2\textsuperscript{nd} hand

Visual representation (VST)

3\textsuperscript{rd} hand

APPLE

SYMBOLIC/ABSTRACT

The most difficult means by which the developing brain learns.
“Student engagement” is predicated on the research indicating that learning is enhanced when students are curious, involved, and enthusiastically receive ongoing feedback from the activity itself (not the teacher).

Curiosity Prepares the Brain for Better Learning: Neuroimaging reveals how the brain’s reward and memory pathways prime inquiring minds for knowledge

Oct 2, 2014 By Daisy Yuhas
Phenomenon: Disturbing the State of Equilibrium

Will pressing on the Unifix cubes in the cup disturb the state of equilibrium? Will we get the same results if the cups are filled with water instead?

“a critical competitor”
Can Oil become a cloak of invisibility?
Investigations and Phenomenon-based Learning
Phenomena-based Learning: curiosity leads to thought-provoking questions → students want to know

1. **What** just happened? What do I know about it and what do I *not* know?

2. **How** did that occur?

3. **Why** did it produce that outcome?

4. Under what conditions would it occur again?
Write Arguments with Evidence

- My argument is that ___, because___.
- My reasons are that____.
- The evidence to support my idea is ______
- My claim is ___. My evidence is ___.
- An argument against that idea is _____, because____.
- I would support that statement, because _____
- That reasoning sounds correct to me, because...
- If someone doubted ___, I would convince them by__.
Phenomena-based Learning (cont.): curiosity leads to thought-provoking questions → want to know

5. How would I verbally explain what just happened?

6. What would someone likely want to see in a written explanation?

7. Where/how can I find out more about what happened?

➢ Phenomena provoke wonder → student learning

➢ Informational literacy - library, Internet, journals, articles, interview a current/local expert in the field (website → contact them via email)

➢ Visual literacy - explanatory YouTube videos, demos
Deep and Long-lasting Learning: Understanding Builds Over Time

What? Information-based (1956 >) to

Why does...? Inquiry-based (1996 >) to


(under knowledge and skills - practices)

What if...?
We **make** observations, **explain** scientific events/phenomena by **describing** those observations in **oral** or **written** forms. We **draw inferences** from our observations, as well as from the numerical **data** we collect and **organize**.
Emotions, Attention and the Brain

- Emotions → attention → learning → memory (integrated in the brain)

- It is neurologically impossible to learn and remember information to which the brain has not paid attention.

Illocutionary intent - what a speaker means to say, although the sentence itself may not be perfectly consistent with the intentions: “The garbage is beginning to smell,” which means, “Take that garbage out!” – Close attention to the words does not aid in understanding the intended message.
Academic Language Learning

So that students understand the learning goals, state explicitly what the language objective/science content goals are at the beginning of class.

“Today we will engage in an experiment where we will investigate air resistance by constructing twirly birds (a.k.a., paper helicopters.)”

• Who has seen a helicopter in flight?
• In what directions did that helicopter fly?
• What is different about how a helicopter flies and how an airplane flies? (“critical competitor”)

[Image of a helicopter]
CCSS Writing standards K-5:

“Conduct short research projects that build knowledge through investigations of different aspects of a topic.”
Deep and Long-lasting Learning

1. **Instructivism** = teacher tells and student listens (the *transmission* of knowledge that gets memorized in isolation).

2. **Constructivism** (Piaget) = the student learns by “constructing knowledge” - making connections, inside the body-brain → building/constructing new brain circuitry.
3. **Constructionism** (Papert): learning comes by way of **actively constructing knowledge** through the act of constructing a meaningful product. Doing/making a tangible and shareable artifact (public) following a deep **investigation** that unfolds over multiple days.
Constructionism (Papert):

Once this object is properly folded, predict what will occur when you hold it as high as you can and release it?
Question:
How do you teach vocabulary best?
Answer: In context
Full answer: In the context of doing (not in the context of reading) and through speaking and writing.
“Predict”
STEM Vocabulary

**Instead of saying:**

“What do you think will happen when...?”

“Let’s look at these two pictures.”

“How can you put those into groups?”

“Let’s work this problem.”

“What do you think would have happened if...?”

“What did you think of this story?”

“How can you explain......?”

“How do you know that’s true?”

“How else could you use this.....?”

**Use MINDFUL LANGUAGE by saying:**

“What do you **PREDICT** will happen when...?”

“Let’s **COMPAR**E these two pictures.”

“How can you **CLASSIFY**...?”

“Let’s **ANALYZE** this problem.”

“What do you **SPECULATE** would have happened if...?”

“What **CONCLUSIONS** can you draw about this story?”

“What **HYPOTHESES** do you have that might explain...?”

“What **EVIDENCE** do you have to support.......?”

“How could you **APPLY** this .......?”
Students need to learn *the language of science* as a **tool** to both **comprehend**, and **communicate** what they learn/know about science investigations, oral discussion, writing, visual, and their mathematical representations.
Engineering Challenge: Build a Twirly-bird


- Engineers approach a design problem by looking for a solution. The success of their solution(s) is determined by how satisfactorily it solves the identified problem (criteria).

- Solutions are limited by constraints (e.g., the available materials, time, budget/costs, tools, conditions, etc.,) and solutions do not occur via a “light bulb experience.” Instead, they require a deliberate, thoughtful, systematic design process.
Engineering Challenge: Build a Twirly-bird

1. **Criteria:** Can you construct a paper helicopter that can fly for 3 seconds?

2. **Constraints:** (a) use only the materials provided, (b) you have minutes to construct and test your paper helicopter.

Use the following items:
- Paper helicopter cut-out
- 2 paperclips
- Scissors
- stopwatch
Vocabulary in Science: Twirly Bird

Basic Parts of a Helicopter

• **Fuselage** -- The main body of the helicopter is known as the fuselage. A frameless plastic canopy surrounds the pilot and connects in the rear to a flush-riveted aluminium frame.

Why are these words important to student discourse?
On your Twirly Bird...
- Where are the rotor blades?
- Where is the fuselage (body)?
- Where is the tail?
Patterns of Motion: Twirly Bird

Observation: STEM practitioners ask questions and *pay attention* (Engineering):

1. In *what direction* did the propellers rotate, *clockwise* or *counter clockwise*? (compare the rotor blade patterns the Blue vs. the white helicopters?)

2. What *modification* could you make to your helicopter that would *cause* the rotor blades to rotate in the *opposite* direction (re-engineering)?
“New and Improved” (vocabulary)

- “The adjacent possible” - advancements and improvements come by way of tinkering with the current technologies (and the resources immediately available) to make gradual changes, not quantum leaps that are several magnitudes “ahead of their time.” Innovative ideas are not conjured out of thin air – they are extensions of the adjacent “existing components” into new combinations (“thinkable” extensions on what currently is.) Pathways to “the adjacent possible” → Brain-storming dialogues, discourse and conversations (infrequently in schools)
Patterns of Motion: Twirly Bird

3. How would you change the outcome if you added a second paperclip? Compare the systems with a one-variable change:

(a) one paperclip
(b) 2 paperclips
(c) no paperclip (tape).

How did changing this one variable affect outcome?

a. Record your results.
b. Share your group’s findings with the class. (Describe the cause-and-effect relationships you observed?)
c. What forces were at work when the helicopter was in motion?
On a new piece of paper, design a second twirly bird, but make one modification to your new system. (or “½ class – longer blades; ½ class shorter” – split-half method)

a. In your science notebook, describe your modification. What exact change (measurable) will you make? How will that change the outcome?

b. What modification did you make? How did that change produce a new outcome? Compare the prediction.

c. What did you discover in the process?

(d. How was the result different for longer vs. shorter rotary blades?)
After your formal investigation, answer the following question:

• Where should you place the paperclip on the helicopter to best meet the criteria? Will you get better results if the paperclip is placed vertically or horizontally on the tail?

Work with a partner, record your data
What are the parts and the important design characteristics on a Twirly Bird that allow it meet the criteria?

The parts of my Twirly Bird include the ___________. The ___ is important because_____________________. Also, the _________ _____ helps the system work by _____________________.

One problem we encountered was ________________, but we solved it by_________________________. However, we could not solve the problem of _______, because ________. In a future re-design, we could possibly_________ to correct this problem.
4. What are the optimal dimensions of a Twirly Bird?

5. Will a larger Twirly Bird fly longer than a smaller Twirly Bird released at the same distance from the ground? Why? Why not? Explain the reasoning behind your prediction. Investigate your prediction and record your results.

6. If two paperclips are placed on the tail instead of one, how will that modification change the results? Explain the reasoning behind your prediction. Test your prediction and record your results.

Record your data and answer questions in full sentences.
Patterns of Motion: Twirly Bird

7. If you extended the length of the rotary blades 2 inches longer than the standard helicopter, can you predict how that might affect the outcome? If you widened each blade 1 inch, how would that change the motion of the twirly bird? (cause-and-effect)

8. How would you design a helicopter that will descend (drag) faster (with blades still rotating)?

9. What would occur if each blade was a different length?

10. If you had “teardrop-shaped” blades, how might that change the outcome of your flying system? (other shapes?)
Patterns of Motion: Twirly Bird

<table>
<thead>
<tr>
<th>Variables (testable modifications)</th>
<th>Slower</th>
<th>Faster</th>
<th>A more vertical drop</th>
<th>Blades spin faster</th>
<th>Blades spin slower</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 paperclips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 paperclips</td>
<td></td>
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</tr>
<tr>
<td>4 paperclips</td>
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<tr>
<td>1 inch wider</td>
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<tr>
<td>2 inches wider</td>
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<td>1 inch longer</td>
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<td>2 inches longer</td>
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<td>3 inches longer</td>
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<td>4 inches longer</td>
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<td>New shape</td>
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<td>Other?</td>
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</table>

1. A standard system
2. Multiple trials (3 times)
3. Share the outcomes
2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

2-PS 1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
Writing standards K-5:

“Conduct short research projects that build knowledge through investigation of different aspects of a topic.”
12. What other **materials** could we use to **construct** a similarly **designed** twirly bird that flies?

13. Is there a “maximum size” for a twirly bird? What factors could cause a limitation? (Recruit the custodian and his ladder.)
Summary Science Sentence Stems

1. Our data indicate that …

2. My hypothesis has been proven to be correct/incorrect because…

3. During our observations, we noticed that…

4. Based on our findings, we can conclude that …

5. This is also an example of __________

6. From our additional research from the library/Internet, we found out that…

7. I would suggest an extension activity to investigate…
14. Why do scientists only change one variable at a time?

15. How many variations of the original Twirly bird design can you create that will still fly in a similar manner? How many different variables could we change? Is there an optimal size for Twirly birds?
“The 30-Million Word Gap”

• Research shows that **vocabulary knowledge** is profoundly influenced by **SES**. By age 4, the average **accumulated experience with words** for children from...
  ✓ professional families = approx. **45M** words
  ✓ working-class families = **26M** words
  ✓ welfare families = only **13M** words.

  (Hart & Risley, 2003)

• Research from Keith Stanovich found that kids who have a **solid word base** get ahead faster and achieve **more** in school, while students with a less-developed vocabulary to **progress more slowly**. K students in lowest 25%le for vocabulary development are **3 grades behind** by Gr. 6.

• State of **AZ**
Developing Early Literacy through Active Learning

• Students most often learn **new words** through **rich conversations** ("serve-and-receive” not by listening).

• Students with **sparse language experiences** including ELLs, need to **actively engage in academic discussions** with peers and adults on a regular basis.

• UCB’s Center for Research in Education, Diversity, and Excellence — CREDE): to **make connections**, learn **new concepts**, and learn the **appropriate words** to describe those concepts, students need to have an abundance of **“instructional conversations”** - academic discussions. **Interactive discussions about new words and attention-grabbing high-utility vocabulary** helps students expand their vocabulary “schemas” (Beck & McKeown).
**Academic Language in Science a Context**

Introduce/reinforce vocabulary in an *active context.* (“Constructive expression” not phonics → vocab. dev.)

<table>
<thead>
<tr>
<th>1. Helicopter</th>
<th>17. Predict</th>
<th>34. Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Experiment</td>
<td>18. Modify</td>
<td>35. Length</td>
</tr>
<tr>
<td>9. Descend</td>
<td>25. Controlled variable</td>
<td>42. Findings</td>
</tr>
<tr>
<td>11. Model</td>
<td>27. Increase/decrease</td>
<td>44. Resistance</td>
</tr>
<tr>
<td>12. Engineering</td>
<td>28. Clockwise/counter...</td>
<td>45. Variation</td>
</tr>
<tr>
<td>15. Friction</td>
<td>31. Forces</td>
<td>48. System</td>
</tr>
<tr>
<td></td>
<td>33. Cause-and-effect</td>
<td>50. Practices</td>
</tr>
</tbody>
</table>
Vocabulary Development

4,000 – 8,000 words when entering elementary school

40,000 avg. when they exit high school

36,000 word difference

For 13 school grades (K-12) = 2,769 words/year

178 days for 2,769 = 16 words/school day

4K- 8,000 words when entering elementary school

87,000 exposed to/should have mastered upon exiting HS

79,000 word difference

For 13 school grades (K-12) = 6,076 words/year

178 days for 6,076 = 34 words/school day
How We Learn/Understand Vocabulary: Connecting Words with Meaning

• Words are used to **think**. The more words we know, the finer our understanding of the world.  
  -- Stahl, 1999

• **Language is recorded thought.**

**Semantic dementia:** a neurodegenerative disorder → lose touch with the meaning of words. When they lose the word for a specific emotion, the patient can no longer recognize that emotion in other people.

Words are also used to **process** in-coming information, to understand and evaluate other’s ideas, and to understand still **other words**.
Three-Tier Model for Vocabulary

CCSS, Appendix A
Originally Developed by Isabel Beck

Tier 1
- Known, basic, common, conversational/oral vocabulary, concrete words: clock, baby, run, book, see, tree, back, sad, animal (80% of text)

Tier 2
- Will encounter in texts, but don’t yet know
- Will encounter during content area study

- AL Words to teach: general academic, frequency, utility across disciplines/written lang., use in spoken lang.: vary, innovation, accumulate, cite, formulate, predict, surface, layer, evaluate, structure, adjust, function, bicker (‘lethargic’ rather than ‘tired’)
All children, and particularly children from language-impoverished backgrounds, benefit most from learning environments that are:

- Experience-rich
- language-rich (“serve and receive” verbal interactions -- primary caregiver feedback)
- print-rich (classrooms with word walls, writing samples, books of every genre, real-world objects, etc., and homes where parents/siblings model that reading and dialogue have tremendous power and value)
3-Dimensions of Learning Science

- **Eight Practices**
  - Asking questions and defining problems
  - Developing and using models
  - Planning and carrying out investigations
  - Analyzing and interpreting data
  - Using mathematics and computational thinking
  - Constructing Explanations and Designing Solutions
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information

- **Seven Crosscutting Concepts**
  - Patterns
  - Cause and effect
  - Scale, proportion, and quantity
  - Systems and system models
  - Energy and matter: Flows, cycles, and conservation
  - Structure and function
  - Stability and change

- **Four Disciplinary Core Ideas:**
  - Life Science
  - Physical Science
  - Earth and Space Science
  - Engineering, Technology and Applications of Science
The best way to predict your future is to invent it.

– Alan Kay

How do we know that a classroom has embraced and implemented the STEAM recommendations?

• What is the teacher doing differently?
• What are the students doing differently?
STEAM – STREAM Recommendations

“What formal education for one child for one year depends on what his/her teacher believes, knows, and does – and doesn't believe, doesn't know, and doesn’t do”.

All professional progress will take place outside of your comfort zone.
“We don’t learn from experience, we learn by reflecting on it.”

-- John Dewey

• What was the most valuable idea(s) that you learned this afternoon?

• Write down two “I will…” statements. (How will you use this new information or knowledge?)