



Network Science Teaching Practice #3: Using Evidence to Revise Student Generated Hypotheses

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A) Constructing and Revising Evidence-Based Explanations – Theoretical Background

- a) Revising Explanations with Evidence –to authentically practice the discipline of science
Beyond the content knowledge of the sciences, today researchers and educators alike recognize the importance of students participating in scientific practices that are critical to the way scientists actually work (Manz, 2014). "Engaging students with standard scientific explanations of the world—helping them to gain an understanding of the major ideas that science has developed—is a central aspect of science education." (NRC, 2012). Constructing explanations is part of a social building of knowledge authentic in science (Reiser, Berland & Kenyon, 2012). Both the constructing of these explanations and the argumentation in which students must engage to construct them are critical scientific processes (Falk & Brodsky, 2014).
- b) Revising Explanations with Evidence - to provide learning opportunities for ALL students
When students engage in the construction of evidence-based explanations (and the models that can support them), they gain "greater appreciation of the explanatory power of the scientific theories that they are learning about in class, and [acquire] greater insight into how scientists operate" (NRC, 2012). It is critical that all students in class have opportunities to participate in constructing explanations and in supporting argumentation (UW, 2014). Designing lessons around construction of explanations helps extend the learning opportunity to all the students in the class, giving each an opportunity to engage in intellectual processes that lead to conceptual changes in their understanding of science (Reiser, Berland & Kenyon, 2012; NRC, 2012). Additionally, students' mental models are not always linear – while causal and correlative connections can influence student thinking, prior knowledge and experience will also be part of students' mental reasoning (Duschl, Schweingruber & Shouse, 2007).
- c) Revising Explanations with Evidence - to increase the rigor and depth of science learning
Recent research reveals that rigor in science classrooms is consistently accessed only when instruction is responsive to students' ideas (Thompson et al, 2016). Responsive instructional episodes included building on students' ideas, providing opportunities and structures for all students

to participate, and accounting for students' lived experiences (Thompson et al., 2016). Research shows that adults and children alike both struggle to reason with evidence and theory, often struggling to differentiate between the two, and that personal experiences and ideas influence how students observe and apply evidence to construct explanations (Duschl, Schweingruber & Shouse, 2007). Therefore, it is critical to provide instructional opportunities for students to reason with evidence in supported ways to help advance their abilities to recognize and apply evidence to explanations

When students are asked to build explanations based on evidence and in ways that allow for connections to their own experiences (rather than simply repeating back explanations presented in texts), they are fundamentally engaging in activities that invite and are founded on responsive learning opportunities. Constructing explanations not only tends to the practice of explaining, but also to arguing/reasoning with uncertainty – while explanations alone can focus solely on “right” answers, argumentation requires that students develop conceptual understanding of the underlying science ideas (UW, 2014). Further, when students struggle to identify the best explanation (often among many hypotheses), they must employ argumentation to assess which is best supported by the data at hand, thereby developing their conceptual understandings (NRC, 2012). Students' abilities to reason about multiple hypotheses (rather than a single explanation) demonstrate greater success in constructing scientific explanations (Duschl, Schweingruber & Shouse, 2007).

d) Revising Explanations with Evidence - for ELL support

It is often the case that English language learners are not given adequate time to participate in the construction of scientific models and explanations (Windschitl & Barton, 2015). By creating opportunities for students to not only construct explanations, but to iterate on and revise these explanations based on evidence, ELL (and all) students are given multiple opportunities to progressively engage with explanation construction and clarification of conceptual understanding. Further, when lessons are constructed with scaffolds to access the explanations in different ways, ELL students get additional opportunities to connect to the scientific concepts through different forms of evidence and different activities.

e) Revising Explanations with Evidence – to support several of the eight science and engineering practices in NGSS

The Next Generation Science Standards (NGSS, 2013) specifically call out eight scientific and engineering practices critical to the development of science learning. Constructing and revising explanations based on evidence directly supports two of the eight practices: “constructing explanations and designing solutions”, and “engaging in argument from evidence”. Beyond this, constructing and revising explanations indirectly engages students in the remaining six practices, particularly: “analyzing and interpreting data”, “asking questions and defining problems”, “developing and using models” and “obtaining, evaluating and communicating information”.

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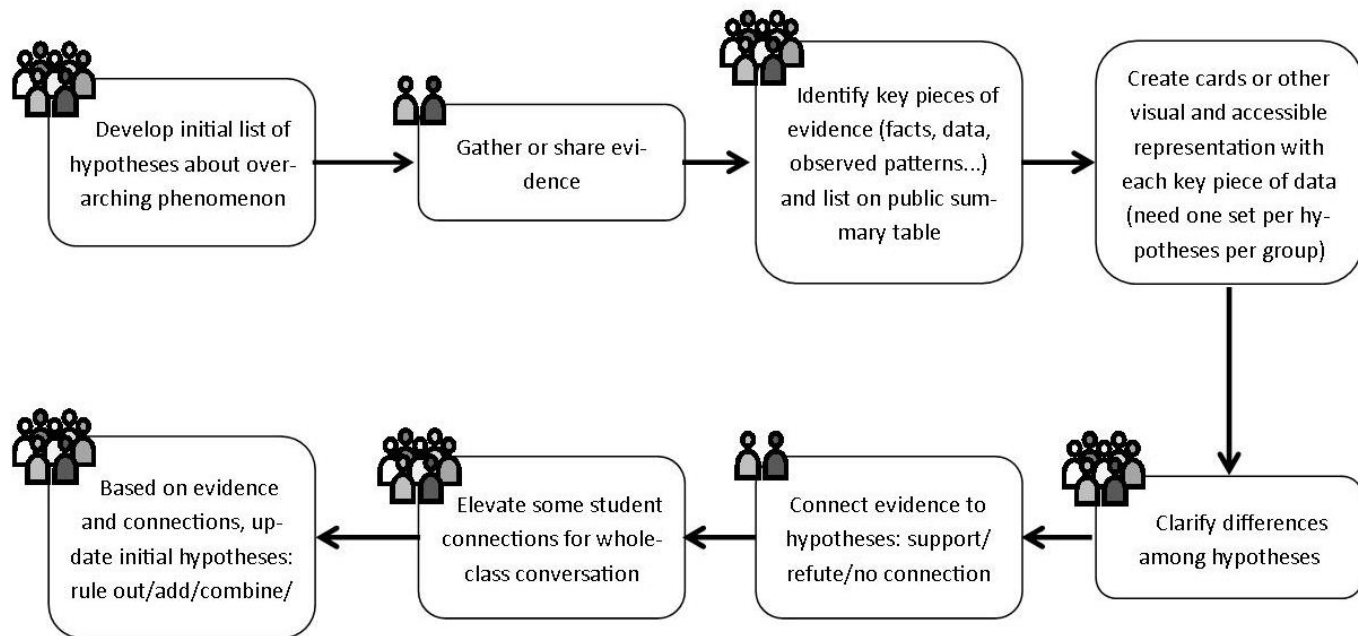
Windschitl, M. and Barton, A.C. (2015). *Rigor and Equity by Design: Locating a Core Set of Core Teaching Practices for the Science Education Community*. (in publication in *The Handbook*)

B) Narrowing possible explanations routine in support of Network Practice #2

Identified Problem of Practice: *How can we help students make stronger and more explicit connections between evidence and their explanations in ways that advance their learning and understanding of science? How can we help students differentiate between evidence and explanation and also help students recognize the importance of changing their thinking over time based on new information?*

Narrowing Explanations Routine

Note that early work with this protocol will require substantial modeling and scaffolding for students to follow. You will want to consider carefully the types of representations and manipulatives you use for both evidence and hypotheses. You will also want to consider the number of pieces of evidence and the number of hypotheses you employ in one given lesson – you don't want to use too many for students to keep track of and you don't want to use too few for them to be able to reason in different and open-ended ways.



This protocol can be adapted (as noted in the ideas below and in other ways that have yet to be explored). Regardless of how you structure the protocol for reasoning with evidence, based on experiences of teachers in the network and what we know from research, we are nominating the following elements as **non-negotiable** parts of this practice of using evidence to revise hypotheses.

- Students have generated multiple hypotheses that they are considering
- The focal activity is based on evaluating one or more student-generated hypotheses that may explain part or all of a given scientific phenomenon or question
- Students interact with some form of evidence (could be data they gathered, facts from readings/videos, third party data or other objective and reliable information)
- Teachers help students distinguish between evidence and hypotheses
- Teachers are explicit about the importance for students to consider changes in their thinking
- Students understand the differences among various hypotheses

Thinking Points: What does it look like to introduce the process to students for the first time? What type of manipulatives and representations work best for students to reason with both evidence and hypotheses?

What are schools in our network inquiring about with respect to this practice?

Cascade: Investigating ways to use summary tables to evaluate how evidence informs multiple hypotheses.

Chinook: How do we provide opportunities for students to engage in this protocol not only at the end of a unit, but also as we do activities along the way? How do we help students recognize the importance of changing their thinking based on evidence? How do we couple this work with opportunities for structured talk and reflective writing to help students make their reasoning explicit?

Highline : How can we use writing and structured talk to help improve the quality of students' written reasoning?

Variations to Consider:

- 1) One evidence “card” at a time. In some cases, teachers are choosing to rotate evidence cards (and some supporting information) around the classroom so that each group works with just one evidence card at a time.
- 2) One hypothesis at a time. In some cases, teachers are choosing to focus students on one hypothesis at a time to weigh evidence against .

Other Questions

Following are questions some of our teachers have raised when working with students to use evidence to revise their hypotheses. You may consider taking one or more of these as you integrate evidence to revise hypotheses with students in your classroom practice.

- How can we get students to be more explicit about the connections between evidence and explanations?
- In what ways might other practices (e.g., structured talk) be employed in conjunction with using evidence to revise hypotheses to yield strong explanations?
- When is it appropriate to chunk the process and have students consider only one hypothesis at a time (rather than considering evidence against multiple hypotheses at once?)
- Similarly, when is it appropriate to chunk the process and have students consider only one piece of evidence at a time?
- What is the right balance and timing of writing as part of this process that can help students make sense of their thinking most effectively?

Network Drivers for Using Evidence to Revise Hypotheses

<p>Working on scientific explanations</p> <ul style="list-style-type: none"> ○ <u>Press students toward “how” and “why”</u> Create an explanation checklist, use a digital forum if possible to afford more writing space ○ <u>Engage students in connecting ideas</u> Return to the specific phenomenon under consideration*, give examples/exemplars of solid explanations ○ <u>Focus students on key science ideas</u> Use worksheets that help students organize how hypotheses and pieces of evidence relate to each other, use a summary table for the phenomenon ○ <u>Have students track how their thinking has changed over time</u> Give students explicit permission to change their hypotheses ○ <u>Help students recognize evidence and differentiate between facts and hypotheses</u> Use a writing format that emphasizes evidence (e.g., CER structure, TIED, etc.), display evidence and hypotheses publicly 	<p>Creating equitable opportunities to learn</p> <ul style="list-style-type: none"> ○ <u>Ensure students understand the protocol</u> Work on small chunks at a time (e.g., single evidence cards) ○ <u>Provide adequate processing/sharing time</u> Engage students in structured partner/small group work ○ <u>Provide access to supportive resources</u> Give students manipulatives when weighing hypotheses (e.g., evidence cards)*, Provide evidence for students to use in their reasoning about different hypotheses in brief written form* ○ <u>Create accessible entry points for students</u> Use visual supports for evidence and hypotheses, provide explanation sentence frames as starting points, ○ <u>Seek out and integrate students’ experiences</u> Invite students to include experiences from past activities and their own lives
<p>Promoting robust classroom discourse</p> <ul style="list-style-type: none"> ○ <u>Plan for sharing out after using evidence</u> Identify and elevate different student-created hypotheses through focused discussion ○ <u>Scaffold talk norms in the classroom</u> Plan and model possible talk students might use when evaluating and revising hypotheses, Provide and engage students in using sentence stems for asking questions, agreeing or disagreeing – post on wall, hand out laminated cards, etc. ○ <u>Create meaningful science contexts for students to work together</u> Give students opportunities to juxtapose ideas, let students choose which hypotheses to investigate, have partners complete a joint worksheet, have partners focus on one piece of evidence together at a time 	<p>Supporting language development</p> <ul style="list-style-type: none"> ○ <u>Identify and plan support for EL students</u> Identify and plan support for EL students prior to the lesson, consider having students write evidence cards in their language

KEY FOR COLORS:

[Learnings from ACE](#)

[Learnings from Cascade](#)

[Learnings from Chinook](#)

[Learnings from College Place](#)

[Learnings from Evergreen](#)

[Learnings from Highline](#)

[Learnings from New Start](#)

[Learnings from Rainier](#)

[Learnings from Renton](#)

C) Network Data Collection Tools

DATA OPTION 1: Tracking Students' Depth of Explanation

This is a classroom observation tool that we have used network-wide in **Studio Days OR when working one-on-one with a coach** to document students' depth of explanation (in talk and in writing). This data can be particularly powerful when pooled and considered in relation to data about classroom practice.

	What Student describes <i>what</i> happened. Student describes, summarizes, or restates a pattern or trend in data without making a connection to any unobservable/theoretical components.	How Student describes <i>how</i> or partial why something happened. Student addresses unobservable/theoretical components tangentially.	Why Student explains <i>why</i> something happened. Student can trace a causal story for why a phenomenon occurred or ask questions at this level. Student uses important science ideas that have unobservable/theoretical components to explain observable events.
Student 1: f) <u>intermediate EL</u> g) <u>advanced EL</u> h) <u>not EL</u>			
Student 2: i) <u>intermediate EL</u> j) <u>advanced EL</u> k) <u>not EL</u>			
Student 3: l) <u>intermediate EL</u> m) <u>advanced EL</u> n) <u>not EL</u>			
Student 4: o) <u>intermediate EL</u> p) <u>advanced EL</u> q) <u>not EL</u>			

DATA OPTION 2: Exit Tickets

Teachers have also designed a variety of exit tickets to gain insight into student thinking and how they are interacting during structured talk. At times, exit tickets have simply been used to get a read from students about what they are doing during when they revise their models. At other times, this information has been combined with items that tap into how (and how deeply) students are thinking about a specific scientific phenomenon.

Principles for Exit Ticket Design:

- Keep it short enough that students can complete it fully at the end of a class period
- Tailor it to what you want to understand and/or elevate for students to think about

DATA

To understand more about **how students are using previous activities**, consider combining a check-box question with an open-ended reflection question about the process.

To understand more about **how revising hypotheses interrelates with student learning**, consider combining a check-box question with content questions that ask students to reason about the science.

OPTION 3: Tracking moves

Context:

This protocol can be used when you have a list of student-generated hypotheses that explain the anchoring phenomenon and evidence from activities your students have conducted. This step will help students to

- Work with their initial ideas;
- Clarify and/or revise their initial ideas;
- Understand an important scientific practice;
- Build (parts of) an evidence-based explanation for the phenomenon.

Teacher moves	Student moves	Comments
Elicit students' ideas: Teacher organizes whole group discussion that gives students opportunities to share their initial reasoning.	Students reason with prior learning and experiences in order to make sense of the anchoring phenomenon with their current understanding.	<i>This comes at the beginning of a unit</i>
Initial hypotheses: Create an initial list of hypotheses when students are sharing their initial ideas about the overarching phenomenon.	Students are involved in combining ideas to create initial hypotheses.	<i>Ideas from all periods can be combined in one set of hypotheses.</i>
Public representation of evidence:		

<p>After students have completed activities, evidence (facts, observed patterns, data, etc.) is gathered on public face-to-face tools, like summary tables, evidence buckets, and must-have lists.</p>	<p>Students suggest how evidence is, gathered, expressed, and publicized. Over time, students take on more and more responsibility.</p>	
<p>Evidence cards: Create cards or other visual and accessible representations with each key piece of data / evidence. Prepare one set for each student group.</p>	<p>Students may create these cards, based on evidence gathered on public representation.</p>	
<p>Clarify: Clarify the difference between evidence and hypothesis. Clarify the differences between the student-generated hypotheses.</p>	<p>Students ask questions and express/clarify their own understanding.</p>	<p><i>This step can be phased out over time.</i></p>
<p>Monitor: Teacher listens for students' reasoning and notes which evidence – hypotheses connections to elevate to the whole class.</p>	<p>Connecting hypotheses and evidence: In pairs, students reason which evidence supports or refutes or has no connection to the hypotheses. Evidence cards are placed and evaluated.</p>	
<p>Elevating: In whole group discussion, make sure selected students have the opportunity to express their reasoning.</p>	<p>Students engage in whole-class discussion.</p>	
<p style="text-align: center;">Revising hypotheses: Based on evidence, the class is revising their initial hypotheses by</p> <ul style="list-style-type: none"> • <u>rewriting / rewording parts of a hypothesis</u> • <u>adding to a hypothesis</u> • <u>deleting incorrect (parts of a) hypothesis</u> • <u>combining hypotheses</u> 		

Example from the Network:

At Cascade Middle School, students recently used evidence to revise their hypotheses about how/why certain landforms came to exist. Following is an exit ticket students completed at the end of that class. After that is a graph summarizing the different ways in which students reporting engaging with the evidence and hypotheses grouped by the level of their responses to the question. From this data, teachers could observe trends and make adjustments to their instruction to help students engage with the material and deepen their understandings.

Sample Exit Ticket Questions:

Where did the ENERGY come from to create the cliffs? *

- Thermal vents under the ocean
- Sun
- Core of the Earth
- Wind

Explain HOW you think these cliffs were made. Make sure you describe the process(es) and use evidence from the picture and from the stations you did to support your explanation. *

When you were working with the different hypotheses and evidence today, which of the following did you have a chance to do? *

Check ALL that apply.

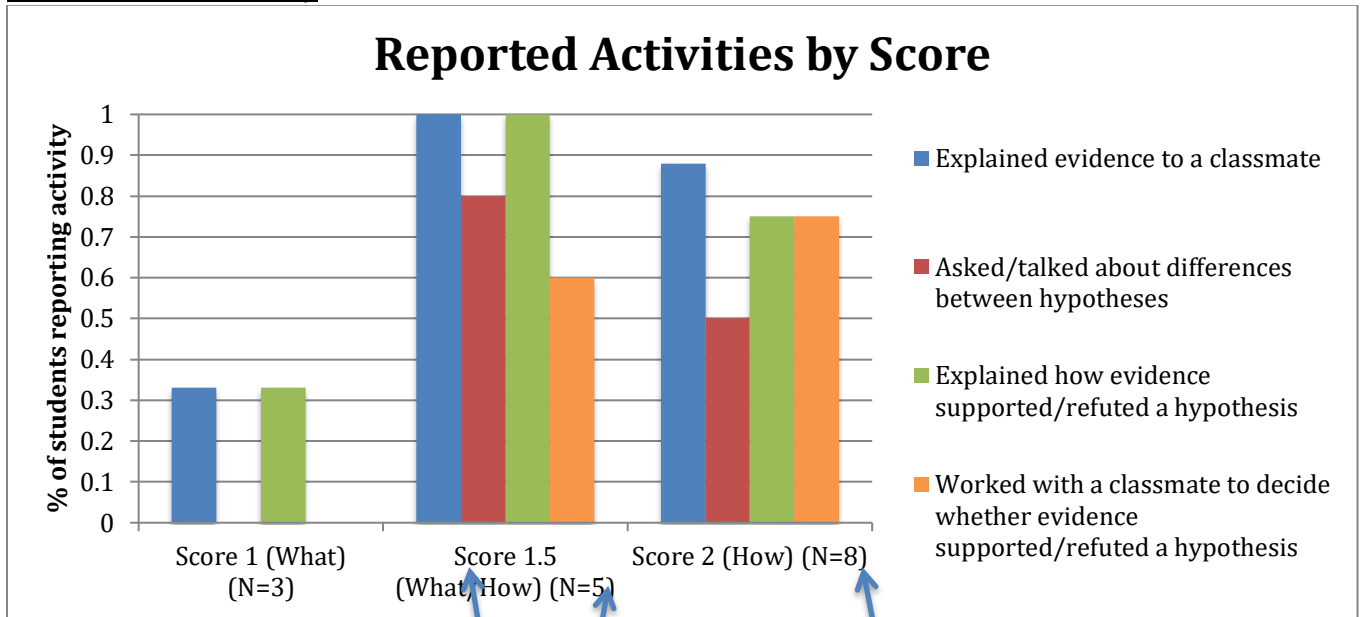
- I read about evidence.
- I explained evidence to a classmate.
- I asked/talked about the differences between the hypotheses.
- I explained how evidence supported or refuted a hypothesis.
- I worked with a classmate to decide whether evidence supported or refuted a hypothesis.
- I changed a hypothesis based on evidence.
- Other:

Of all the things you did today, which helped you learn the most? *

You can only choose ONE.

- I read about evidence.
- I explained evidence to a classmate.
- I asked/talked about the differences between the hypotheses.
- I explained how evidence supported or refuted a hypothesis.
- I worked with a classmate to decide whether evidence supported or refuted a hypothesis.
- I changed a hypothesis based on evidence.
- Other:

Annotated Data Summary

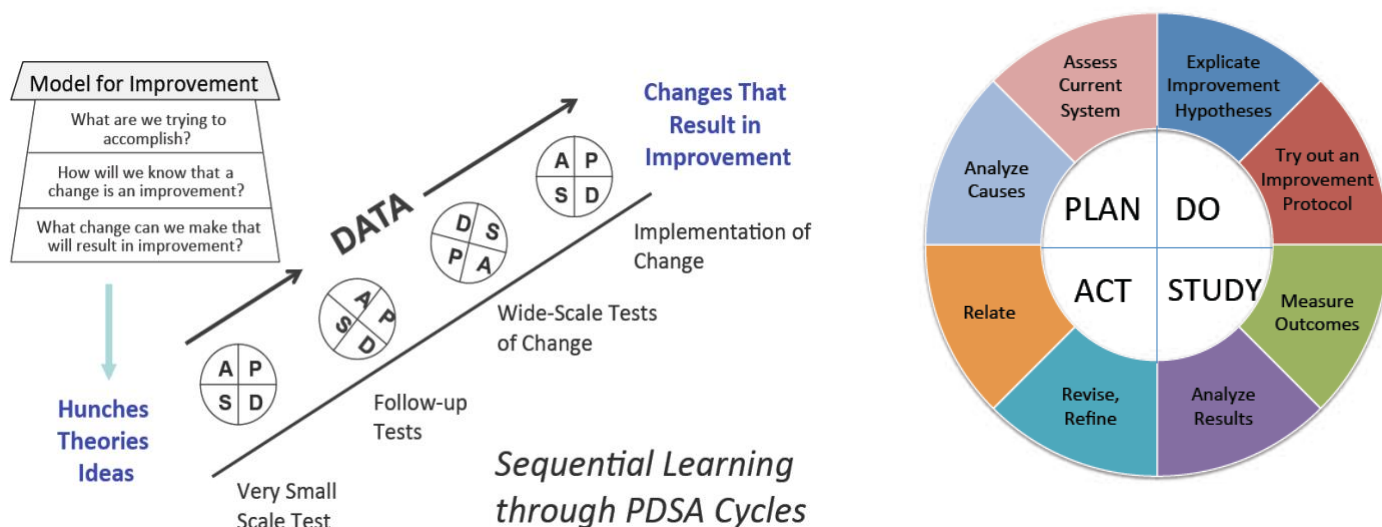


Students with “what” level explanations reported doing little talk, and only explaining

Students with “what/how” level explanations reported explaining to others and clarifying hypotheses

Students with “how” level explanations reported more collaborative talk, overall and proportionally

Coordinating Evidence and Hypotheses PDSA



Identified Problem of Practice: How can we help students explain how evidence from particular activities supports, refutes, or does not clarify their initial hypotheses?

What we are focused on improving: Increased frequency with which students actively determine how evidence supports varying initial hypotheses. We will aim for 100% of major activities in a unit ending with an evaluation of how the activity builds on a set of initial student hypotheses. **At the end of each activity/lesson students will weigh evidence against multiple hypotheses.** During a unit students can complete a summary chart organized around a finite short list of student hypotheses/partial hypotheses. Students will be asked to indicate whether evidence from the most recent lesson supports, refutes or does not apply to each of the hypotheses, and to explain why. Students should identify which portion of the hypotheses are relevant to the given activity (and evidence it provides). Student explanations and related conversations may sound like students constructing partial explanations or asking each other questions about parts of a causal explanation they are developing.

What we believe drives us to these changes are reflected in our driver diagram (4 quadrants).

Plan for data collection: Engage in as many PDSA cycles as possible by the first school year convening, **November 10**, and help us refine our understanding of the practices and problems of practice. Any time you ask students to apply core evidence from a given lesson to a set of hypotheses, record data on the data snap tool (the evidence and hypotheses being considered, other practices you had in play, & student data). For one of the lessons take a short 3-5 min video (or have a coach take it), upload it to IRIS connect, and share it with colleagues/coaches.

D) REVISING HYPOTHESES WITH EVIDENCE DATA SNAP TOOL

Name _____

Date _____ Class Period _____

1) Science lesson
topic _____

2) Who tried the practice?

- Teacher
- Teacher + Coach

3) How often have students been explicitly asked to determine if evidence from a lesson supports, refutes or does not apply to a set of initial hypotheses?

- This is the first time
- They have tried it 1-2 times before
- They have tried it 3-5 times before
- This is done regularly in my class 1-2x/week
- This is done regularly in my class 3-5x/week
- We practice building on ideas daily in my class

5) Below are some drivers for supporting ambitious and equitable instruction in small group interactions. Bubble all that applied to this lesson:

4) **PLAN**: Name the forms of evidence in the lesson:

Possible initial hypotheses and connection to evidence:

Hypothesis 1:
Evidence: *supports* *refutes* *doesn't apply*
Explanation:

Hypothesis 2:
Evidence: *supports* *refutes* *doesn't apply*
Explanation:

Hypothesis 3:
Evidence: *supports* *refutes* *doesn't apply*
Explanation:

Working on scientific explanations

- Press students toward "how" and "why"
Create an **explanation checklist**, use a digital forum if possible to afford more writing space
- Engage students in connecting ideas
Return to the specific phenomenon under consideration*, give examples/exemplars of solid explanations
- Focus students on key science ideas
Use worksheets that help students organize how hypotheses and pieces of evidence relate to each other, use a summary table for the phenomenon
- Have students track how their thinking has changed over time

Creating equitable opportunities to learn

- Ensure students understand the protocol
Work on small chunks at a time (e.g., single evidence cards)
- Provide adequate processing/sharing time
Engage students in structured partner/small group work
- Provide access to supportive resources
Give students manipulatives when weighing hypotheses (e.g., evidence cards)*, Provide evidence for students to use in their reasoning about different hypotheses in brief written form*
- Create accessible entry points for students

<p>Give students explicit permission to change their hypotheses</p> <ul style="list-style-type: none"> ○ <u>Help students recognize evidence and differentiate between facts and hypotheses</u> <p>Use a writing format that emphasizes evidence (e.g., CER structure, TIED, etc.), display evidence and hypotheses publicly, model as a class how to look at a piece of evidence and decide whether it supports or refutes a hypothesis</p>	<p>Use visual supports for evidence and hypotheses, provide explanation sentence frames as starting points,</p> <ul style="list-style-type: none"> ○ <u>Seek out and integrate students' experiences</u> <p>Invite students to include experiences from past activities and their own lives</p>
<p>Promoting robust classroom discourse</p> <ul style="list-style-type: none"> ○ <u>Plan for sharing out after using evidence</u> <p>Identify and elevate different student-created hypotheses through focused discussion</p> <ul style="list-style-type: none"> ○ <u>Scaffold talk norms in the classroom</u> <p>Plan and model possible talk students might use when evaluating and revising hypotheses, Provide and engage students in using sentence stems for asking questions, agreeing or disagreeing – post on wall, hand out laminated cards, etc.</p> <ul style="list-style-type: none"> ○ <u>Create meaningful science contexts for students to work together</u> <p>Give students opportunities to juxtapose ideas, let students choose which hypotheses to investigate, have partners complete a joint worksheet, have partners focus on one piece of evidence together at a time</p>	<p>Supporting language development</p> <ul style="list-style-type: none"> ○ <u>Identify and plan support for EL students</u> <p>Identify and plan support for EL students prior to the lesson, consider having students write evidence cards in their language</p>

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Learnings from New Start

Learnings from Rainier

Learnings from Renton

DO DURING CLASS

6) Main data collection: Choose 2-4 underserved students (EL or not) and listen in on their conversation and/or look at their work. List evidence of what/how/why level engagement for each student (use initials).

	What	How	Why
	Student describes <i>what</i> happened. Student describes, summarizes, or restates a pattern or trend in data without making a connection to	Student describes <i>how</i> or partial why something happened. Student addresses unobservable/theoretical	Student explains <i>why</i> something happened. Student can trace a causal story for why a phenomenon occurred or ask questions at this level. Student uses important science ideas that have

	any unobservable/ theoretical components.	components tangentially.	unobservable/theoretical components to explain observable events.
Student 1: r) <u>intermediate</u> <u>EL</u> s) <u>advanced EL</u> t) <u>not EL</u>			
Student 2: u) <u>intermediate</u> <u>EL</u> v) <u>advanced EL</u> w) <u>not EL</u>			
Student 3: x) <u>intermediate</u> <u>EL</u> y) <u>advanced EL</u> z) <u>not EL</u>			
Student 4: aa) <u>intermediate</u> <u>EL</u> bb) <u>advanced EL</u> cc) <u>not EL</u>			

7) Additional data collection: Create an exit ticket that asks for student feedback on their activity (e.g., how well they connected multiple ideas together, what they struggled with, etc.).

STUDY AFTER CLASS

8) What did you learn from the data (listening, observing, exit tickets)?

9) What parts of the practice seemed to work for these students? What did not?

ACT

10) What might you try next time to better support these students? Highlight ideas on the driver diagram/add to the drivers if needed.

E) Case Studies of Learning from the Network

Cascade Middle School: Testing a summary table variant

During the 2014-2015 school year, Cascade teachers took on the focus of helping students consider how pieces of evidence from class activities related to their hypotheses about a unit phenomenon. They tried several ideas throughout the year that integrated their school's focus on blended learning and technology, such as having students work with individual pieces of evidence in pairs and complete an online table to record how the evidence related to their class hypotheses.

At the network convening in March 2015, the team settled on a main change idea that would guide their work for the rest of the year – an adapted summary table that combined sense-making about class activities *and* student hypotheses. You can see an example of the summary table variant below. The main change from a regular summary table is in the righthand column. This column is usually used to record a general sense of how the activity connects to the unit phenomenon; here, the column is segmented so that students consider how the activity connects to each of their class hypotheses about the

The

the

help

Big Question: Why aren't antibiotics killing *Iraqibacter* anymore?

- **Hypothesis #1:** *Iraqibacter* cells have chosen to change so that the antibiotics can't kill them anymore
- **Hypothesis #2:** Some *Iraqibacter* cells just happen to be different, so the antibiotic can't kill them.
- **Hypothesis #3:** The *Iraqibacter* reproduced so quickly that there are just too many for the antibiotic to kill now.

Activity	Observations/Data	Claim Statement	Does the data we collected in this activity support , refute or not connect to the each hypothesis? Why?			
<i>What did we do in class?</i>	<i>What did you observe in this activity?</i>	<i>What conclusion can you make, based on what you observed in this activity?</i>	<ul style="list-style-type: none"> • Supports Hypothesis #... because... • Refutes Hypothesis #... because... • Does not connect to Hypothesis #... because... 			
			<table border="1"> <tr> <td>Hypothesis #1</td> <td>Hypothesis #2</td> <td>Hypothesis #3</td> </tr> </table>	Hypothesis #1	Hypothesis #2	Hypothesis #3
Hypothesis #1	Hypothesis #2	Hypothesis #3				

integrate evidence in their final unit explanations and improve in their abilities to explain why evidence supports, refutes, or does not apply to hypotheses.

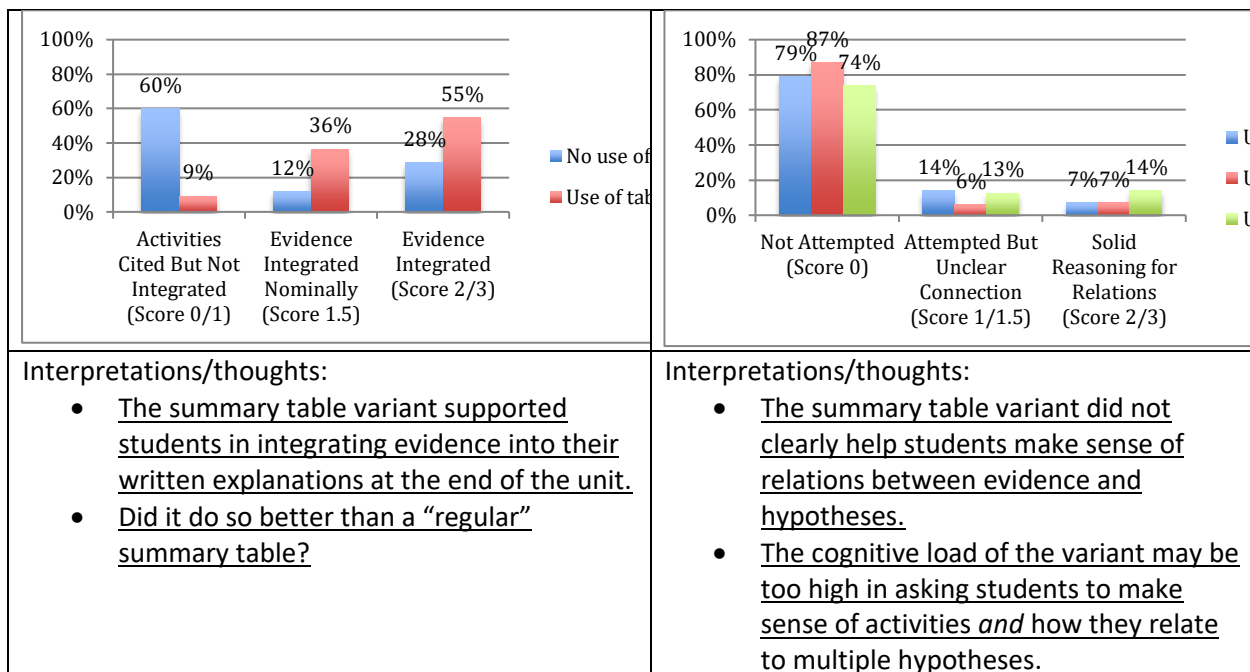
unit phenomenon. teachers expected that summary table variant would students



Main change: Segmenting the righthand column into consideration of different hypotheses.

All teachers tried iterations of the summary table variant in their classrooms, and several teachers incorporated it into multiple units. This provided us with data to see how the summary table variant was working.

Integration of evidence into final unit explanations	Improvement in abilities to explain relations between evidence and hypotheses
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At a final data meeting for the year, the team agreed on some possible next steps:

- Keep the regular summary table and evaluation of hypotheses separate (but tightly coupled) activities.
- Reconsider whether the summary table is a good computer-based activity – does it lose some of its social support in this forum? Does it make the table more or less accessible for students?

F) Making Connections to Danielson and NGSS – section is a work in progress

Although using evidence to revise student hypotheses as a practice itself is not called out specifically in the Danielson Framework or in the Next Generation Science Standards (NGSS), it relates to many of the principles and practices represented in both. Following are some points of relevance/overlap to help you make these connections. This is not a comprehensive set of overlap points, but more a highlight of those points of overlap that are most relevant. In summary, relevant connections may be found between model revisions and Danielson Instructional Practice Domains 3a, 3c 3d & 3e, and between model revisions and NGSS practices 1, 3, 4, 5, 6, 7 & 8.

CONNECTIONS TO DANIELSON FRAMEWORK

Danielson Domain	3a: Communicating with Students	3c: Engaging Students in Learning	3d: Using Assessment in Instruction	3e: Demonstrating Flexibility and Responsiveness
Relevant Quotes from each Domain Description	<p>"The goals for learning are communicated clearly to students."</p> <p>"Teacher presents complex concepts in ways that provide scaffolding and access to students."</p> <p>"Students are clear about what they are expected to</p>	<p>"[In classes in which students are engaged], they are intellectually active in learning important and challenging content...students are developing their understanding through what they do."</p>	<p>"when teachers are monitoring student learning, they are alert to student learning, they look carefully at what students are writing, or listen carefully to the questions students ask, in order to gauge whether they require additional activity or</p>	<p>"Flexibility and responsiveness" refers to a teacher's skill in making adjustments in a lesson to respond to changing conditions."</p> <p>"Teacher incorporates students' interests and questions into the heart of a lesson."</p>

	<p>do during a lesson, particularly if they are working independently or with classmates, without direct teacher supervision."</p>	<p>"...[students] are engaged in discussing, debating, answering "what if?" questions, discovering patterns, and the like."</p> <p>"The best evidence for student engagement is what students are saying and doing as a consequence of what the teacher does, or has done, or has planned."</p> <p>"Activities and assignments that promote learning are aligned with the goals of the lesson, and require student thinking that both emphasizes depth over breadth and that may allow students to exercise some choice."</p> <p>"Keeping things moving, within a well-defined structure, is one of the marks of an experienced teacher."</p> <p>"Learning tasks have multiple correct responses or approaches and/or demand higher-order thinking."</p> <p>"Materials and resources support the learning goals and require intellectual engagement, as appropriate."</p> <p>"Virtually all students are intellectually engaged in challenging content through well-designed learning tasks and suitable scaffolding by the teacher and fully aligned with the instructional outcomes."</p>	<p>explanation to grasp the content."</p> <p>"A teacher's skill in eliciting evidence of student understanding is one of the true marks of expertise."</p> <p>"The teacher elicits evidence of student understanding during the lesson. Students are invited to assess their own work and make improvements."</p>	<p>"The teacher's adjustments to the lesson are designed to assist individual students."</p>
<p>Examples of what this May Look Like in the Classroom</p>	<p>The process of aligning evidence and student-generated hypotheses are modeled for students by writing and physically showing how to do the process.</p> <p>The overarching question is posed to students, so students are aware of how the activity relates to the phenomena and will move their explanation further along.</p>	<p>Students are held accountable for their ideas by doing a whole class share out or sharing in new groups.</p> <p>Students use a variety of scaffolds to help their work - sentence stems, strategic partnering, etc.</p>	<p>Teacher reads the ideas of students and asks questions to press for deeper explanation.</p> <p>Teacher has students present their ideas to other groups or the class to increase accountability, but also to use that to gauge how other students/groups are processing new ideas.</p>	<p>Teacher might take a step back and explain the differences in evidence and hypothesis, based on student understanding.</p> <p>Teacher uses student-generated hypotheses to create worksheets for students.</p>

CONNECTIONS TO NGSS Science & Engineering Practices

NGSS Practice	Relevant Quotes from Practice Descriptions
1. Asking questions (for science) and defining problems (for engineering)	"Asking questions and defining problems also involves asking questions about data, claims that are made, and proposed designs."
3. Planning and carrying out investigations	"Students should design investigations that generate data to provide evidence to support claims they make about phenomena. Data aren't evidence until used in the process of supporting a claim. Students should use reasoning and scientific ideas, principles, and theories to show why data can be considered evidence."
4. Analyzing and interpreting data	<p>"Once collected, data must be presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others. Because raw data as such have little meaning, a major practice of scientists is to organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data—and their relevance—so that they may be used as evidence."</p> <p>"As students mature, they are expected to expand their capabilities to use a range of tools for tabulation, graphical representation, visualization, and statistical analysis."</p> <p>"Students are also expected to improve their abilities to interpret data by identifying significant features and patterns, use mathematics to represent relationships between variables, and take into account sources of error."</p>
5. Using mathematics and computational thinking	<p>"Students are expected to use mathematics to represent physical variables and their relationships, and to make quantitative predictions. "</p> <p>"Students are also expected to engage in computational thinking, which involves strategies for organizing and searching data,..."</p>
6. Constructing explanations (for science) and designing solutions (for engineering)	<p>"The goal of science is to construct explanations for the causes of phenomena. Students are expected to construct their own explanations, as well as apply standard explanations they learn about from their teachers or reading."</p> <p>"The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories."</p> <p>"An explanation includes a claim that relates how a variable or variables relate to another variable or a set of variables. A claim is often made in response to a question and in the process of answering the question, scientists often design investigations to generate data."</p> <p>"Asking students to demonstrate their own understanding of the implications of a scientific idea by developing their own explanations of phenomena, whether based on observations they have made or models they have developed, engages them in an essential part of the process by which conceptual change can occur."</p>
7. Engaging in argument from evidence	<p>"...students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose..."</p> <p>"In science, reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon."</p> <p>"Whether investigating a phenomenon, testing a design, or constructing a model to provide a mechanism for an explanation, students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits."</p> <p>"Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims."</p>
8. Obtaining, evaluating, and communicating information	<p>"Being a critical consumer of information about science and engineering requires the ability to read or view reports of scientific or technological advances or applications (whether found in the press, the Internet, or in a town meeting) and to recognize the salient ideas, identify sources of error and methodological flaws, distinguish observations from inferences, arguments from explanations, and claims from evidence."</p> <p>"Scientists and engineers employ multiple sources to obtain information used to evaluate the merit and validity of claims, methods, and designs."</p>

