Making Science Instruction Compelling for All Students: Using Cultural Formative Assessment to Build on Learner Interest and Experience

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With contributions from Shelley Stromholt, Tiffany Neill, Sam Shaw, Lizette Burks, Bill Penuel, Robbin Riedy, Kris Kilibarda, and Megan Schrauben.

September 2018 • Adaptation of ACESSE Resource C

ADVANCING COHERENT AND EQUITABLE SYSTEMS OF SCIENCE EDUCATION

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Slides for Today:
tinyurl.com/Bell-Bang-Culture-2018
Overview of the Session Goals

1. Learn how to promote equity and social justice as the focal point of standards implementation work by focusing on learning and teaching as an inherently cultural process.

2. Develop a shared understanding of how cultural formative assessment can reveal the interests, experiences, and identities of students.

3. Learn to see the range of sense-making resources learners bring to sense-making experiences.

4. Understand how and when to use different kinds of cultural formative assessment to guide instruction — and ‘overlap’ the curriculum with the lives of youth.
Overview of the Workshop

30 minutes  Background on equity & NGSS shifts
45 minutes  Science learning as cultural process, multiple ways of knowing
45 minutes  Self-documentation technique & example

60 minutes  Learning to See the Resources Students Bring to Sense-Making
45 minutes  Co-designing culturally responsive instruction
15 minutes  Wrap up
ACESSE Resource C

Overview: Participants learn how to design formative assessments that build on learners’ interest and experience, promoting equity and social justice in the process.
Professional Learning Resources to Support NGSS Implementation

- Co-designed by practitioners & researchers
- Tested & refined over time
- Easily shareable—over social media, email, paper

STEMteachingtools.org
@STEMteachtools (Twitter)
facebook.com/STEMTeachingTools
At school, Brenda routinely fails to engage in the practice of systematic mixing called for during science instruction.
But she routinely engages in that practice at home.
Overview of the Micros & Me Curriculum: The Microbiology of Human Health

- Part 1: Framing around microbiology and community-based health practices
  - Germ simulation
  - Community self-documentation / interviews

- Part 2: Select lessons from original Microworlds kit
  - Microscope use/magnification
  - What are cells?

- Part 3: Student-led investigations into microbiology and health (*informed by student self-documentation*)
  - Micros in the school (sampling and studying microorganisms)
  - Beneficial micros (yeast fair test, yogurt making)
  - Handwashing technique fair test
  - Effectiveness of "green" cleaners fair test

- Part 4: Research project and development of Public Service Announcement (PSA)
  - *Based on practices documented in student self-documentation*
  - Based on scientific research

Brenda’s participation shifts in the classroom when personal and cultural connections are leveraged. She discloses her science identity at school.
How can formative assessment support culturally responsive argumentation in a classroom community?

http://STEMteachingtools.org/brief/25
Agency in Sustained Problem-Based Inquiry: Learning Science Through and As Innovation
Research Team: Bob Abbott, Philip Bell, John Bransford, Leslie Herrenkohl, Andrew Morozov, Andrew Shouse, Giovanna Scalone, Kari Shutt, Phonraphee Thummaphan, Carrie Tzou & Nancy Vye
Investigations build on prior interest and everyday practices
Learner Interest & Agency Matters

Curriculum Redesigned For Agency & Relevance

Traditional Inquiry Curriculum

Vye, Shutt, Morozov, Thummaphan & Abbott (2015)
Yuna’s experiences with Science...

At the start:
Yuna saw science as something “White people do” or “We do it at school. It’s not something that really helps us. I think actually its hurt us.”

Yuna & ISTEAM
Studying Climate Change in the Pacific Northwest

Yuna participated in a summer “ISTEAM” program that deliberately engaged Indigenous students identities, interests, histories and ways of knowing in investigating climate change, its impacts, and explored solutions to develop climate change stories.

Learning environment engaged in:
1. Field based investigations;
2. Indigenous practices;
3. Partnered with community leaders, elders families and artists.
Yuna: Okay. This is the year before settlers came and everything was really peaceful. This is now.

Sara(T): Okay.

Yuna: This is in the future.

Sara(T): What's happening in the future? So wait, okay, so this is–

Yuna: Everything's dead. Everything is dying.

Sara(T): Everything is dying. And–

Yuna: And while the world goes into destruction. Then you can see a slow motion of what will happen.

Sara(T): Wow. That's a pretty sad story you told. Why are you smiling?

Yuna: Because ...

Sara(T): No no, tell me about it. Do you think .... Is that really what you think is going to happen?

Yuna: Yup. If nobody will change it probably what is going to happen.
Yuna’s Story of Climate Change

Sara(T): Do you think that we can change?

Yuna: Yes.

Sara(T): Yeah?

Yuna: This is just story number one.

Sara(T): Okay.

Yuna: I want to make another story to see if the next one has possibilities.

Sara(T): Ah. So this is one possible future, huh?

Yuna: Uh-huh (affirmative).

Sara(T): And you think we could have other ones? What would it take you think to have other ones?

Yuna: Everyone will work together to make better places. Unlike this part. We can change that. Everything will be living here. Healthy.

Sara(T): Okay, cool.

Yuna: If we do that then this won't happen.
Sam & Engineering Design
(Bricker & Bell)

• Sam’s leading definition for science is “building technology”
• He is a consummate designer, builder, and engineer

• Sam has a troubled academic identity at school
Students learn science best by engaging in science and engineering practices as part of sustained investigations. In the process, they come to understand disciplinary core ideas and cross-cutting concepts.
The school is in an urban neighborhood near a historical industrial section of town with factories and airfields. The community includes many first generation immigrant families. One year, students engage in a cross-setting environmental science curriculum sequence culminating in an engineering design project. (Stromholt & Bell, 2017)
Table 1  Flow of student activity for the year-long study

<table>
<thead>
<tr>
<th>Learning settings + activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Classroom: <em>About Us</em> Investigation at school using mobile platform (September 2013)</td>
</tr>
<tr>
<td>2. Forest Grove Camp Fieldtrip: <em>Data collection</em> at Living Machine wastewater treatment system works. (September 2013)</td>
</tr>
<tr>
<td>4. Classroom: Seven investigations as part of the <em>Land and Water district science kit</em> curriculum. CER. (December 2013–February 2014)</td>
</tr>
<tr>
<td>5. Classroom: <em>Background research and visits from three stakeholder organizations</em> in the Superfund clean-up process. (February–March 2014)</td>
</tr>
<tr>
<td>6. Superfund Site Fieldtrip: <em>Water quality field tests</em> of the Superfund river at a local park. (March 2014)</td>
</tr>
<tr>
<td>7. Superfund Site Fieldtrip: <em>Boat tour of the Superfund river</em> with community-based activist group. (April 2014)</td>
</tr>
<tr>
<td>8. Watershed Education Center Fieldtrip: <em>Water quality tests</em> at the source of the city’s water supply (April 2014)</td>
</tr>
<tr>
<td>9. Classroom: <em>Analysis of the water quality data</em>. Compiled student work about the Superfund site into a book that argued for increasing awareness of the environmental issues. CER. (April 2014)</td>
</tr>
<tr>
<td>10. Mayor’s Office Fieldtrip: <em>Presentation</em> of book to the Mayor to ask him to increase signage for the river in order to increase awareness of the environmental issues. (May 2014)</td>
</tr>
<tr>
<td>11. Municipal Wastewater Treatment Plant Fieldtrip: <em>Data collection</em>. (May 2014)</td>
</tr>
<tr>
<td>12. Classroom Design challenge: Used data from wastewater plant field trip to <em>design storm drain treatment system</em> to address pollution issues. CER. (May 2014)</td>
</tr>
</tbody>
</table>

Co-designed learning settings and activities across the school year
Science Learning Happens Across Settings

Everyday Settings & Family Activities
(e.g., Bell et al., 2006; Callanan & Oakes, 1992; Crowley & Galco, 2001; Goodwin, 2007)

Designed Informal Settings
(e.g., Allen & Gutwill, 2004; Callanan & Jipson, 2001; Rennie & McLafferty, 2002)

Classroom Instruction
(e.g., Barton, et al., 2003; Bell, 2004; Davis, 2003; Linn, 2006; Newton et al., 1999; Reiser et al., 2008)

Out-of-School Programs
(e.g., Halpern, 2002; Noam, et al., 2003; Gibson & Chase, 2002)
“Learning science depends not only on the accumulation of facts and concepts but also on the development of an identity as a competent learner of science with motivation and interest to learn more.”

— NRC Framework, p. 287
Building on Prior Interest & Identity

“Instruction that builds on prior interest and identity is likely to be as important as instruction that builds on knowledge alone. All students can profit from this approach, but the benefits are particularly salient for those who would feel disenfranchised or disconnected from science should instruction neglect their personal inclinations.”

— NRC Framework, p. 287
Make Deep Community Connections

“A major goal for science education should be to provide all students with the background to systematically investigate issues related to their personal and community priorities. They should be able to frame scientific questions pertinent to their interests, conduct investigations and seek out relevant scientific arguments and data, review and apply those arguments to the situation at hand, and communicate their scientific understanding and arguments to others.”

— NRC, 2012, p. 278
Students learn to ‘figure out’ how to explain and model phenomena—and design solutions
We actually need 5D Learning!

For Meaningful Experiences

Building on Learners’ Prior Interest & Identity is Key
THE MOST IMPORTANT THING IS TO KEEP THE MOST IMPORTANT THING THE MOST IMPORTANT THING.

- DONALD P. CODUTO
Equity and Justice

Quick Write

What is your leading theory / explanation for educational inequity in science?
Equity-oriented STEM education must promote a **rightful presence** for all students across the scales of justice. — Tan & Calabrese Barton (2010)

Progress frequently involves **de-settling** systems associated with historical inequities (Bang, et al., 2012) — while imagining and resourcing expansive cultural learning pathways (Bell, et al., 2012).
Equitable Science Instruction from NRC Framework Chapter 11

1. Learning is cultural. Instruction should grow out of everyday experience of learners and connect to their interests and identities.

2. Instruction should leverage science-related values, knowledge, and practices of students, their families, and cultural communities.

3. Instruction should allow students to bring their full communicative resources to bear on the situation.
## Different Equity Discourses

<table>
<thead>
<tr>
<th>Intellectual Tradition</th>
<th>Multicultural Education</th>
<th>Social Justice Education</th>
<th>Culturally Responsive Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Celebrates diversity and recognizes strength through diversity that occur in the scientific endeavor.</td>
<td>Interrogates social and political contexts and histories of marginalization in the scientific endeavor.</td>
<td>Focuses on the whole student; leverages diverse assets learners bring to situations; promotes cognitive and cultural learning through relevance.</td>
</tr>
<tr>
<td>Strategy</td>
<td>Promotes positive social interactions and relationships across difference.</td>
<td>Promotes critical consciousness work around inequity across the arenas of everyday life.</td>
<td>Legitimizes the knowledge of students and community members by relating it to academic pursuits.</td>
</tr>
<tr>
<td>In Practice…</td>
<td>Curriculum includes diverse literary pieces and perspectives.</td>
<td>Education helps people develop lenses for recognizing and disrupting inequities.</td>
<td>Instruction builds on the cultural knowledge, interests, practices, identities, and worldviews of learners &amp; communities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Underlying Concept</th>
<th>Social Harmony</th>
<th>Critical Consciousness</th>
<th>Meaningful Learning</th>
</tr>
</thead>
</table>
Whose interests are being served?
Science Learning as a Cultural Process
Assessment is often talked about as an instrumental practice related to monitoring / supporting educational achievement.

If caring is thought of as a way to make yourself more susceptible to some matters than others, assessment can be a caring practice. It is a way to focus instruction on learner voice, knowledge, and relevant supports. In the process, it can support important relationship building.

Analyzing student work is a very powerful process that supports teacher learning.
Different Formative Assessment Intervention Models (Penuel & Shepard)

Data-Driven Decision-Making Strategy-Focused

<table>
<thead>
<tr>
<th>Student 1</th>
<th>Student 2</th>
<th>Student 3</th>
<th>Student 4</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Where the learner is going</th>
<th>Where the learner is</th>
<th>How to get there</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>Clarify and share learning intentions</td>
<td>Engineering effective discussions, tasks and activities that elicit evidence of learning</td>
<td>Providing feedback that moves learners forward</td>
</tr>
<tr>
<td>Peer</td>
<td>Understand and share learning intentions</td>
<td>Activating learners as learning resources for one another</td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>Understand learning intentions</td>
<td>Activating learners as owners of their own learning</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Key aspects of formative assessment (Black and Wiliam, 2009)

Cognitive Cultural
“All science learning can be understood as a cultural accomplishment....What counts as learning and what types of knowledge are seen as important are closely tied to a community’s values and what is useful in that community context.”

— NRC, 2012, p. 284
What does “culture” mean?

• Culture is not a trait that some people have and others do not. **We are all cultural beings.**

• Culture includes **the ways in which human beings engage and make sense of the world** as we participate in the everyday activities of our communities.

• Culture reflects socially and historically organized ways of living and making sense of life—or what might be called “**sensemaking repertoires.**”

• Often, cultural worlds of youth from non-dominant communities are viewed from a deficit perspective—rather than a source of **increased rigor and relevance.**
What does “culture” mean?

“By ‘culture,’ we mean the constellations of practices communities have historically developed and dynamically shaped in order to accomplish the purposes they value, including the tools they use, social networks with which they are connected, ways they organize joint activity, and their ways of conceptualizing and engaging with the world.”

— Nasir, et al., 2014, p. 686

Activity: Make a list of cultural groups you belong to—at work, in your personal life, in your communities. Describe a few of your cultural groups with elbow partners.
What does “culture” mean?

Did you include something about science in your list of cultural communities? All science educators participate in the cultural endeavor of science, and we want students to participate in it as well.

“In this [cultural] view, learning and development can be seen as the acquisition throughout the life course of diverse repertoires of overlapping, complementary or even conflicting cultural practices.”

— Nasir, et al., 2014, p. 686

The cultural practices we need to attend to most are those used to make sense of the natural world. Learning in this view means shifts in participation.
What does “culture” mean in science education?

• Cultural specifics related to science may involve:
  – How students experience, observe, and narrate phenomena
  – To what extent they find scientific topics salient or interesting
  – How familiar they are with design and working through failure
  – How they communicate and how they engage with elders
  – How they pose questions or engage in argumentative and explanatory talk and writing

• Research shows it is crucial to approach the different cultural ways of knowing that youth bring to science learning from as an asset perspective (NRC Framework, 2012).
How Diversity Makes Us Smarter

Being around people who are different from us makes us more creative, more diligent, and harder-working. It promotes innovation.

STEM-related endeavors are better when they include culturally diverse perspectives and approaches.
Implementing Meaningful STEM Education with Indigenous Students & Families

http://STEMteachingtools.org/brief/11
What does “culture” mean?

“Everyday experience provides a rich base of knowledge and experience to support conceptual changes in science.”

“Everyday contexts and situations that are important in children’s lives not only influence their repertoires of practice but also are likely to support their development of complex cognitive skills.”

– NRC Framework, 2012, p. 284
Educational Implications of Culture

“A culturally responsive approach to science instruction involves the recognition of community practices and knowledge as being central to the scientific endeavor.”


Activity: Think of a science topic and a community you are deeply familiar with. How might the community’s sense-making practices, knowledge, history, and interests help frame the topic?
Cultural Formative Assessment Focused on Learner Interests & Experiences
Cultural formative assessment can be used to support equity & social justice

How can science instruction...

• be inclusive to the interests and goals of all students and their communities?

• connect the science students learn in class to experiences outside the classroom—in personally or culturally relevant ways?

• build on student’s experiences with natural phenomena?

• make connections between everyday and disciplinary knowledge, discourse, and ways of knowing?

• help students leverage or extend personal identities in relation to science?
Focus is on ways of knowing, doing, and being that are specific to science and other subjects. It presumes that students bring to the learning environment important knowledge, interests, and experiences from their daily lives that teachers must elicit and use to inform instruction.
“Students are likely to bring diverse interests and experiences to the classroom from their families and cultural communities. A potential focus of classroom assessment at the outset of instruction is to elicit students’ interests and experiences that may be relevant to the goals for instruction.”

— NRC, p. 127
The Equity Stance of Cultural Formative Assessment

- In terms of **rightful presence**, we should legitimize and center the cultural lives of learners—especially those from non-dominant communities—in instruction.

- In terms of **de-settling**, we want to disrupt the idea (and related materials) that science and science learning are acultural—and that only some people live cultural lives.

- In terms of **extending learning pathways**, by leveraging the interests and identities of learners we can support expansive learning experiences for youth.
How to launch STEM investigations that build on student and community interests and expertise

http://STEMteachingtools.org/brief/31
Overview of the Micros & Me Curriculum: The Microbiology of Human Health

• Part 1: Framing around microbiology and community-based health practices
  – Germ simulation
  – Community self-documentation / interviews

• Part 2: Select lessons from original *Microworlds* kit
  – Microscope use/magnification
  – What are cells?

• Part 3: Student-led investigations into microbiology and health *(informed by student self-documentation)*
  – Micros in the school (sampling and studying microorganisms)
  – Beneficial micros (yeast fair test, yogurt making)
  – Handwashing technique fair test
  – Effectiveness of “green” cleaners fair test

• Part 4: Research project and development of Public Service Announcement (PSA)
  – Based on practices documented in student self-documentation
  – Based on scientific research
Surfacing cultural health practices through self-documentation (Tzou & Bell, 2006)

- Used community health practices to guide instruction
- Self-documentation technique used to bridge community activities with school inquiry and sense-making
What are the things you and your family do to stay healthy and keep from getting sick?

As you take your pictures, please fill out the following chart. We have given you three examples.

<table>
<thead>
<tr>
<th>What is this picture?</th>
<th>Where did you take this picture?</th>
<th>What activity does this picture explain?</th>
<th>How does this activity help you stay healthy and/or keep you from getting sick?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. This is a picture of a bottle of vitamins.</td>
<td>This was in my bathroom.</td>
<td>I take a vitamin every morning.</td>
<td>I take vitamins so that my body has everything it needs to do its job, even if I don’t eat all of the types of foods I should.</td>
</tr>
<tr>
<td>2. This is a picture of a shot.</td>
<td>This is a picture of a magazine ad.</td>
<td>I get a flu shot every year.</td>
<td>I get a flu shot every year so that I hopefully don’t get the flu.</td>
</tr>
<tr>
<td>3. This is a picture of me making tea.</td>
<td>My brother took this picture of me in the kitchen of our house.</td>
<td>My family drinks this tea that we get from a store in our neighborhood.</td>
<td>My grandmother says that this tea helps people not catch the flu.</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IN THE KITCHEN

MY FAMILY DRINKS TEA

WE THINK DRINKING TEA IS HEALTHY

IN THE BATHROOM

WASHING HANDS

WASHING HANDS HELP KEEP GERMS AWAY

IN THE BACKYARD

WE EAT VEGETABLES EVERY DAY

EATING VEGETABLES IS HEALTHY THAT’S WHAT MOM SAYS

IN THE KITCHEN...

ACTIVITY: I DRINK SALTED LEMONS WITH HONEY WHENEVER I HAVE A COUGH.

WHY? MY MOM SAID IT WILL HELP ME CURE MY COUGH.

IN THE BATHROOM...

ACTIVITY: WE WASH OUR HANDS EVERY DAY.

WHY? WE WON’T PUT GERMS IN OUR FOOD AND IT HELPS US WASH THE BAD STUFF IN OUR HANDS.

IN THE DRAWER...

ACTIVITY: WE RUB THIS MEDICINE ON OUR HEADS OR OUR STOMACHS WHEN WE ARE SICK.

WHY? IT HELPS US WHEN WE HAVE A HEADACHE OR STOMACHACHE.
Activity: At your tables, analyze the student “self-docs.” Look for interests and everyday practices that could be connected to a ‘microbiology of health’ unit.

Be ready to discuss:
1. One or two interest-driven lesson connections or investigations students could engage in
2. Whether or not you would want students to scientifically test their family practices
3. How you might use the self-doc instructional technique in your teaching
Learning to See the Resources Students Bring to Sense-Making

Philip Bell, Megan Bang, Deb Morrison & Enrique Suárez
University of Washington

August 2018

Advancing Coherent and Equitable Systems of Science Education (ACESSE)

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A Few High-Level Reminders...

1. Teaching is as complex as any other profession. Expertise in teaching continues to develop for decades.

2. Strategic, incremental shifts in practice—with support and feedback from others—is the best way to refine your teaching. Continue being experimental.

3. Promoting uniformity (e.g., in curriculum, assessment, instruction,...) is in direct tension with fundamental human cultural diversity. Build capacity to attend to difference!
Whose interests are being served?
“Realizing [the] potential of [the practices] is particularly important in relation to students of color, students who speak first languages other than English, and students from low-income communities who, despite numerous waves of reform, have had limited access to high-quality, meaningful opportunities to learn science.”

—Bang, Brown, Calabrese Barton, Rosebery & Warren (2017, p. 34)
“Creating equitable learning opportunities depends critically on teachers’ skill in seeing and hearing students’ ideas and reasoning as connected to science (as opposed to being off topic, or, worse, disruptive).”

—Bang, Brown, Calabrese Barton, Rosebery & Warren (2017, p. 36)
Taking an Asset Approach to Learner (Cultural) Diversity
“Human beings, no matter who we are, where we live, or what language we speak at home, develop our ways of knowing, talking, valuing, and acting as we live our day-to-day lives inside family and community. These ways of living are what is now understood as culture. Indeed, across communities, human beings make sense of the world in ways that are both similar and different.”

—Bang, Brown, Calabrese Barton, Rosebery & Warren (2017, p. 35)
A culturally responsive approach to science instruction involves the recognition of community practices and knowledge as being central to the scientific endeavor."

Culturally Sustaining Pedagogy

Instruction can be culturally relevant by connecting to the cultural lives of youth and their communities—their languages, literacies, and practices.

It can also be a context for sustain*ing* cultural communities—by valuing and working to maintain the languages, literacies, and practices of cultural communities. Culturally sustaining pedagogy promotes cultural pluralism within our democracy.
"The bottom line is, the more you show genuine intellectual and scientific interest in your students’ sense-making [of phenomena], the more you expand the space of possible relations among you, your students, and science."

—Bang, Brown, Calabrese Barton, Rosebery & Warren (2017, p. 34)
Curriculum and assessment often promote very narrow views of “what counts” as desired ways of speaking, knowing, acting, and valuing.

We need to broaden what counts as they make sense of phenomena—especially for multilingual students, students of color, and students from low-income communities.

Diagram from page 14 in this chapter of this book:
Three principles towards more equitable science education

Principle 1: Notice sense-making repertoires. Consider students’ diverse sense-making as connecting to science practices.

Principle 2: Support sense-making. Support students to use their sense-making repertoires and experiences as critical tools in engaging with science practices.

Principle 3: Engage diverse sense-making. Students’ scientific practices and knowledge are always developing and their community histories, values, and practices contribute to scientific understanding and problem solving.

From: Bang, Brown, Calabrese Barton, Rosebery & Warren, Toward more equitable learning in science, In Helping students make sense of the world using next generation science and engineering practices, NSTA.
Conceptual Charades!
How do learners spend their time making sense of the phenomena in their everyday lives and communities?

How can we leverage those sense-making resources? We first need to learn to see them.
Learning to See Cultural Sense-Making Repertoires

What are the sense-making resources that learners are showing evidence of in each of these scenarios?
Particle physicists are theorizing about their phenomena in the lab. One of the physicists projects himself into the model of the phenomena—imagining himself to be a particle—as a way to clarify his thinking to others in the research group.

**Sense-making resources:**
- creative theorizing
- imaginative perspective-taking
- gestures + talk used for communication

One way to think about this is that our more full set of sense-making resources get “cleaned up” as we produce technical accounts of knowledge.

Sixth grade students are studying plate tectonics using a data visualization tool. As students work to make sense of key concepts — subduction, rift, and buckling — they use their hands to express their developing conceptual models before they are able to describe them in speech. Once the models appear in speech, speech and gesture together figured prominently in the elaboration, modification, and refinement of the concepts. Students often compared and negotiated their understandings.

A young Native American boy, second grade, starts at a new school. The teacher calls the parents a few weeks later. She is concerned that the boy isn’t socializing with the other children during recess.

The parent asks the teacher what he is doing—and the teacher says he spends recess slowly walking the perimeter of the school grounds. The parent pauses for a second and then responds: “Oh, I’m not sure you should be worried. He’s probably just meeting his plant and animal relations there in that setting. He’s getting to know his relations. And likely knows some there already, so he may be feeling most comfortable there. Let’s make sure he does eventually develop relationships with kids, but I think it will be fine.”

Megan Bang, personal communication, 2018.
The LAN Party Scenario

It is several days before Steve’s 10th birthday, and his family will be throwing a “LAN party” for him, his friends, and other family friends where they will play his favorite multiplayer videogame (Halo) against each other. Steve is pouring over the player profiles and analytics of the people coming to the party which are represented through various graphs and statistics. He spends hours analyzing their game-time preferences and stats while developing strategies for how he can beat them during the party.

Sense-making resources:
- time-series data analysis
- probabilistic reasoning
- predictive modeling with planning

Many youth deeply engage in videogaming with sustained design, analysis, and problem solving.

Using conductive ink, fourth grade students were investigating how altering the length and width of a conductor changes its resistance and, therefore, the brightness of a lamp connected to the circuit. Yesenia, a Latina student who was Spanish-English bilingual, observed that the lamp was brighter when connected to a circuit with wide conductive lines. In her reasoning she used the Spanish verb "estar"—which refers to a temporal state of being—to describe what was happening with the electricity as it experienced resistance. She did not use the verb "ser" which refers to a permanent state of being. This suggests that Yesenia was aware of the temporal nature of electrical phenomena, rather than thinking of electricity as a permanent steady-state phenomena.


Sense-making resources:
• material construction with sense-making
• conceptual resource in linguistic repertoire
• diagrammatic representation of model

Yesenia’s explanation:
“La energía puede ir más rápido en este lado que en este lado... porque está muy chiquito y hay menos espacio para que la electricidad vaya, y aquí hay más espacio. Entonces está más fácil que vaya acá; pero a veces se atora aquí y no puede volver a la batería.”

[The energy can go faster on [wide conductor] than on this side [thin conductor] because it [thin conductor] is very small and there is less space for the electricity to go, and here [wide conductor] there is more space. So, it is easier for it to go here [wide conductor], but sometimes it gets stuck here [thin conductor] and it can’t go back to the battery.]
The Family Robotics Scenario

A family in a robotics program are designing an animated diorama—using microprocessors, actuators, and sensors—to convey a deeply meaningful family story about when they went camping in a cabin. The five year old daughter does not appear to be centrally engaged. As they discuss options she puts a cardboard frame with a galaxy image to help her family conceptualize a starry night sky element and then starts building pieces of it. Her father starts building a reflective "star cage" using three LEDs to illuminate stars on a large black field (like a Lite Brite). The eight year old son starts programming the LEDs to gently twinkle. They continue to co-develop it.

Sense-making resources:
- problem framing and exploration
- learning through failure
- science-based, collaborative design (ideation and negotiation)
- developing solutions through iterations and optimizing

Hip Hop Science Explanations

Sense-making resources:
- everyday explanations and arguments (as a communicative literacy)
- conceptual science ideas
- personal life experiences

See #HipHopEd on Twitter & NPR Story; Video
And there are others...
Three principles towards more equitable science education

**Principle 1: Notice sense-making repertoires.** Consider students’ diverse sense-making as connecting to science practices.

**Principle 2: Support sense-making.** Support students to use their sense-making repertoires and experiences as critical tools in engaging with science practices.

**Principle 3: Engage diverse sense-making.** Students’ scientific practices and knowledge are always developing and their community histories, values, and practices contribute to scientific understanding and problem solving.

From: Bang, Brown, Calabrese Barton, Rosebery & Warren, Toward more equitable learning in science, In *Helping students make sense of the world using next generation science and engineering practices*, NSTA.
How can you learn to stop and recognize these different resources in moments of instruction? How can you cultivate a learning community where they are welcome contributions?

Instructional Strategy: Listen closely and “open up” one student’s thinking deeply. Don’t popcorn!

Once you have noticed these kinds of sense-making resources—from the repertoires of students—leverage them in making progress on science investigations.

Principle 1 → Principle 2 → Principle 3

It centers multiple ways of knowing and making
Reflection

How else do your students spend their time making sense of the phenomena in their world?

How can we leverage those sense-making resources? We need to learn to see them and then leverage them.
Designing Culturally Relevant Instruction: Overlapping Curriculum with the Lives of Students
Reminder: The very idea of phenomena

Natural phenomena are observable events that occur in the universe and that we can use our science knowledge to explain or predict. The goal of building knowledge in science is to develop general ideas, based on evidence, that can explain and predict phenomena.

Definition from Achieve, Next Generation Science Storylines & STEM Teaching Tools
Phenomena are not just what we can observe directly...
Phenomena are not just what we can observe directly...
With NGSS / Framework there are different instructional uses for natural phenomena:

❖ Anchoring Phenomena
  frame curriculum units

❖ Investigative Phenomena
  focus student investigations & sense-making

❖ Everyday Phenomena
  make personally and culturally relevant connections

http://STEMteachingtools.org/brief/42
http://STEMteachingtools.org/brief/28
Equity-Centered Science Phenomena

**Strategy:** Select phenomena that are part of broader justice projects. Some examples include:

- **Abolition:** to abolish institutions of unfreedom
  - *Life Sciences Phenomena Example:* Use of DNA identification technology to prove innocence of Blacks who were wrongly convicted; shows how science can help disrupt the school-to-prison pipeline

- **Decolonization:** the rematriation of Indigenous land and life; disrupt settler-colonialism
  - *Earth Sciences Phenomena Example:* Community greening engineering projects; promote relational knowledge of human-nature ecosystems; use science to disrupt the view that animals, plants, air, and earth are “natural resources” to be commodified

- **Of course, there are other justice projects.**
Different Ways Cultural Assessment Can Guide Instruction

1. Identifying cultural endeavors from the lives of learners and relating them to instruction. This could be done at the start of the unit or by making connections along the way.

2. Identifying compelling phenomena or culturally-grounded, local investigations for students to engage in.

3. Identifying community “action projects” that connect to science concepts (e.g., public service announcements, community building projects, justice projects).

4. Placing students in teacher-like roles, in which they can support their peers based on their life experiences and knowledge.

5. Identifying and resourcing desired identities (i.e., kinds of people they may want to become) that fit student interests, dispositions & responsibilities.
How to avoid known pitfalls associated with culturally responsive instruction

http://STEMteachingtools.org/brief/53
Sample Self-Doc Prompts

Goal: Culturally Responsive Instruction
What are the things you and your family do to stay healthy? Where do you see Newton’s second law in your life? How do you make big decisions in your community?

Goal: Identifying Community Sources of Knowledge
Which groups or individuals in our community have knowledge of how the environment is changing / has changed? How do they know what they know?

Goal: Relating Science to a Community Project
What science-related justice projects do you see in your setting / community? What challenges are faced by your community?

Goal: Establishing a New Interest
Take pictures of things, events, or people you see that you want to learn more about.

Goal: Surfacing Student Identities & Expertise
Take pictures of objects that represent who you are. Take pictures of your developing areas of expertise or interest.
Getting Our Feet Wet: Designing a Self-Doc Assessment

1. Think about a self-doc task you could use for a specific instructional purpose.

2. Select the purpose for the self-doc and draft a prompt for your self-doc task.

3. Share your draft with colleagues, review their feedback, and revise it.
What might you ask students to do to help you bridge their everyday lives and classroom experiences?

Think about a specific piece of instruction that you want to make more culturally responsive—then consider which of the following goals you have for that instruction...
Goal: Establishing a New Interest

Are you trying to help students develop a new interest in a science-related topic, phenomena, idea, or practice?

If so, highlight the relevant aspect of science and discuss related details with students. Use an exit ticket to identify which students want to learn more about it—and provide them with follow-on learning resources.
Goal: Culturally Responsive Instruction

Are you trying to connect instruction to student’s interests, hobbies, experiences, or expertise? Or to the practices and goals of their community?

If so, use self-documentation or an interest survey to draw out learning assets that can be related to instruction. You may identify phenomena students can investigate—or you may want to identify students who have relevant expertise to serve as “co-teachers.”
Goal: Connecting to Global / Local Equity Project (Social Focus Question)

Are you trying to help students understand how scientific knowledge relates to global / local contexts?

Focus instruction on having students make sense of how scientific knowledge relates to specific equity projects.
Goal: Relating Science to a Community Project or Source of Knowledge

Are you trying to help students see how scientific knowledge can inform a community endeavor? How it can leverage community knowledge?

If so, use self-documentation to identify actual community connections and focus an “action project” on researching and engaging with the community about the topic. Have students map and explore local expertise.
Goal: Learning about Possible Futures

Are you trying to help students learn how instruction connects to a possible future they might find desirable?

If so, help them see how the science knowledge and practices relate to social endeavors in the world, get them to express their interests, and resource them as possible. Support students using productive identity archetypes that help them build towards desired possible futures.
Design Time! What instructional sequence could be developed (or adapted) to be culturally responsive? Center the cultural lives of learners and their communities. Push yourself!

Here are the design directions to consider:

• Establishing a New Interest
• Culturally Responsive Instruction / Support Multiple Ways of Knowing
• Connecting to Global / Local Equity Project
• Relating Science to a Community Project or Source of Knowledge
• Learning about Possible Futures
Reflection & Wrap Up
Reflecting back...

“All science learning can be understood as a cultural accomplishment... What counts as learning and what types of knowledge are seen as important are closely tied to a community’s values and what is useful in that community context.”

— NRC, 2012, p. 284
Equity-oriented STEM education must promote a **rightful presence** for all students across the scales of justice. — Tan & Calabrese Barton (2010)

Progress frequently involves **de-settling** systems associated with historical inequities (Bang, et al., 2012) — while imagining and resourcing expansive cultural learning pathways (Bell, et al., 2012).
Three principles towards more equitable science education

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From: Bang, Brown, Calabrese Barton, Rosebery & Warren, Toward more equitable learning in science, In *Helping students make sense of the world using next generation science and engineering practices*, NSTA.
1. Increase representation & participation in STEM
2. Emphasize increased student achievement in science—often starts (and sometimes ends) with opportunity & access, perhaps ‘sameness’, often ‘rigorous’ instruction
3. Problematize the privileged forms of science—work to expand ‘what counts as science,’ ‘who does science,’ ‘when is science’
4. Focus science learning on youth & community purposes—youth & community agency is centered; accountability shifts to personal & community goals
5. Leverage science in justice movements—prioritizes science as a tool in community organizing and social movements, requires view of historical inequity

Adapted from Philip & Azevedo, *Science Education*, 2017
Professional Learning Resources to Support NGSS Implementation

- Co-designed by practitioners & researchers
- Tested & refined over time
- Easily shareable—over social media, email, paper

STEMteachingtools.org
@STEMteachtools (Twitter)
facebook.com/STEMTeachingTools
Help us improve the resource

Please take this brief survey to help the ACESSE team improve this resource for others...

http://tinyurl.com/AcesseResourceC
Thank you! For more info...

Relevant Resources

• STEM Teaching Tools
  STEMteachingtools.org (web site)
  @STEMTeachTools (twitter)
  STEMTeachingTools (Facebook)
  STEMteachingtools.org/newsletter (newsletter sign-up)

• Indigenous Education Tools
  indigenouseducationtools.org

• Other ACESSE PD Modules on Formative Assessment
  STEMteachingtools.org/PD

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