Adapting Curriculum for Equitable 3-Dimensional Learning

Philip Bell & Shelley Stromholt
University of Washington

Bill Penuel, Katie Van Horne & Tiffany Clark
University of Colorado, Boulder

March 2016

RESEARCH + PRACTICE COLLABORATORY

Overview of Session Themes

+ How to engage networks of teachers in curriculum adaptation and curriculum development to build capacity for equitable 3-D instruction while developing instructional materials

+ How to develop and adapt 3-D formative assessments using “task formats”

+ How to identify anchoring phenomena for instructional units

Break the Norm!
Stand as much as you like!

Students learn science best by engaging in science and engineering practices in sustained investigations as they learn and apply disciplinary core ideas & cross-cutting concepts.

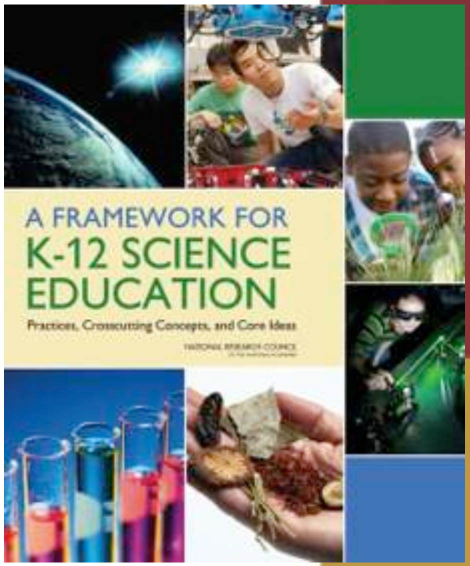
"The most important thing is to keep the most important thing the most important thing."

— Donald P. Coduto

Equity in science education: The struggle continues…

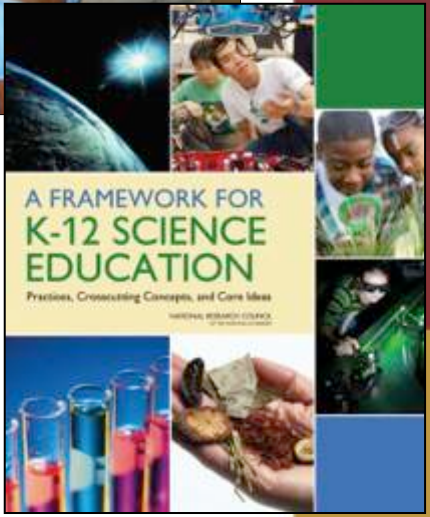
"Equity in science education requires that *all* students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with **access to quality space, equipment, and teachers** to support and motivate that learning and engagement; and **adequate time spent on science**. In addition, the issue of **connecting to students' interests and experiences** is particularly important for broadening participation in science."

— *NRC Framework*, p. 28



Equity & Diversity (Chapter 11)

- Equalizing opportunities to learn
- Inclusive science instruction
  - Science Learning as Cultural Accomplishment
  - Relating Youth Discourses to Scientific Discourses
  - Building on Prior Interest & Identity
  - Leveraging Students' Cultural Funds of Knowledge
- Making diversity visible
- Value multiple modes of expression



In groups of 3, quickly share one equity-focused initiative in science education you have observed in your state this year?

Research+Practice Collaboratory

Developing research-practice partnerships to investigate problems of practice and develop useful instructional strategies and tools that can be shared broadly.

Collaborating Organizations

- University of Washington Institute for Science + Math Education (Bronwyn Bevan, PI)
- Exploratorium
- Education Development Center, Inc.
- University of Colorado, Boulder
- Inverness Research Associates
- SRI International

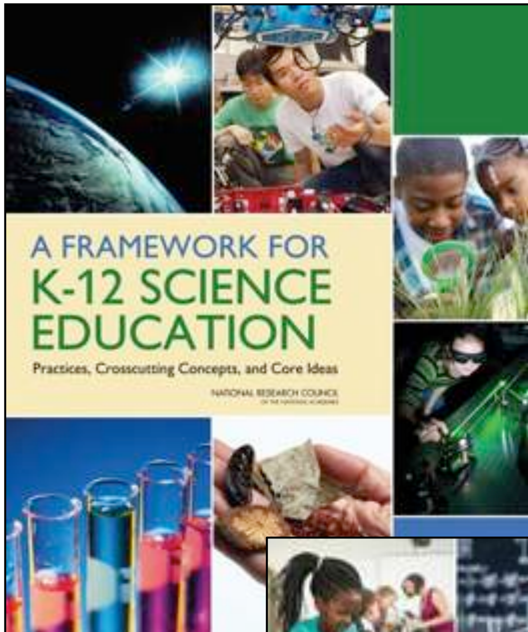
Four Themes of Work

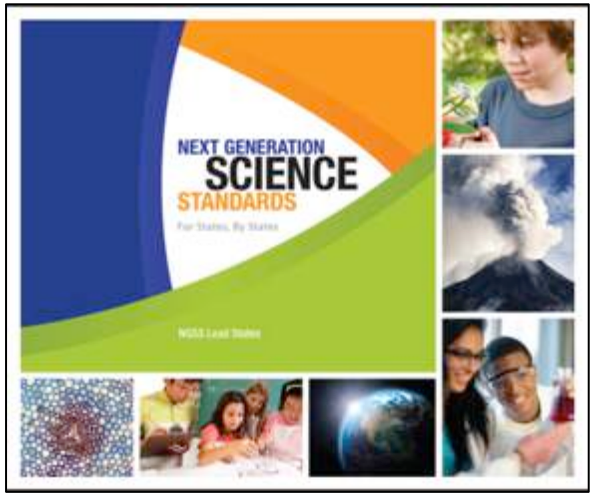
- **STEM Practices**
- **Formative Assessment**
- **Implementation Research**
- **Interactive Technologies**
- **Learning Across Settings**

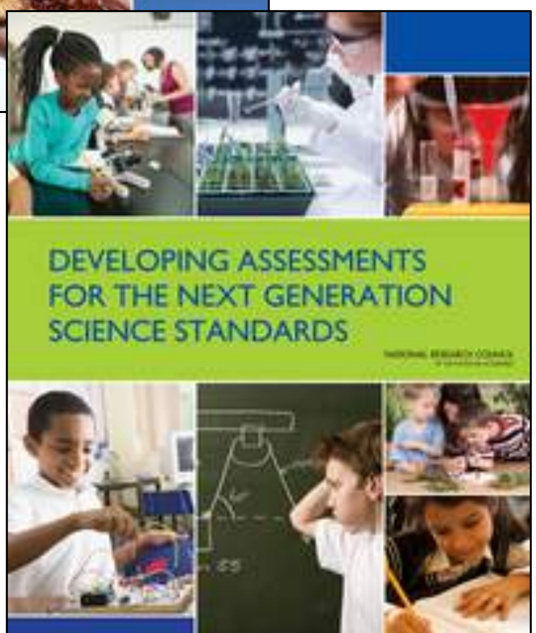
Partnership for Science & Engineering Practices
Seattle & Renton School Districts
Photo by Institute for Systems Biology, June 2013

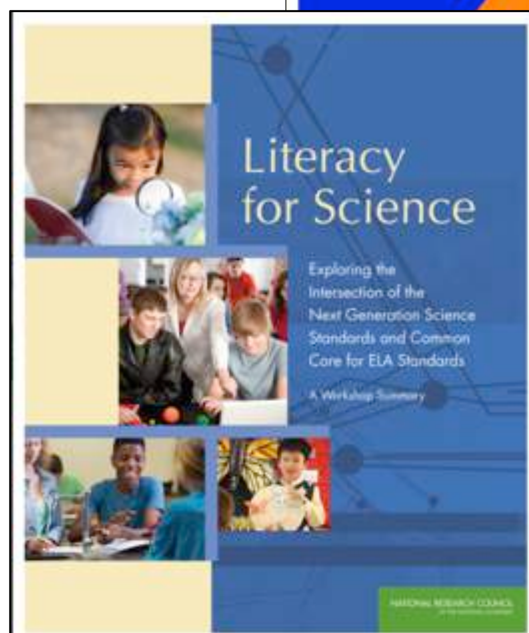
nap.edu

THE NATIONAL ACADEMIES









Professional Learning Resources to Support NGSS Implementation


STEM #5

Using curriculum adaptation as a strategy to help teachers learn about NGSS *and* developing aligned instructional materials

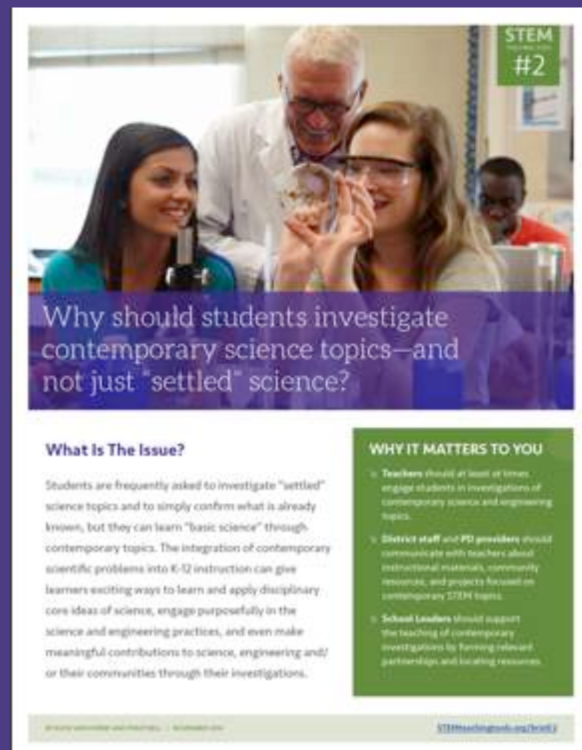
What Is The Issue

Using curriculum materials aligned to NGSS is a crucial part of implementation, but there is very little aligned curricula to choose from, districts may not have resources to purchase it, and teachers typically don't have time to develop new curriculum from scratch. However, teachers can effectively adapt existing curriculum materials and instruction to better align with NGSS. This can help them learn about important parts of the NGSS vision for learning—and result in instructional materials for use across classrooms.

WHY IT MATTERS TO YOU

- **Teachers** should analyze and adapt tasks in existing curriculum to support student engagement in the science and engineering practices.
- **District staff** and **PD providers** should learn about how to support networks of teachers to engage in curriculum adaptation and share the resulting instructional materials.
- **School leaders** should support efforts to engage teachers in adapting, testing, and refining enhancements of currently-aligned curriculum materials.

STEMteachingtools.org/brief/5


STEM #2

Why should students investigate contemporary science topics—and not just "settled" science?

What Is The Issue?

Students are frequently asked to investigate "settled" science topics and to simply confirm what is already known, but they can learn "basic science" through contemporary topics. The integration of contemporary scientific problems into K-12 instruction can give learners exciting ways to learn and apply disciplinary core ideas of science, engage purposefully in the science and engineering practices, and even make meaningful contributions to science, engineering and/or their communities through their investigations.

WHY IT MATTERS TO YOU

- **Teachers** should at least at times engage students in investigations of contemporary science and engineering topics.
- **District staff** and **PD providers** should communicate with teachers about instructional materials, community resources, and projects focused on contemporary STEM topics.
- **School Leaders** should support the teaching of contemporary investigations by forming relevant partnerships and locating resources.

STEMteachingtools.org/brief/2


STEM #7

Learning STEM Through Design: Students Benefit from Expanding What Counts as "Engineering"

What Is The Issue?

Engineering design activities can be a powerful entry point into science learning. Engineering is typically defined very narrowly in K-12 education, which keeps students from engaging in rich classroom activities that connect professional practices to the many ways engineering and design can play out in their personal lives and communities. For this reason, it is useful to promote a broad view of "engineering" in the classroom.

WHY IT MATTERS TO YOU

- **Teachers** should embed engineering cycles in their science instruction and heighten relevance by focusing on local and community-centered design.
- **District staff** and **PD providers** should help teachers include engineering design in their teaching and provide them with relevant tools and skills to facilitate the design work of students.
- **School Leaders** should support building capacity in engineering and design instruction in science across K-12 grades as an equity priority.

STEMteachingtools.org/brief/7

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

STEMteachingtools.org (web)
@STEMteachtools (twitter)
pinterest.com/stemeducation (pinterest)

Promoting Deep & Lasting Change in Education (Coburn, 2003)

- Educators, policymakers, and researchers still grapple with the question of how pockets of successful reform efforts might be "scaled up."
- The solitary focus on increasing "the numbers" in improvement efforts is too simplistic.
- There is a need for greater attention to the *depth of implementation* and a focus on *shifts in reform ownership*.
- Four dimensions are relevant: depth, sustainability, spread, shift in reform ownership.

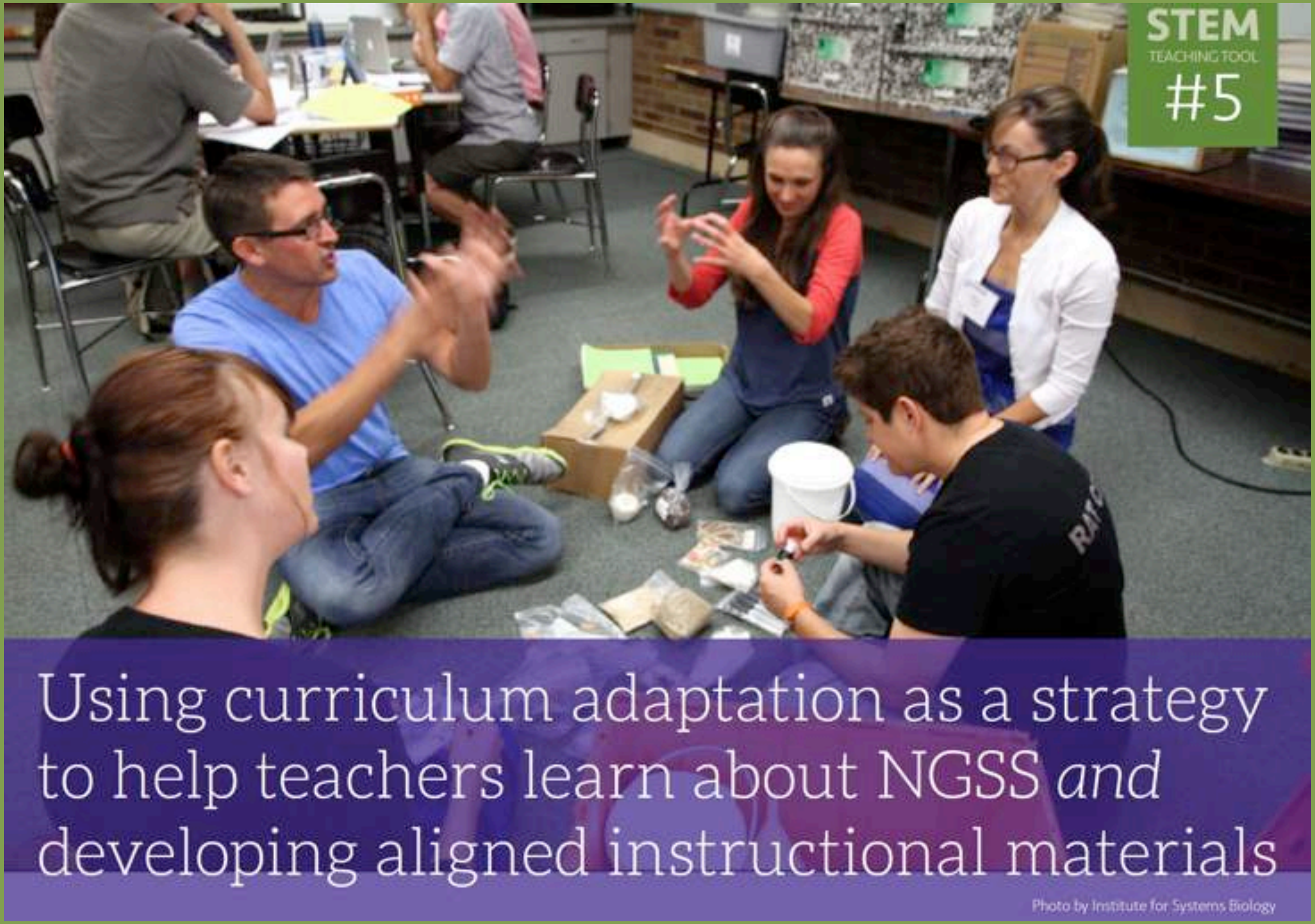
Interrelated Dimension 1: **Depth**

- Reforms must effect deep and consequential change in classroom practice—in support of learning.

- *Deep Change*: structures or materials, clas f specific activi norms of soci principles as

But, how can this be supported through educational improvement projects focused on instructional materials working at systems-level scale?

  - Deep change is culture change.



Skim the tool. At your tables discuss: What new ideas occur to you? What opportunities do you have to support curriculum adaptation within your state?

Partnership
For Science & Engineering Practices

Seattle Public Schools & Renton School District; UW Education & UW Biology; Institute for Systems Biology

CURRICULUM ADAPTATION PD MODEL

Build capacity with networks of 100 teachers per year to teach science kits adapted to support student engagement in NGSS science & engineering practices.

Curriculum adaptation, enactment, and iterative refinement of existing materials is the educational improvement strategy. Teacher leadership development and resource development / sharing are secondary strategies.

Photos by Institute for Systems Biology, June 2013

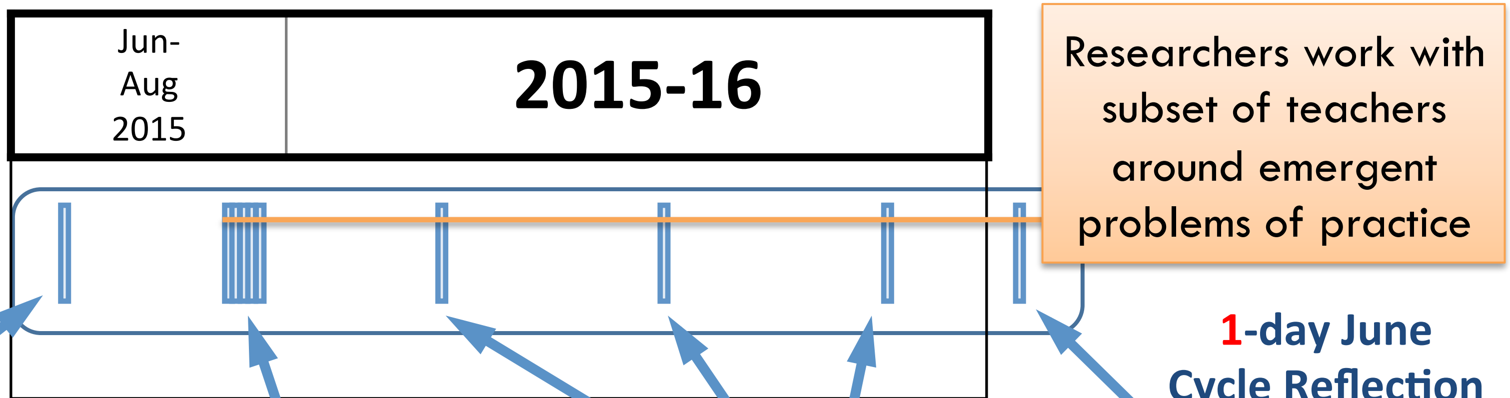
RESEARCHER & PRACTITIONER COLLABORATION

Teachers learned about NGSS practices through worked examples, readings, student work, and real world applications. Grade-level groups adapted existing curriculum. Modified units taught by group members and iterated upon over school year.

Researchers: worked with PSEP staff to inform the improvement effort; collaborated with select teachers to study, refine, and disseminate instructional materials & tools; and conducted design-based implementation research across the teacher network.

Photo by Institute for Systems Biology, August2013

Year-long PD cycle (80 hours)



1-day June Cycle Launch

- Brief NGSS overview
- STEM professionals' authentic Science & Engineering Practices

5-day August workshop

- Disciplinary science models
- Language acquisition principles & strategies
- Collaborative adaptation of curricular materials

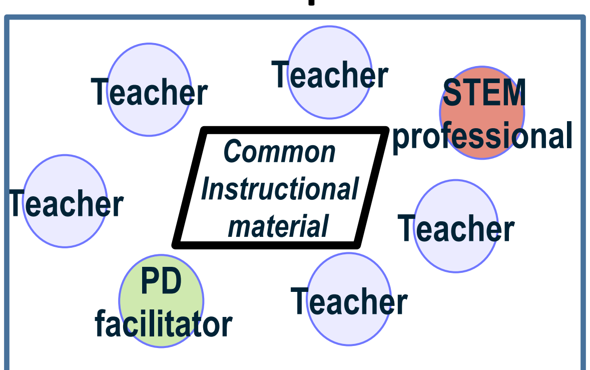
3 school-year release days

- Analysis of student work
- Discourse strategies
- Deepening content knowledge
- Refinement of curriculum adaptations

1-day June Cycle Reflection

- Analyze outcomes
- Apply learning to district curriculum policies

Curriculum adaptation teams



Three Year Project

+ Teachers in grade-level, small groups of 4 to 6
+ Small groups are engaged in parallel innovation to adapt a specific unit
+ Units were taught, refined, and handed off across each year
+ Year 1: Deep dive into 3D & practices; initial curriculum adaptation work; subject matter learning
+ Year 2: Added Practices 201 sessions & Differentiated PD sessions; added next set of units
+ Year 3: Integrating subset of adaptations into coherent curriculum units; polishing work

Teacher Reactions to the Curriculum Adaptation Project

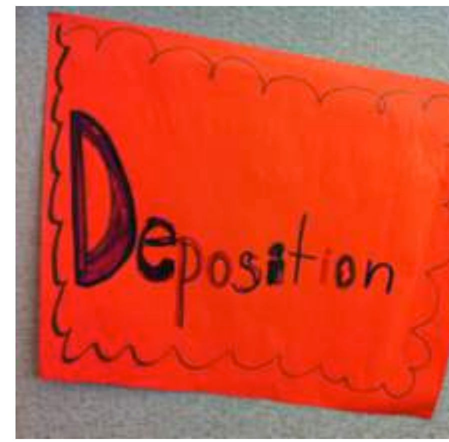
- Appreciated how we leveraged practitioner differential expertise with implementation, but also supported them to learn new things in safe ways
- Appreciated how it was "real work" focused on direct needs of practice (curriculum materials, rubrics, instructional strategies…)
- It helped them develop cross-building relationships with their peers that they found meaningful
- Veteran teachers were saying that it was some of the best district PD they had experienced

Focusing curriculum adaptation on supporting equity

+ Adapting curriculum to support learner agency

+ Embedding discourse strategies into instruction to promote more equitable participation

+ Developing 3D formative assessment sequences to integrate into the units



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

Agency-focused Redesign

- Redesigning hands-on, commercial inquiry science kits for fifth and second grade to afford elementary students greater *agency*
- Based on the STAR Legacy learning model (Schwartz & Bransford, 1998) & culturally relevant instruction (Tzou & Bell, 2010; Bell et al., 2012)
- Design-based implementation research (DBIR) initiative across a suburban district (Penuel, Fishman, Cheng & Sabelli, 2011)

Funded by NSF DR-K12#1019503 & LIFE SLC#0835854

Challenge-based Activities

- Phenomena that are evocative invite inquiry (Bransford et al., 1990; Petrich et al., 2013)

Is the water clean? Would <u>you</u> swim in the water?

- Students scaffolded to conduct investigations

Investigations build on prior interest and everyday practices

Investigations build on prior interest and everyday practices

Students in both conditions thought science was "fun."
Students using FOSS = hands-on, more autonomy
Students using agency design = science served a real social purpose, self-designed investigations

Interest-driven, agentic investigations led to…
→ Broadened view of STEM participation
→ Greater Social Value for Science
→ Greater Science Identification

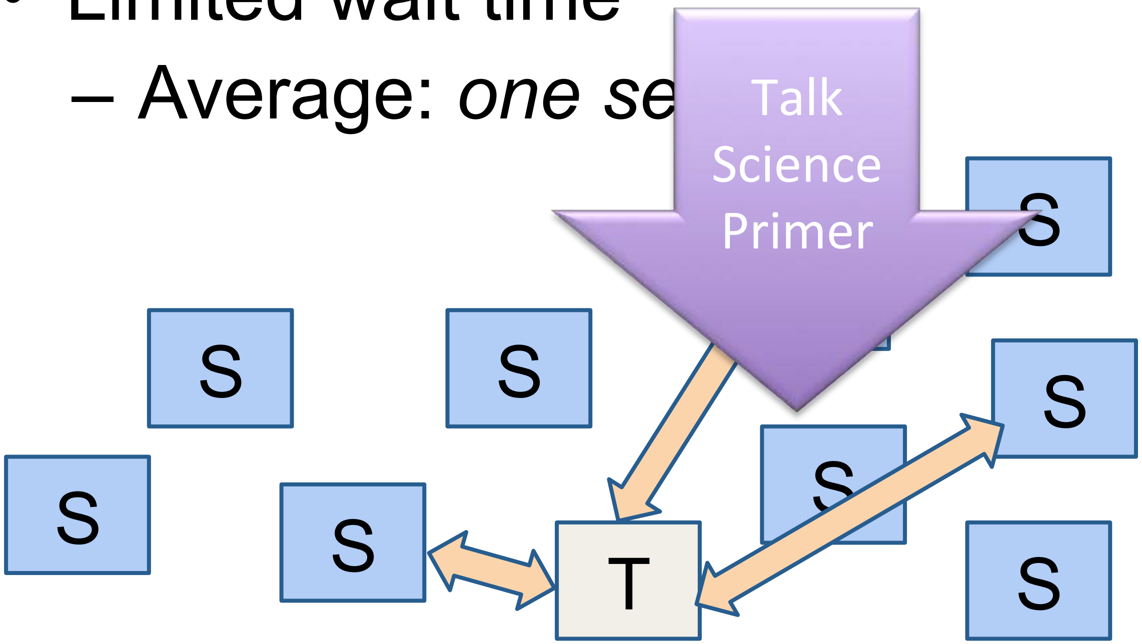
Giovanna Scalone (2015)

Learner Interest & Agency Matters

Discourse Strategies

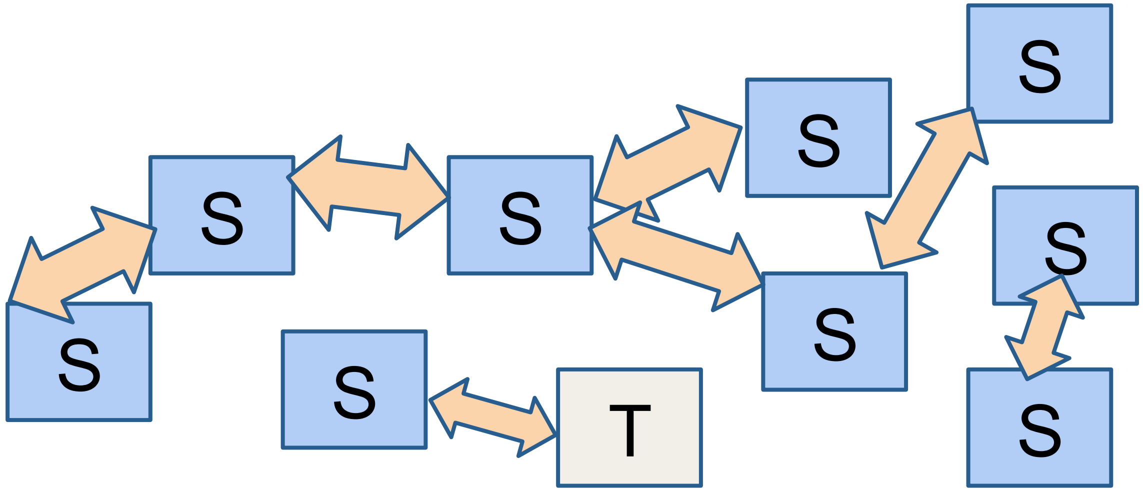
Common Patterns in Classroom Talk

- Cycles of Initiate, Response, Evaluate (IRE)
- Limited wait time
  - Average: *one se*



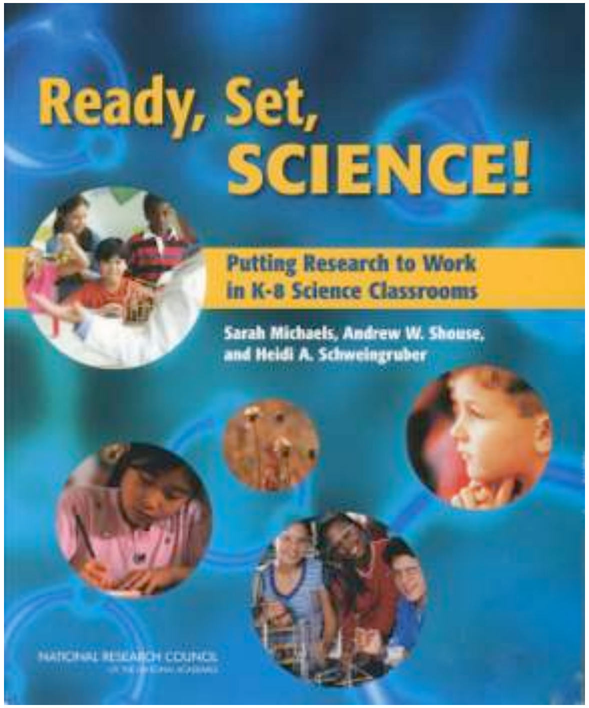
More Supportive Classroom Talk

- Students must listen to each other
- Clear goals and format



Why should we consider classroom discourse in science?

"In order to process, make sense of, and learn from their ideas, observations and experiences, students must talk about them... Talk forces students to think about and articulate their ideas. Talk can also provide an impetus for students to reflect on what they do—and do not—understand."



Why should we consider classroom discourse in science?

Talk…

- Builds a chance for students to be themselves (Nasir, 2012)
- Builds science language in low-pressure, highly authentic environment
- Relates youth discourse with science discourse—from home to school (NRC, 2012; Warren et al., 2001)
- Aligns with how scientists construct and apply knowledge (Lemke, 1990)
- Adheres to goals of the Framework (NRC, 2012)

NGSS Discourse Strategy Resources

1. Read and explore the links in this brief:

   [How Can I Get My Students to Learn Science By Productively Talking with Each Other?](http://stemteachingtools.org/brief/6)

   http://stemteachingtools.org/brief/6

   [How can formative assessment support culturally responsive argumentation in a classroom community?](http://stemteachingtools.org/brief/25)

   http://stemteachingtools.org/brief/25

2. Take a deeper look into the resources we discussed today.

   http://tinyurl.com/sciencediscourse

   http://tinyurl.com/sciencediscourse2

Assessment of Student Thinking

How can you explain a fogged mirror?

Sample Classroom Assessment

UNIVERSITY *of* WASHINGTON

Imagine that it is a cold, winter day. You take a hot shower and the mirror in the bathroom fogs up.

1. Briefly describe 1 or 2 possible explanations for this phenomenon.

   1)

   2)

2. Pick one of your explanations to investigate by circling it above. Write a general science question that would test your selected explanation.

   ____

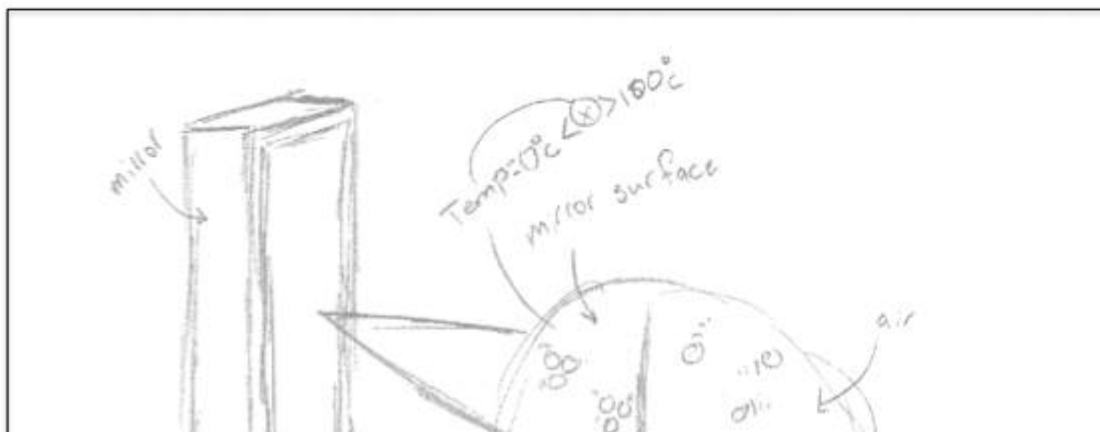
   ____

   ____

   ____

3. Imagine that you had a powerful microscope and could see what happens when water vapor coming from the shower hits the cold mirror. Draw a scientific model of this and be sure to show:
   - temperature change
   - particle motion
   - kinetic energy
   - phase change

   Clearly label all model components.



3D NGSS & CCSS Learning Targets

Bundle: MS-PS1-4, MS-PS1-5, MS-PS3-5, CCSS ELA-Literacy.RST.6-8.7

The assessment cluster focuses on:

1) Practices = Asking Questions; Develop and Using Models; Construc[...] Designing Soluti[...]
2) DCI: Changes in [...] and change of sta[...] thermal energy a[...] of mass / energy [...]
3) CCC: Cause & Effect

For the purpose of highlighting student understanding, groups of items were designed to have students draw visual representations of their models and write an explanation.

Modeling Rubric for Student Work

Rubric for Student's Scientific Modeling (DRAFT) — base elements plus optional ones based on instruction

Base Scoring Elements	Not Yet		Approaches Expectations		Meets Expectations		Advanced
	1	1.5	2	2.5	3	3.5	4
1) Explains Phenomena: Does my model explain the phenomenon?	Model does not explain the phenomenon of the investigation.		Model includes some of the relevant parts of the model to explain what *caused* the phenomena. Model might include text and diagrams.		Model connects all relevant components and relationships (observable and unobservable) of the model to explain what *caused* the phenomena. Model includes text and diagram(s) to describe model pieces and processes.		Model includes the relevant parts of the model to explain what caused the phenomena (as in Level 3)—as well as additional components and relationships that fit the scientific model.
2) Fits with Evidence: Does my model fit with the evidence collected?	Evidence is not correctly related to the model.		Model correctly incorporates some of the evidence collected through the investigations.		Model refers to a sufficient amount of relevant evidence collected through the investigations to be compelling.		Model fits with all of the evidence collected and additional evidence that could be collected is described.
3) Builds on Science Ideas: Does my model incorporate established scientific ideas?	Model does not include relevant science ideas.		Model includes some of the essential concepts to explain the phenomena—but not all that are needed.		Model includes essential disciplinary science concepts AND crosscutting concepts needed to explain the phenomena.		Model includes essential science concepts and other relevant science ideas.
4) Clarity of Communication: Would someone else be able to understand my model?	Model is not clearly described.		Model is somewhat clearly described.		Model is clearly explained in a way that allows others to understand how and why the phenomenon happens. Diagram and text include agreed-upon AND personally compelling conventions for representation.		Model is clearly described and additional communication or educational pieces are included for the audience.
5) Generality: Can my model be used to explain related phenomena?	Model is not related to phenomena beyond the focal phenomenon.		Description of the model is applied to the phenomenon of the investigation and an attempt is made to another.		Model-based explanation is applied to the phenomenon of the investigation and one other that is directly parallel or about a broader natural system.		Description of the model is applied to the phenomenon of the investigation, a parallel phenomenon AND some other natural system.

Assessment Task Formats for the Practices

We are creating compendium of task formats for the science and engineering practices that help with the design of assessment components—might also guide instruction.

http://researchandpractice.org/NGSSTaskFormats

Task Formats for Developing & Using Models

Format	Task Requirements for Students
1	Present two models to students, *then* Ask them to compare the models to identify both common and unique model components, relationships, and mechanisms.
2	Present students with an illustration or drawing of a scientific process or system, *then* Ask students to label the components, interactions, and mechanisms in the model, *and* Write a description of what is shown in the drawing.
3	Present students with a model of an observable scientific process or system and some evidence about how the system behaves that does not fit the model, *then* Ask students to revise the model to better fit available evidence.
4	Present students with a textual description of an observable scientific phenomenon, *then* Ask students to draw and label the model components, interactions among components, and mechanisms in the model, *and* Ask students to write an explanation for the phenomenon, using the model as supporting evidence.

Task Formats for Engaging in Argument from Evidence

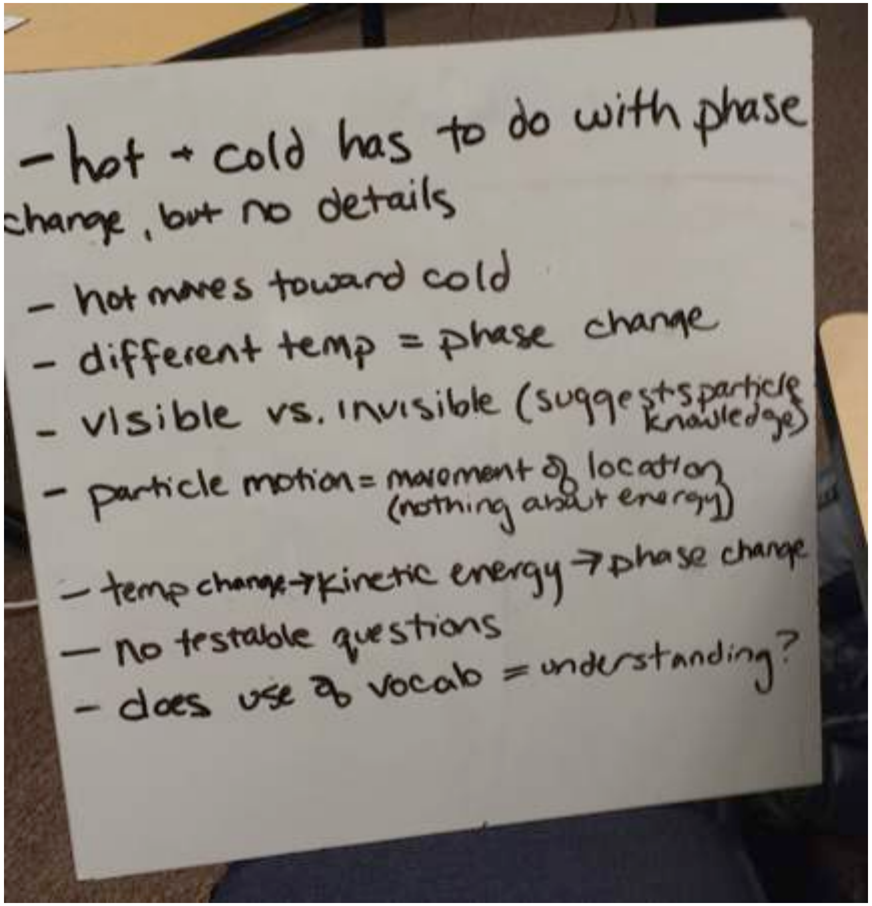
Format	Task Requirements for Students
1	Present two different arguments related to a phenomenon, one with evidence and one with-out, *then* Ask students to identify the argument that is more scientific and ask them why they think that is the case.
2	Describe a phenomenon to students, *then* Ask students to articulate (construct) a claim about that phenomenon, and Identify evidence that supports the claim, *and* Articulate the scientific principle(s) that connect each piece of evidence to the claim.
3	Present students with a claim about a phenomenon, *then* Ask students to identify evidence that supports the claim, *and* Articulate the scientific principle(s) that connect each piece of evidence to the claim.
4	Present students with a claim **and** evidence about a phenomenon, *then* Ask students to assess how well the evidence supports the claim.

Task Formats for Designing Solutions (Engr)

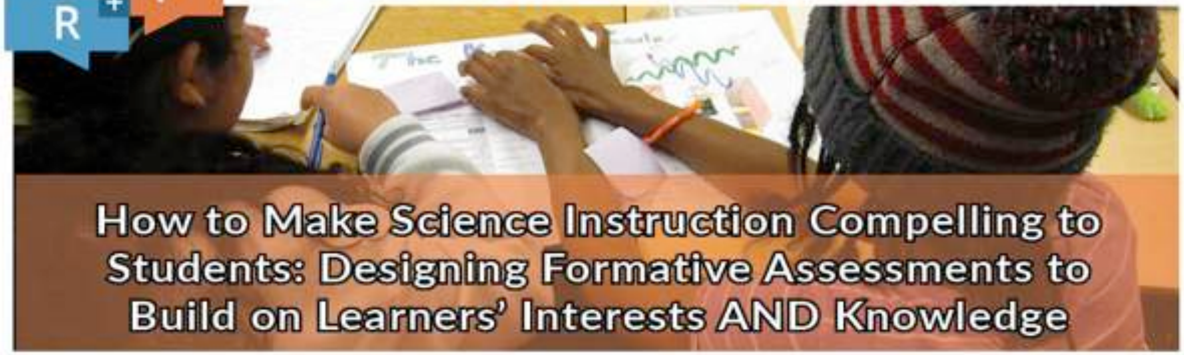
Format	Task Design for Students
1	Describe or showcase a human problem, desire, or need along with design criteria and con-straints, *then* Ask students to sketch or describe a design approach that develops a possible solution to the problem. *and* Ask them to explain how the relevant scientific ideas are taken into account within their design.
2	Describe or showcase a human problem, desire, or need along with design criteria and con-straints, *then* Ask students to sketch and prototype a design that is a possible solution to the problem using relevant materials. (Performance Task)
3	Describe a designed system and data from a failure scenario associated with the design, *then* Ask them to analyze the data and identify the scientific causes of the failure. Possibly ask them to sketch or describe a design iteration that might be an improvement to the design.

Teacher Analysis of Student Thinking

- Teacher groups analyzed student responses and tried to identify facets of thinking (Minstrell, 1989)
- Teachers then developed instructional plans to extend student thinking
- Traditional views of right/wrong scientific ideas and misconceptions interfered with the task



Join us for a NSTA Conference Workshop



March 31, 3:30pm–4:30pm | Renaissance Nashville Hotel, Fisk Two

Led by Philip Bell and Shelley Stromholt (University of Washington) and William Penuel and Katie Van Horne (University of Colorado at Boulder)

Join us for a NSTA Conference Workshop

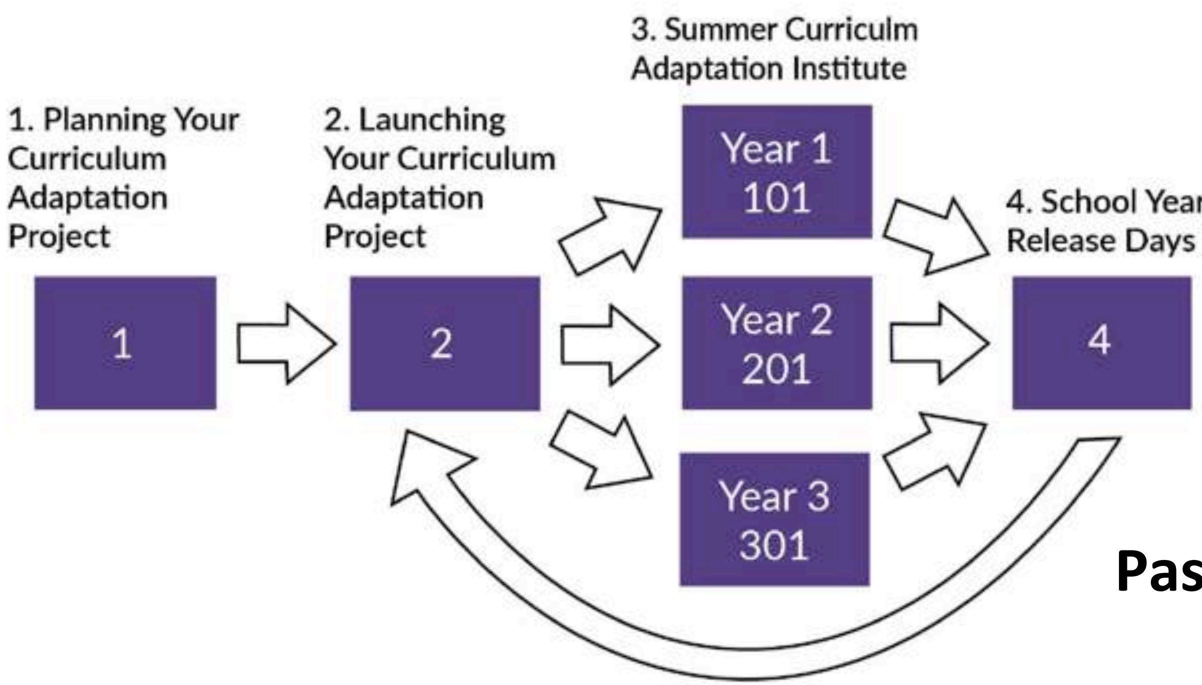
April 2, 11am–12pm | Music City Center, 105B

Led by William Penuel and Katie Van Horne (University of Colorado at Boulder) and Philip Bell and Shelley Stromholt (University of Washington)

RESEARCH + PRACTICE COLLABORATORY

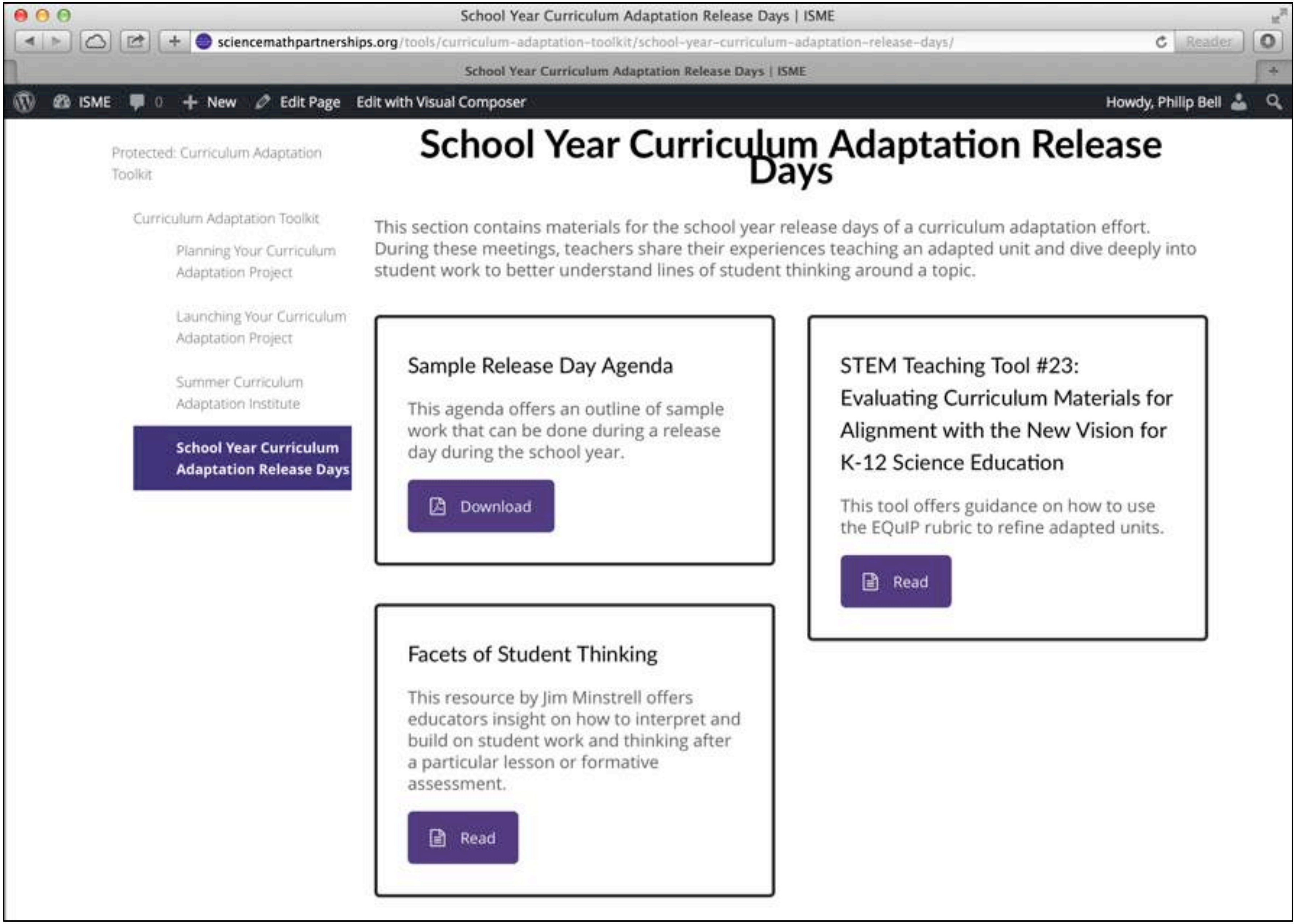
TOOLKIT

Curriculum Adaptation Toolkit



Password: Test

sciencemathpartnerships.org/tools/curriculum-adaptation-toolkit



sciencemathpartnerships.org/tools/curriculum-adaptation-toolkit

With respect to curriculum adaptation, what are the problems of practice you have witnessed—or could anticipate?

http://tinyurl.com/CurricAdaptation

Problems of Practice for Curriculum Adaptation

+ Keeping equity foregrounded in the work
+ Having adequate resources to build teacher capacity for curriculum adaptation
+ Managing variation in teacher's pedagogical approaches while working towards coherent unit design
+ Working against practices turning into routinized procedures (CER, design, modeling)

Selecting a Scientific Phenomenon or Engineering Design Challenge to Anchor a Sequence of Lessons

Katie Van Horne & Bill Penuel, University of Colorado Boulder

Phenomena Are Everywhere, Which Are Useful for 3D Learning?

+ What approaches have you seen?

+ Which ones strike you as promising? As unsuccessful?

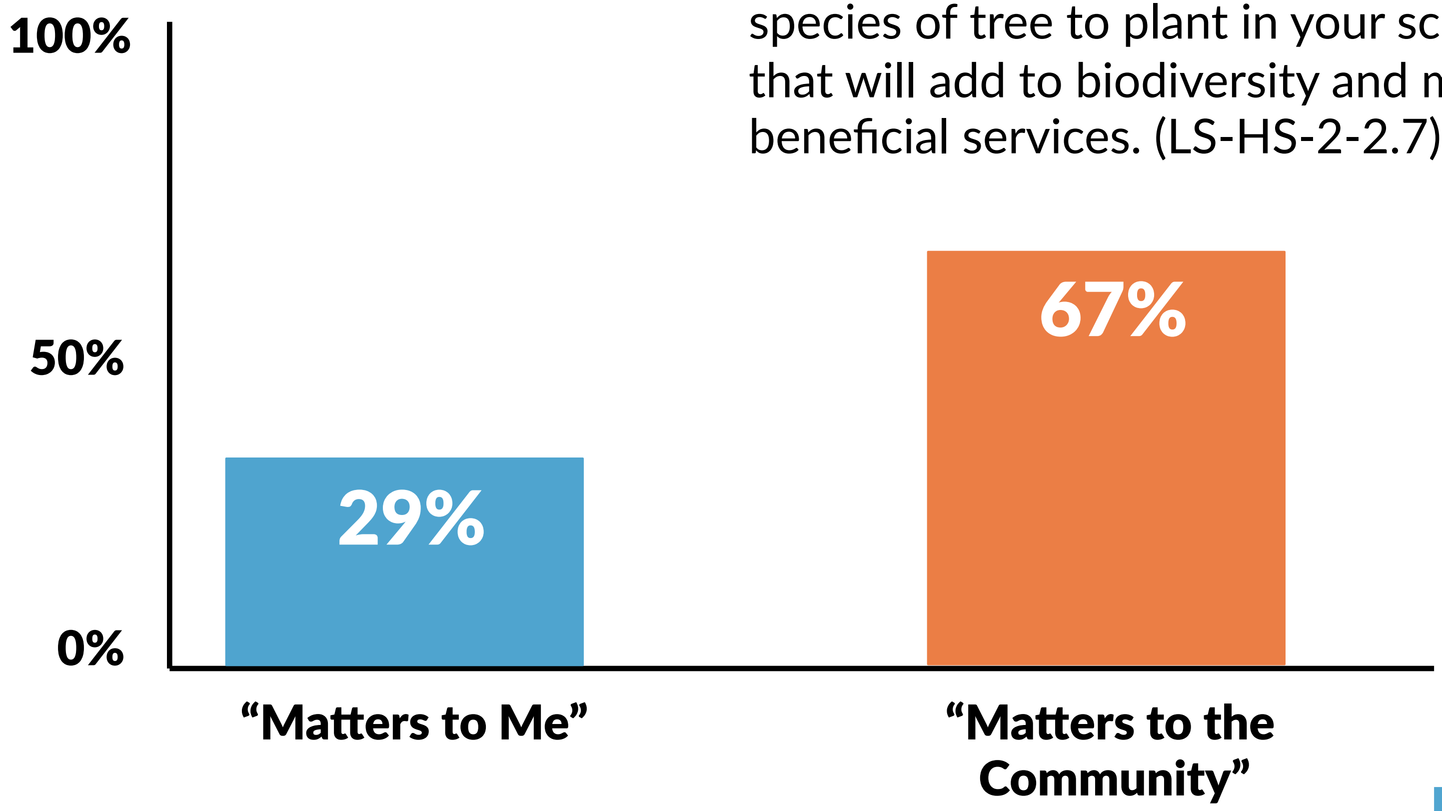
+ What distinguishes the promising from the unsuccessful strategies for identifying candidate phenomena?

Denver iHub Partnership

+ Focused on curriculum development as a strategy
+ Use Reiser's *storyline* approach to developing sequences of lessons
+ Unique addition: A process for selecting "anchors" that are both viable means to support student learning and that have strong connections to students' interests and experiences
    + Engineering design challenges with a real-world connection ("citizen engineering")
    + Science phenomena that are **personally** and **community** relevant

Evidence of Relevance

Engineering Design Challenge: Choose a species of tree to plant in your school yard that will add to biodiversity and maximize beneficial services. (LS-HS-2-2.7)



Our Design Principles

- Embody the principles of the *Framework*, especially:
  - Promoting 3-D science learning
  - Connecting to student interests and experiences
  - Promoting equity
- Deeply address multiple standards
  - *Next Generation Science Standards*
  - *Colorado Academic Standards*
- Connect teachers and learners to the community through technology and partnerships
- Support student investigations that contribute to larger citizen science/community initiative

Our Four Phase Approach

- Identifying and selecting good anchors for sequences of lessons **takes time.**
- Expect **false starts**, but researching possibilities before designing assessments and lessons can **improve efficiency** by increasing the likelihood that phenomena and design challenges:
  - are "viable," that is, have potential to support students' three dimensional science learning
  - have necessary data that are accessible to students
  - connect to a broad range of students' interests and experiences

Phase/Meeting 1

Analyze ("Unpack") the Focal DCIs

Participants:
Teachers and Teacher Leaders

Do ahead of time:
Decide on focal DCIs for lesson sequence

Phase/Meeting 2

Brainstorm and Conduct Research on Candidate Phenomena/Challenges

Participants:
Teachers and Teacher Leaders, and if available, a local scientist or engineer

Do ahead of time:
Identify any local scientists or engineers to participate

Criteria for a Good Anchor (1 of 2)

A good anchor builds upon everyday or family experiences: Who they are, what they do, where they came from.

A good anchor will require students to develop understanding of and apply multiple performance expectations.

It is too complex for students to explain after a single lesson.

Criteria for a Good Anchor (2 of 2)

A good anchor is observable to students.

A good anchor can be a case (*pine beetles' destruction of lodgepole pine forests*) or something that is puzzling (*Why isn't rainwater salty?*).

A good anchor has relevant data, images, and text to engage students in the range of ideas students need to understand.

Phase/Meeting 3

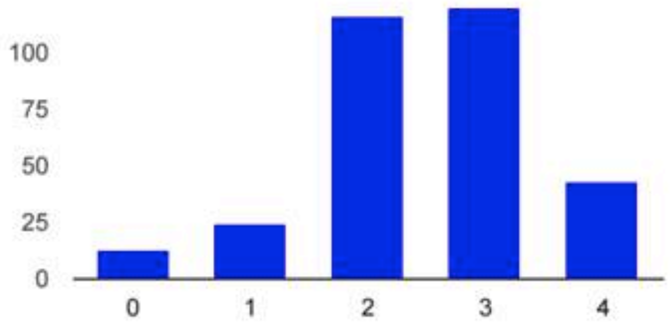
Engage Students in Prioritizing Candidate Phenomena/Challenges

Participants:
Teachers and their students

Do ahead of time:
Construct a survey of student interest in candidate phenomena and design challenges, ideally using an electronic survey tool that allows for immediate aggregation of results.

Phase/Meeting 3

1. How do some bacteria become resistant to medicines developed to fight them?



Not at all interesting: 0	**13**	4.1%
1	**24**	7.6%
2	**116**	36.7%
3	**120**	38%
Very interesting: 4	**43**	13.6%

Phase/Meeting 4

Select Best Candidate Phenomena/Challenges

Participants:
Teachers and teacher leaders

Do ahead of time:
Aggregate results from student surveys

Gallery Walk: Review Descriptions of Candidate Phenomena HS Genetics

- An example of current work of the team, in progress (Phase 2)
- Evaluate against:
  - Opportunities to explore DCI
  - Availability of student-accessible data and scientific models
  - Likely interest to students (we'll find this out, but where are likely connections)

- *What do you notice about what's here?*
- *What's missing that would help you or others select phenomena?*

screens

Gallery Walk

Task Formats for Designing Assessments (Shelley Stromholt)

Curriculum Adaptation Toolkit (Phil Bell)

Each round…

Redesigning Inquiry Kits for Student Agency (Tiffany Clark)

…for 10 min each

Selecting Phenomena for Units (Katie Van Horne)

Storyline & Lesson Plan Template (Bill Penuel)

RESEARCH + PRACTICE COLLABORATORY

is made up of 4 collaborating laboratories....

exploratorium

EDC Learning transforms lives.

Institute for Science + Math Education

working in partnership with....

Auburn School Department

Community Science Workshop Network

California Tinkering Afterschool Network

DiscoveryCube Orange County

Design Based Implementation Research

Institute for Systems Biology

Inverness Research

Renton School District

Seattle Public Schools

STEM teaching tools

techbridge Inspire a girl to change the world

University of Maine Farmington

usm University of Southern Maine

University of Washington College of Education

College of Engineering University of Washington

with funding from...

NSF

Funded by the National Science Foundation. Opinions expressed do not necessarily reflect the views of the Foundation.

Learn more at:

researchandpractice.org

Questions? Some resources…

Web Links

- http://tinyurl.com/CSSS3Dlearning
- http://researchandpractice.org
- http://STEMteachingtools.org

Twitter, Pinterest & Facebook

- @STEMTeachTools
- http://www.pinterest.com/STEMeducation
- http://www.facebook.com/STEMTeachingTools

Download All STEM Teaching Tool PDFs

- http://STEMteachingtools.org/link/allSTT