Technology-Enhanced Assessments for Contemporary Science Classrooms

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Successful STEM Education Workshop

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A Question For You…

How Well Do You Understand the Framework for K-12 Science Education and NGSS?

1. *I don't. Should I?*
2. *I've heard of the Framework and NGSS, but don't really know how it impacts students.*
3. *I'm familiar with the Framework and NGSS, but I have questions and would like more specifics*
4. *I'm very familiar with the Framework and NGSS. I may be able to help others understand what it is and its impact.*

Another Question For You…

How prepared are you to assess your students' proficiency with NGSS Performance Expectations?

1. *I'm not sure at all how to do this, but eager to learn!*
2. *I have some ideas of how I might assess for NGSS, but haven't tried them out.*
3. *I'm familiar with assessment for NGSS, but I have questions and would like more specifics*
4. *I'm very familiar with assessment for NGSS. I may be able to help others create assessments for classroom use*

Session Overview

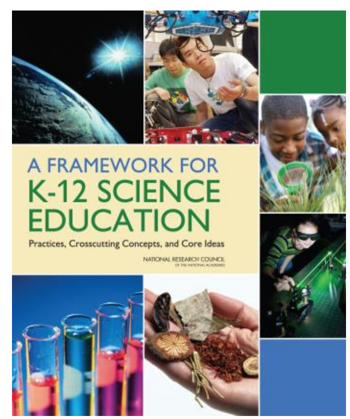
- Vision underlying NGSS
- Incorporating the vision of NGSS into assessment
- Designing assessments to support next generation science learning
- WISE Technology-enhanced assessments

The Vision Behind NGSS

Knowing how to use and apply what you know…

empowers you – in your own learning about the world and your participation in it.

Goal is for every student, from the earliest grades onward, to have coherent and sequenced instruction that provides opportunities to do the "walk and talk" of science and engineering.



How NGSS is Different

Standards expressed as <u>performance expectations</u>:

- Combine practices, core ideas, and crosscutting concepts into a single statement of ***what is to be assessed***
- Requires students to demonstrate ***knowledge-in-use***
- Performance Expectations are not instructional strategies or objectives for a lesson – ***they describe achievement, not instruction***
- Intended to describe the end-goals of instruction – ***the student performance at the conclusion of instruction***

Incorporating the NGSS Vision into Assessment

NGSS will require dramatic changes in assessment

- Build a coherent system of assessments; begin at the classroom level
- Critical need for assessments *for* learning; classroom-based instructionally supportive assessments for practical use to support 3-dimensional learning

- NGSS is pushing the assessment field to consider how embedded, continuous assessment can be designed
- Technology-enhanced science assessment tasks have the potential to change how children's science learning is measured and understood

Assessment Challenges

- How do we use performance expectations in order to construct assessment tasks that can be used during instruction?
- How do we design tasks that provide evidence of 3-dimensional performance (i.e., knowledge-in-use)?
- How do we make these tasks (in)formative so that they can be used during instruction to help teachers gauge students’ progress toward achieving the performance expectations?

Next Generation Science Assessment

Collaborative Research Project: ***Designing Assessments in Physical Science across Three Dimensions***

SRI Education

CREATE for STEM Institute

UIC The University of Illinois at Chicago

The Concord Consortium

Taking on the challenge of how to create instructionally supportive assessments that Integrate the three dimensions of the NGSS and help teachers assess student's progress toward achieving performance expectations.

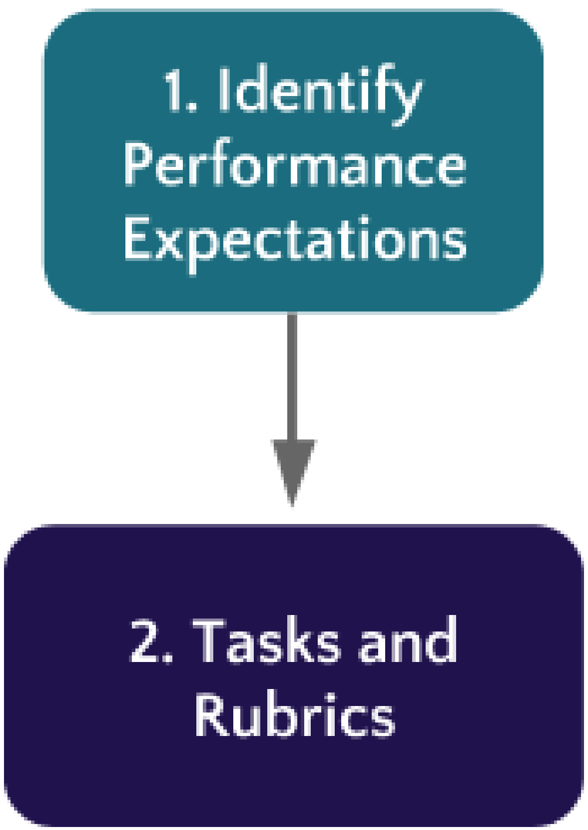
http://nextgenscienceassessment.org

How do you assess students building toward this Performance Expectation?

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

[Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

Typical Assessment Design Approach

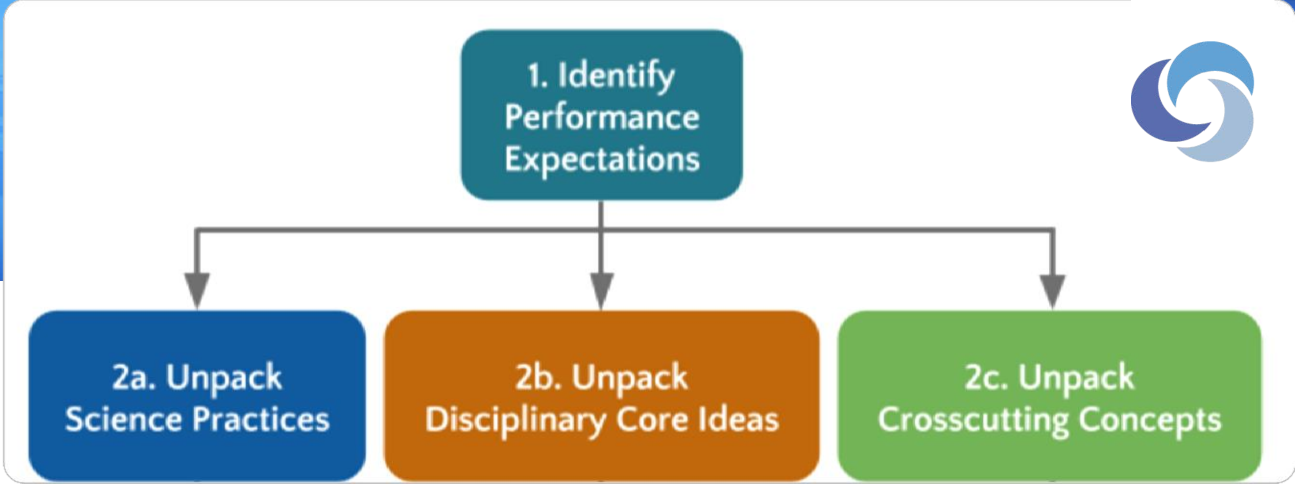


- **Implicit** design decisions
- **Inconsistent** elicitation of core ideas, practices and crosscutting concepts
- **Unexplained variation** in contexts, difficulty, evidence elicited from students, and approaches for scoring across tasks

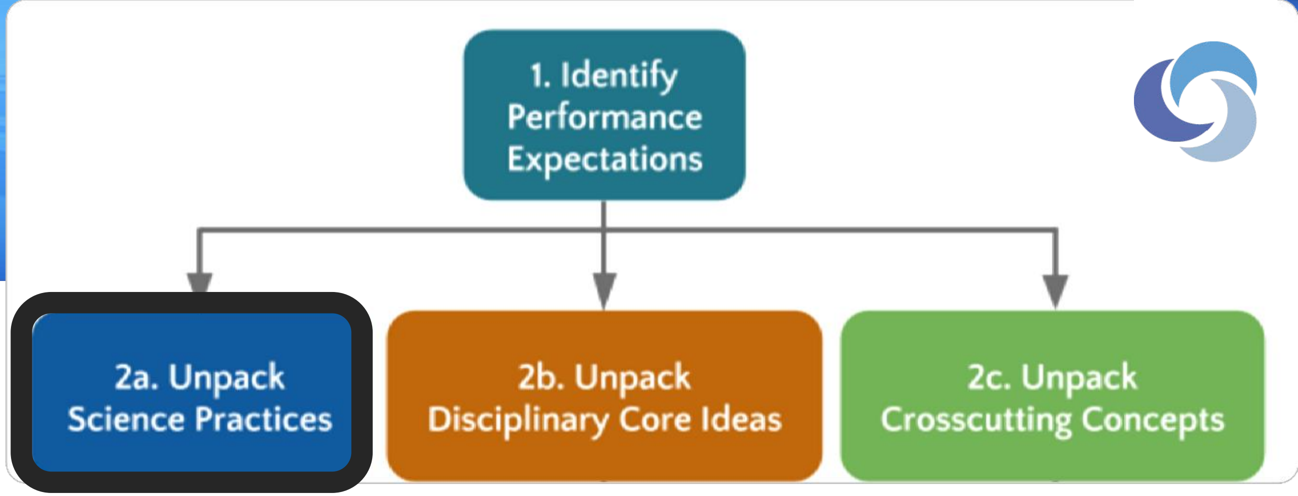
NGSA Design Approach

Intentional and Explicit

Phase 1: Unpack the Dimensions of the PE

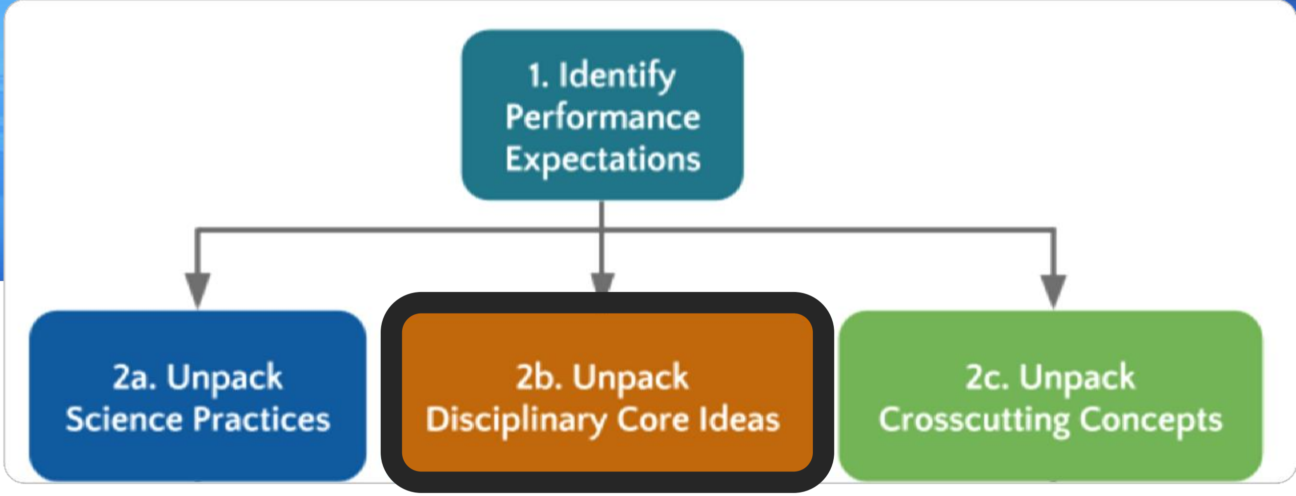


NGSA Design Approach



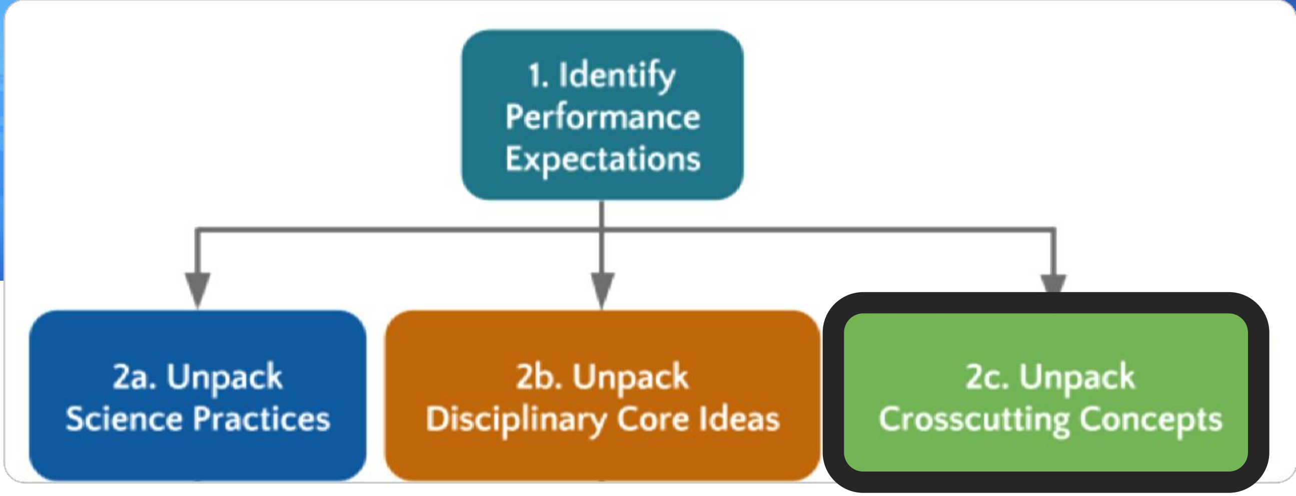
- **Describe the practice and its components**
- **Identify intersections with other practices**
- **Identify requisite knowledge and skills**
- **Specify features of a high level of performance**

NGSA Design Approach



- **Elaborate Major Ideas**
- **Define Boundary Conditions**
- **Describe Prior Knowledge**
- **Identify Student Challenges**
- **Brainstorm Phenomena**

NGSA Design Approach



- **Describe essential features**
- **Describe prior knowledge/skills**
- **Identify substantive intersections with science practices and disciplinary core ideas**

Why Unpack??

The unpacking process enables you to:

- Understand what each dimension really means
- Identify the essential components of each dimension
- Pinpoint the knowledge and capabilities students need to use in order to use a given dimension
- Describe levels of performance for the dimensions at the grade level you are interested in. *Always – unpack with the "student" in mind*

This process is of high value because it:

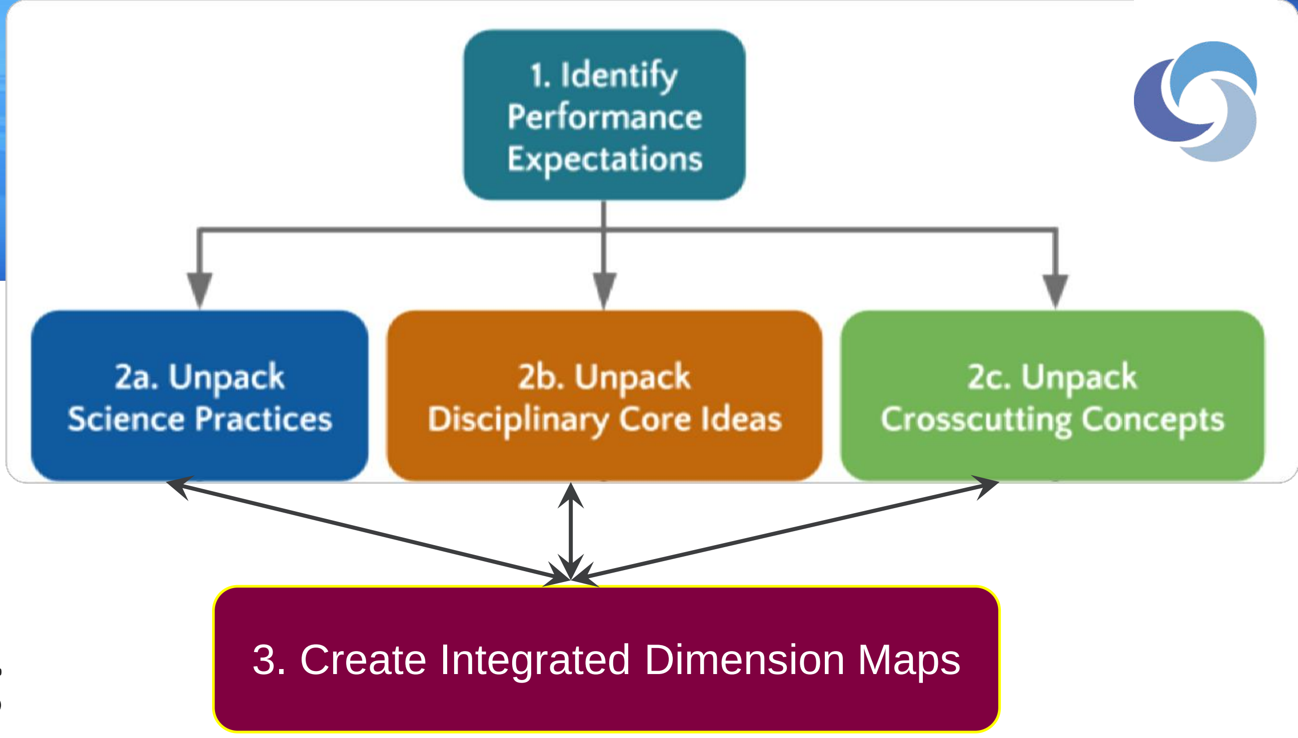
- Promotes consistency in your use of dimensions
- Sustains the essential aspects of the dimensions
- Informs how the dimensions can work together

NGSA Design Approach

Intentional and Explicit

Phase 1:

Use the Unpacking to Create Integrated Dimension Maps



Creating Integrated Dimension Maps

Each map is intended to represent the "terrain" of the Performance Expectation

- Illustrates how the 3 dimensions are intended to work together to demonstrate proficiency with a PE
- Shows the possible ways for combining aspects of the 3 dimensions

Creating a map entails:

1. mapping out the essential disciplinary relationships (very much like a typical concept map)
2. Layering on top of the DCI map the crosscutting concepts and practices

Example: Integrated Dimension Map

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

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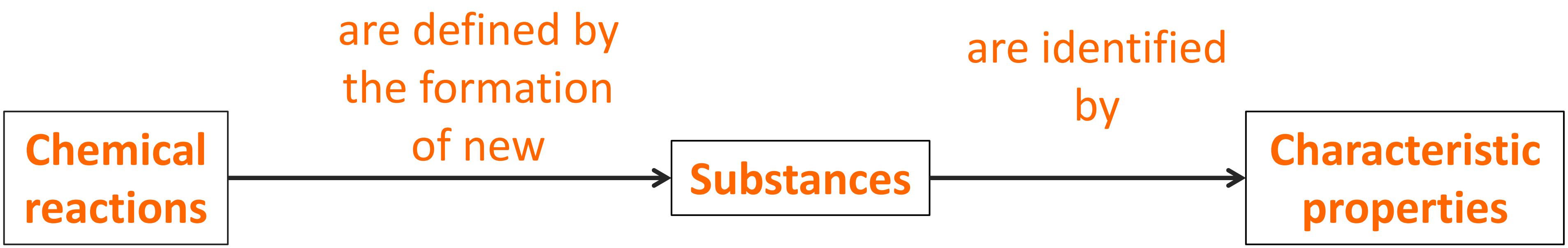

Integrated Dimension Map

MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Chemical reactions → are defined by the formation of new → **Substances** → are identified by → **Characteristic properties**

Key Practices
- Analyzing data
- Constructing explanations

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Example: Integrated Dimension Map

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Key Practices

- Analyzing data
- Constructing explanations

Key CC aspects

- Patterns (similarities & differences; relate micro/macro)
- Energy & Matter (transformation)

Key Practices

- Analyzing data
- - Constructing explanations

Key CC aspects

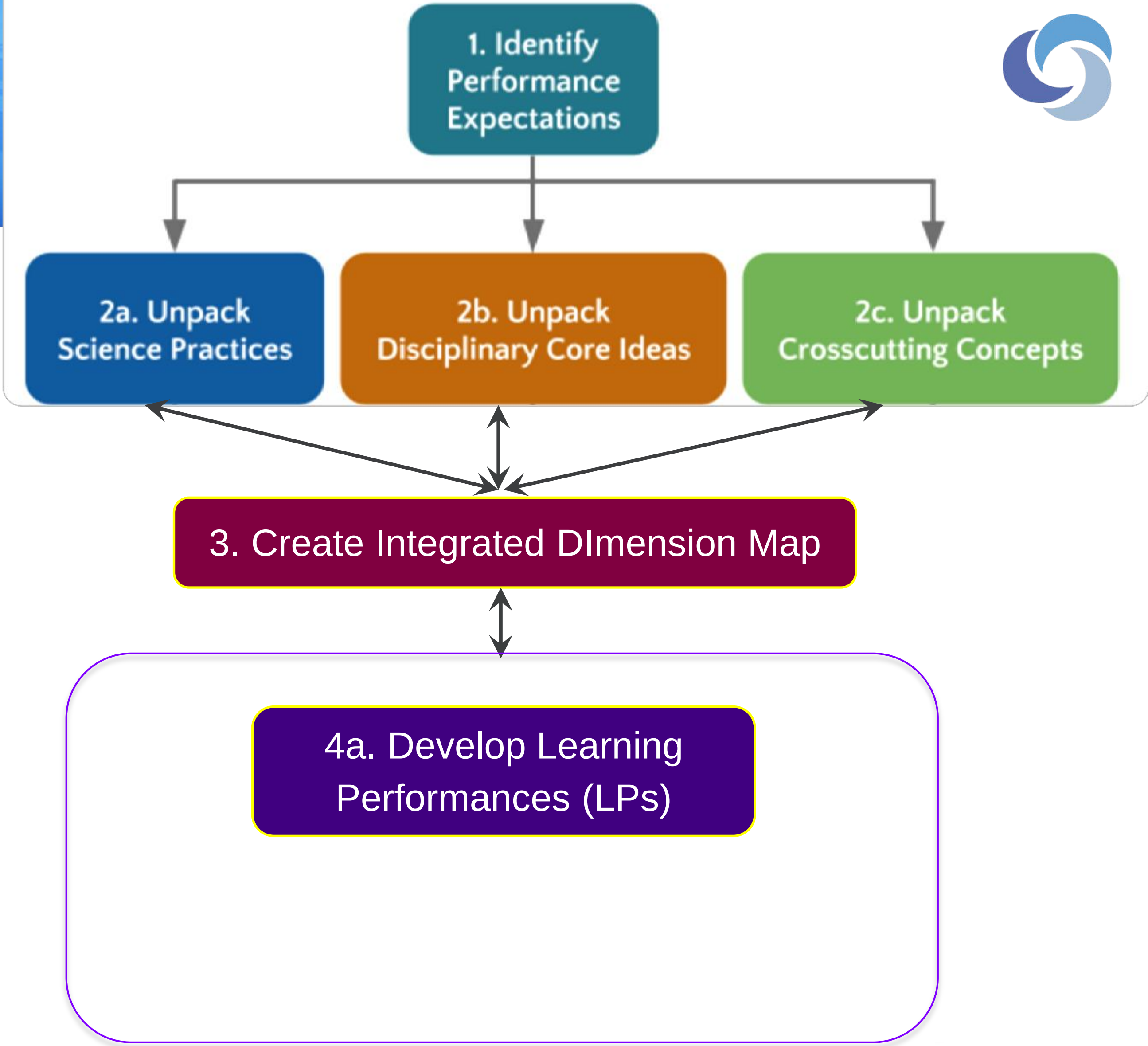
- Patterns (similarities & differences)

NGSA Design Approach

Intentional and Explicit

Phase 1: Unpack the Dimensions of the PE

Phase 2: Develop Learning Performances



Learning Performances

What is a Learning Performance?

- Statement that integrates *aspects* of a disciplinary core idea, practice, and crosscutting concept encompassed in a performance expectation
- Smaller in scope and partially represents a performance expectation
- A related set of learning performances function together to describe the performances needed or “what it takes” to achieve a performance expectation(s)

Why use Learning Performances?

- Ideal for classroom-based assessment – answers the question: *How will I know if students are making progress toward this large performance expectation?*
- Specifies “knowledge-in-use” – using “know” or “understand” is too vague
- Emphasizes understanding as embedded in practice and not as memorizing static facts

Constructing a set of Learning Performances

a. Identify key component(s) of disciplinary knowledge from the disciplinary core unpacking in tandem with key component(s) from the practices unpacking the CC unpacking

b. Lay out the key components from the unpacking in an integrated dimension map

c. Use the integrated dimension map to construct statements or “claims” of what a student should be able to do

Unpack Disciplinary Practices

Unpack Disciplinary Core Ideas

Unpack Crosscutting Concepts

Create Integrated Dimension Map

Construct Learning Performances (LPs)

MS-PS1-2 : Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

LP C-01

Chemical reactions are defined by the formation of new **Substances**

Key Practices
- Analyzing data
- Constructing explanations

Key CC aspects
- Patterns (similarities & differences; relate micro/macro)
- Energy & Matter (transformation)

Substances are identified by **Characteristic properties**

Key Practices
- Analyzing data
- Constructing explanations

Key CC aspects
- Patterns (similarities & differences)

Learning Performance C-01:

Students analyze and interpret data to determine whether substances are the same or different based upon characteristic properties.

MS-PS1-2 : Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Practice:
Analyze and Interpret data

✖

DCI Components:
Structure and properties of matter: **Each pure substance has characteristic physical and chemical properties…that can be used to identify it.**
Chemical Reactions: …In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new **substances have different properties** from those of the reactants.

✖

Crosscutting Concept:
Patterns
(similarities & differences)

Learning Performance C-01:

Students analyze and interpret data to determine whether substances are the same or different based upon characteristic properties.

MS-PS1-2 : Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Practice:

Constructing Explanations

DCI Components:

Structure and properties of matter: **Each pure substance has characteristic physical and chemical properties…that can be used to identify it.**

Chemical Reactions: …In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new **substances have different properties** from those of the reactants.

Crosscutting Concept:

Patterns

(similarities & differences)

Learning Performance C-02:

Students construct a scientific explanation to support a claim that substances are the same based upon characteristic properties.

Item Development

Steven found four different bottles filled with unknown pure liquids. He conducted measurements of each liquid. The measurements are displayed in the data table below. Steven wonders if any of the liquids are the same substance.

Liquid	Density	Color	Volume	Boiling Point
1	1.0 g/cm^3	Clear	6.1 cm^3	100 C^o
2	0.89 g/cm^3	Clear	6.1 cm^3	211 C^o
3	0.92 g/cm^3	Clear	10.2 cm^3	298 C^o
4	0.89 g/cm^3	Clear	10.2 cm^3	211 C^o

Use the data in the table to:

1) Write a claim stating whether any of the liquids are the same substance.
2) Provide at least two pieces of evidence to support your claim.
3) Provide reason(s) that justify why the evidence supports your claim.

Variable Task Features

- Number of properties included as data/evidence – 2 (**density and boiling point)**
- State of matter of substances – **all liquids**
- Inclusion of irrelevant data – **yes**
- Level of scaffolding to develop claim, evidence, and reasoning – **yes**

Qualities of a "good" Learning Performance

- Integrates disciplinary core ideas, scientific practices and crosscutting concepts
- Functions in relation to other learning performances to identify "what it takes" to make progress toward meeting a standard (e.g., NGSS performance expectations)
- Helps to identify an important opportunity that teachers should attend to and assess *before* the end of a unit
- Usable in that it provides guidance for creating tasks

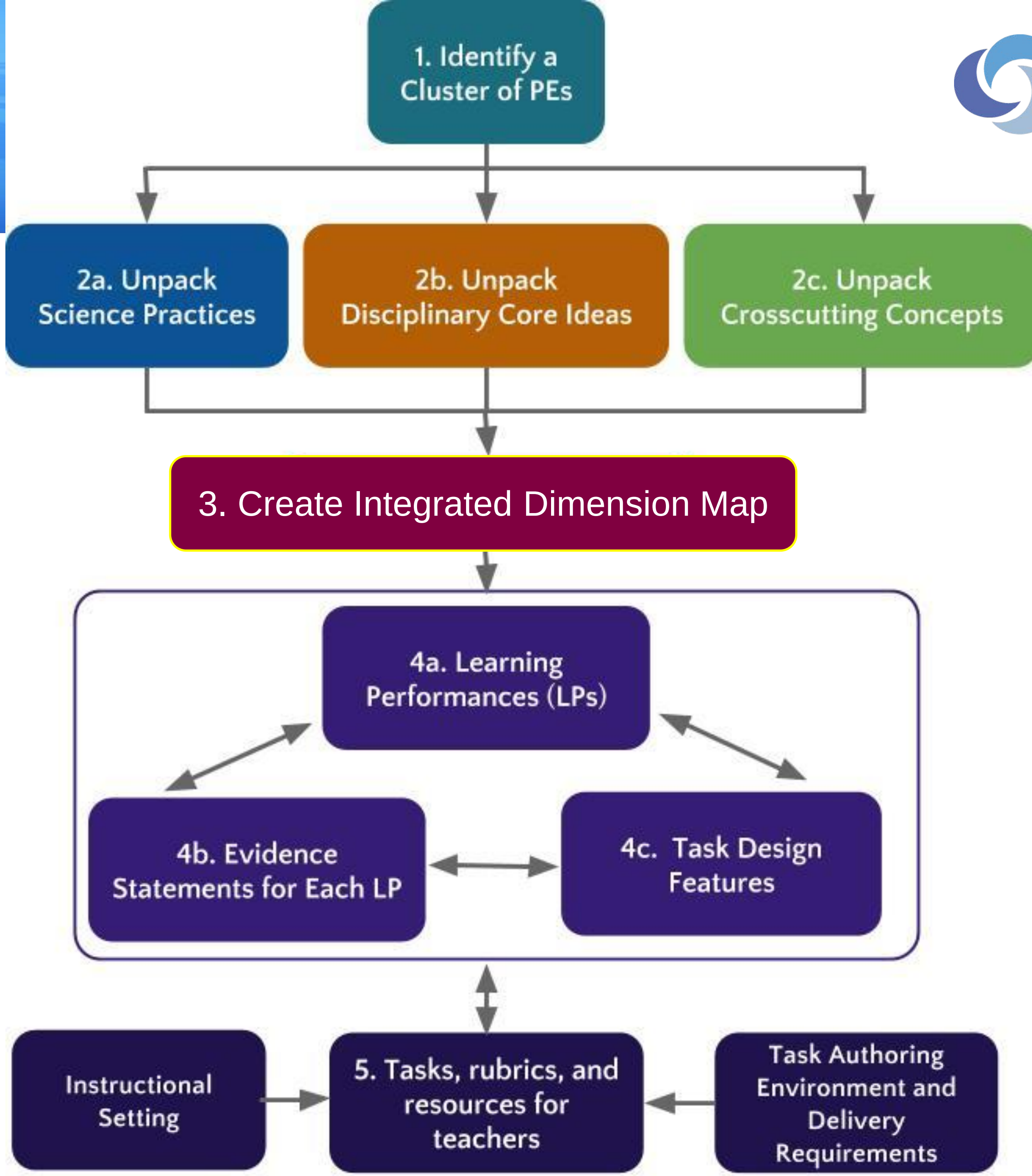
NGSA Design Approach

Intentional and Explicit

Phase 1: Unpack the Dimensions of the PE

Phase 2: Develop Learning Performances

Phase 3: Create tasks and rubrics



From Performance Expectation -> Learning Performances -> tasks

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

LP E-01: Students **evaluate a model** that uses a particle view of matter to explain how states of matter are similar and/or different from each other.

LP E-02: Students **develop a model** that explains how particle motion changes when thermal energy is transferred to or from a substance without changing state

LP E-03: Students **develop a model** that includes a particle view of matter to predict the change in the state of a substance when thermal energy is transferred from or to a sample.

LP E-04: Students **construct a scientific explanation** about how the average kinetic energy and the temperature of a substance of a substance changes when thermal energy is transferred based on evidence from a model.

LP E-05 Students **develop a model** that includes a particle view of matter **to predict** what happens to the average kinetic energy and the temperature of a substance when thermal energy is transferred from or to a sample.

MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Practice: Developing and Using Models

Clarification Statement: Emphasis on qualitative molecular-level models of solids, liquids and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state of occurs.

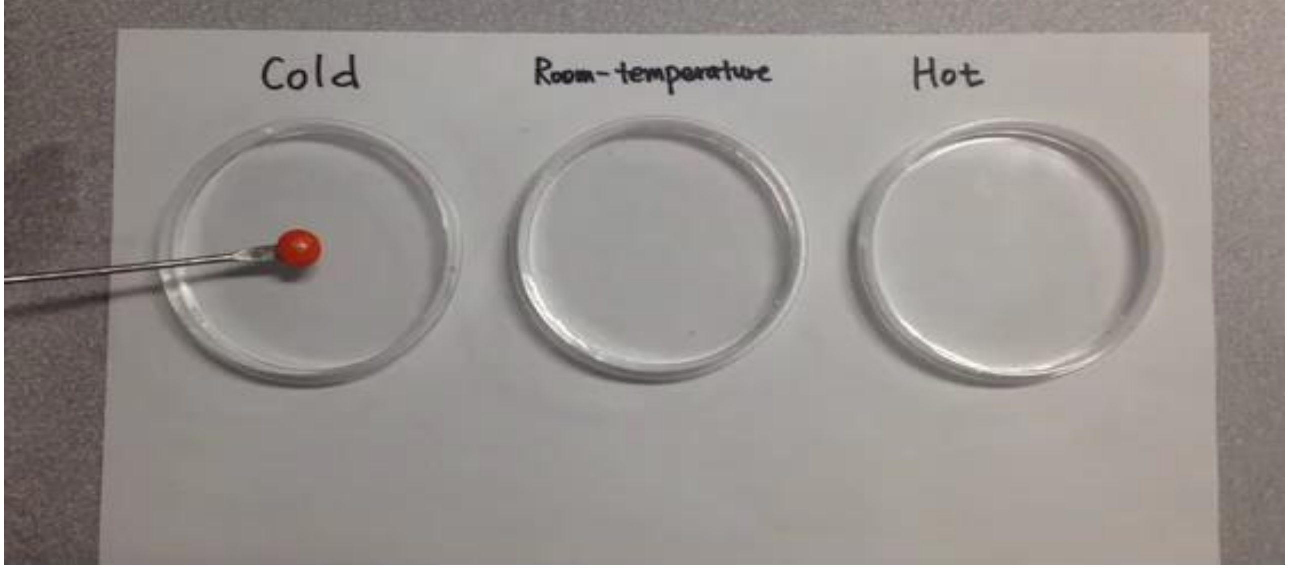
***Relevant DCI Components*:**

Structure and properties of matter:

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced…

***Crosscutting Concept*:** Cause and Effect

***Learning Performance E-02*:** Students **develop a model** that explains how particle motion changes when thermal energy is added or removed (within each state of matter).



Watch the video clip. Construct models to show why the dye on the candy spreads differently in cold, room temperature, and hot water. Your models should include both pictures and words to explain the movement of dye particles in the water at different temperatures.

Cold Water (5°C)	Room Temp. Water (20°C)	Hot Water (80°C)

Describe how your models explain the observed spread of the dye.

Variable Task Features

- Use of words, graphics, and/or video to present context – **text & video**
- State of matter of substances – **liquid**
- Language demands – **reduced**
- Level of scaffolding to construct model – **yes**

Assessment Summary

Performance Expectations

- Provide clear targets to be achieved ***by the end*** of instruction
- In classrooms, assessment tasks **should be integrated** with instruction and used formatively to help students build toward science proficiency – ***but how?***

Our solution – Learning Performances

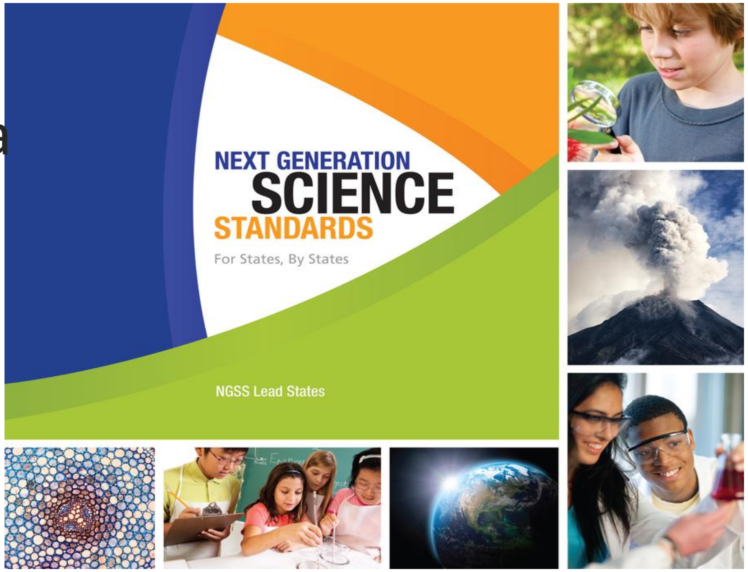
- Integrate aspects of all 3 dimensions of a given performance expectation
- Function in relation to other LPs to identify “what it takes” to make progress toward meeting a performance expectation (or set)
- Provides guidance to assessment designers for creating instructionally supportive tasks

5 Main Points

① NGSS “performance expectations” can be a powerful guide in developing classroom-based assessments

② Unpacking can help ensure that the essential components of practices, DCIs, and crosscutting concepts will be consistent across assessment tasks

③ Integrated dimension maps provide a visual representation of the terrain of a PE that can be used to construct Learning performances



④ Learning performances inform the design of tasks

⑤ Assessment tasks should prompt students to engage in all 3 dimensions

For more information

Project Website: http://nextgenscienceassessment.org

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Thank you

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TELS
TECHNOLOGY ENHANCED LEARNING IN SCIENCE

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WISE

CLASS

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GRIDS

VISUAL

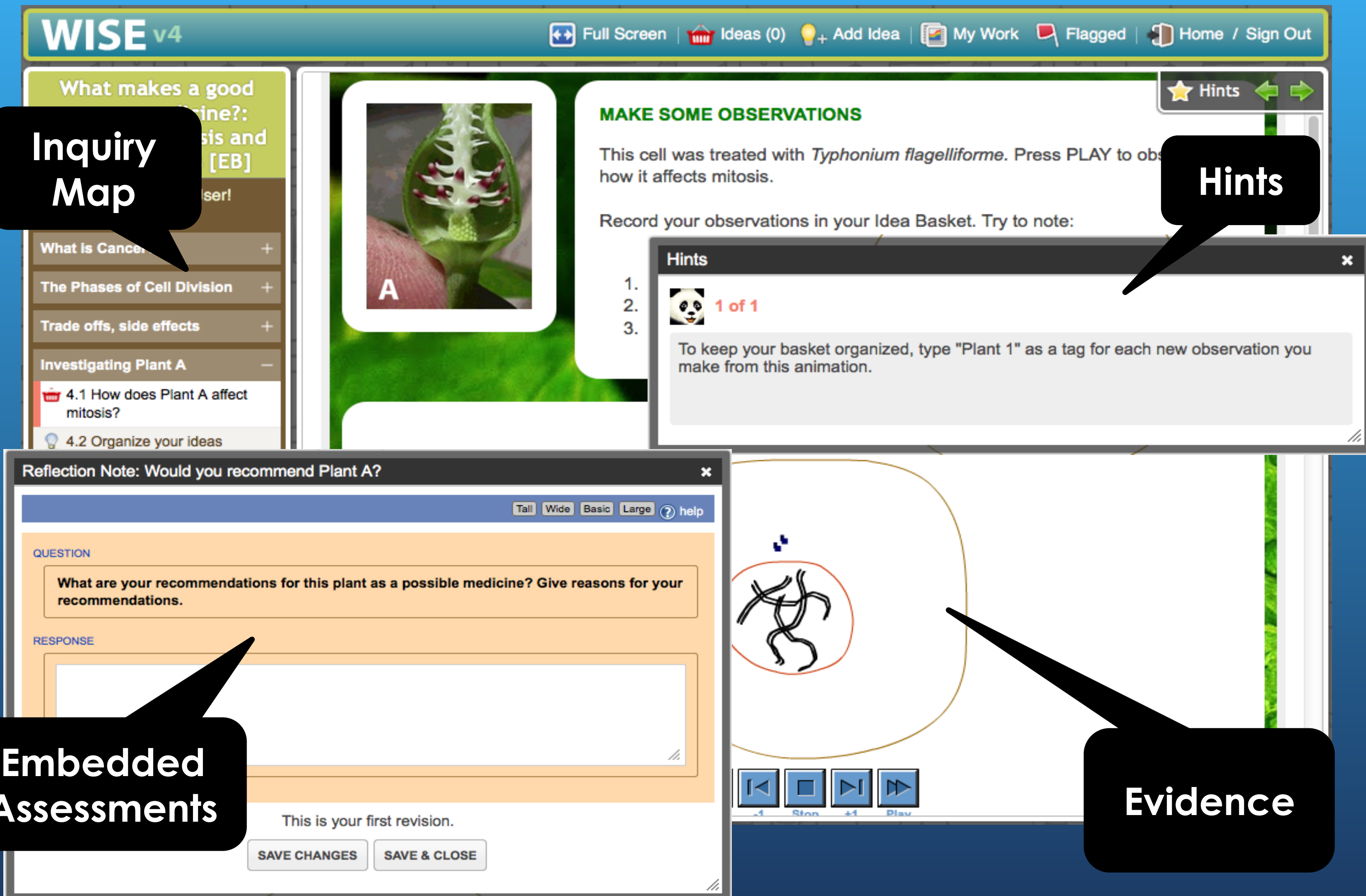
Assessment Challenges

- How do we use performance expectations in order to construct assessment tasks that can be used during instruction?
- How do we design tasks that provide evidence of 3-dimensional performance (i.e., knowledge-in-use)?
- How do we make these tasks (in)formative so that they can be used during instruction to help teachers gauge students' progress toward achieving the performance expectations?

Web-based Inquiry Science Environment

Web: wise.berkeley.edu;

Video: http://tinyurl.com/VIDEOWISE



Global Climate Change

Burning coal to produce electricity has increased the amount of carbon dioxide in the atmosphere. What possible effect could the increased amount of carbon dioxide have on our planet?

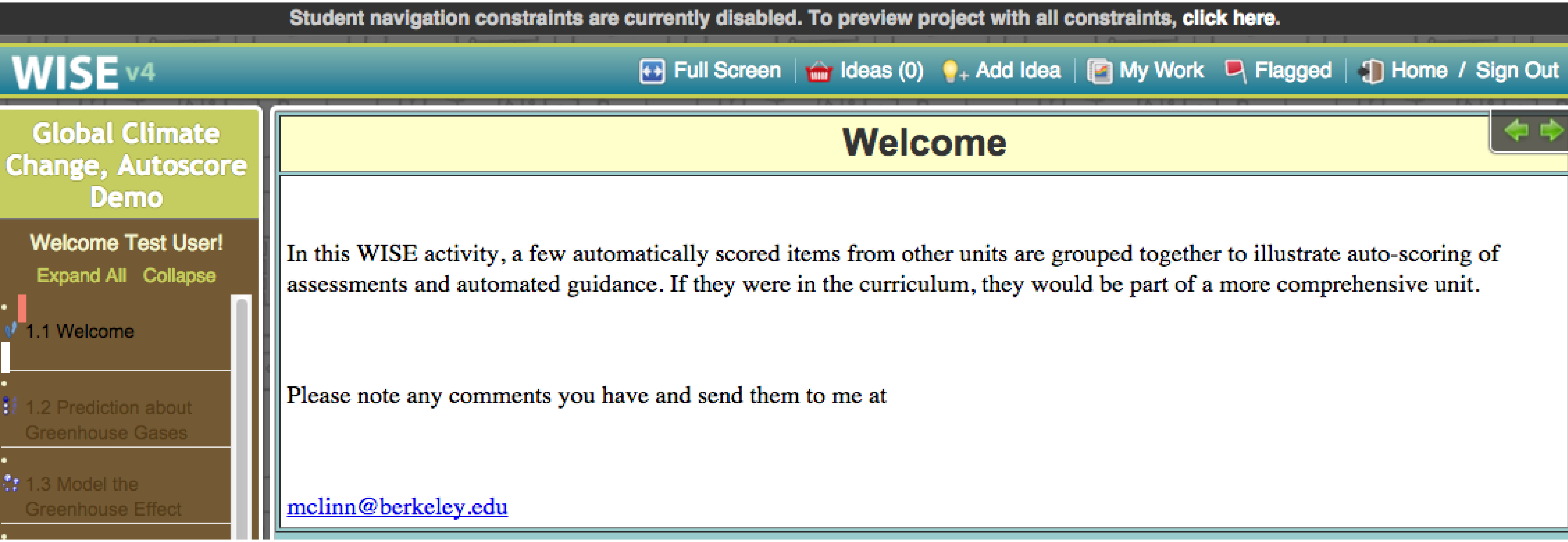
Because Carbon Dioxide is produced by factories, which warms the climate by reflecting infrared radiation back into the earth and causing it to change back into heat energy.

I have heard about global warming and saving the polar bears so I believe it is warming the climate by creating holes in the ozone layer letting in more sunlight and heat.

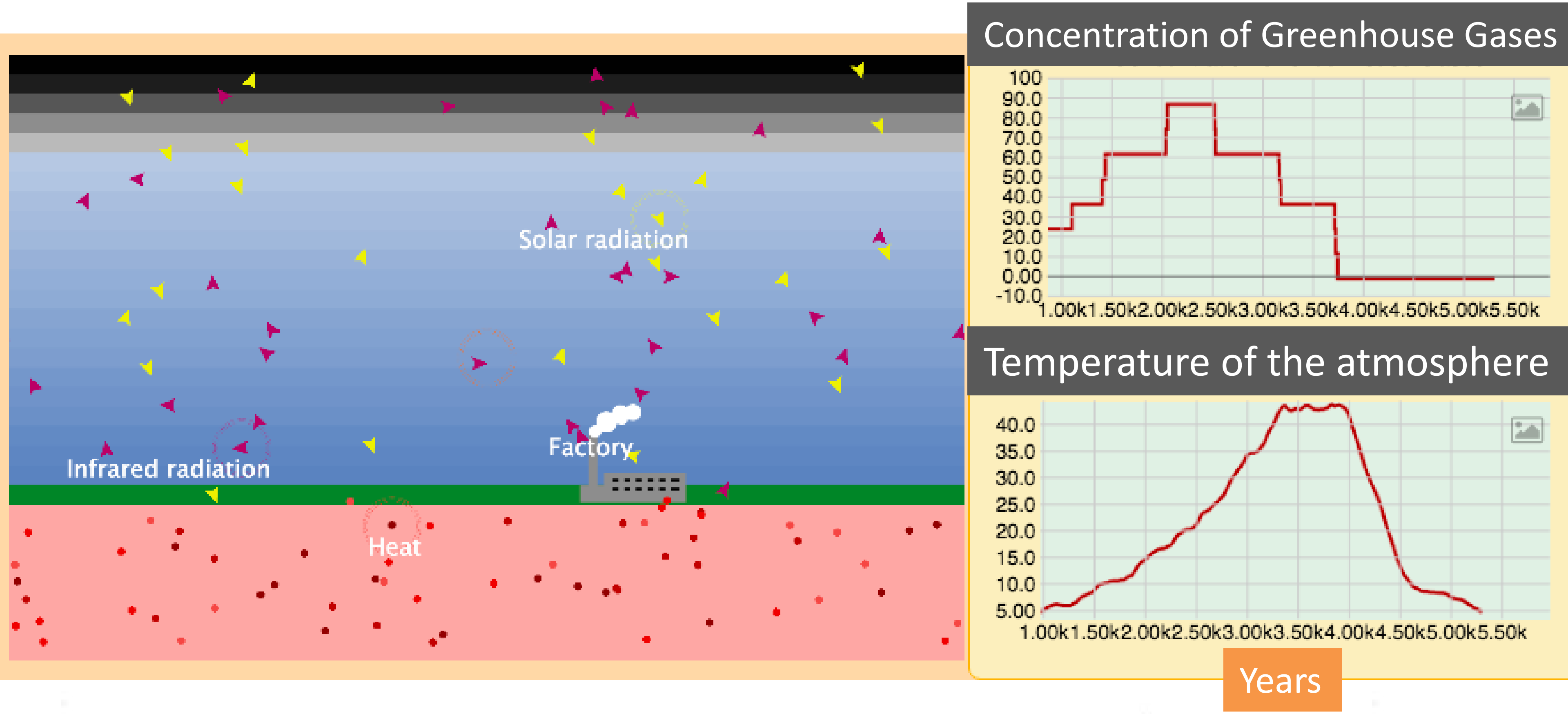
Knowledge Integration Scoring & Guidance: Global Climate

Score	Example Response	KI Guidance
2 Non-normative	I think that it has a lower relative humidity because the carbon dioxide takes up the space of the air molecules	Redo. Look at the graph in Step 4.4. Add evidence about how increasing carbon dioxide, a greenhouse gas, affects global temperature. Write your new explanation below
3 Partial	this is just like the car because of the green house effect the extra carbon dioxide will trap the sun's rays in our atmosphere.	You are on the right track. Revisit Step 4.4 and add details. **How** does carbon dioxide interact with infrared radiation to increase global temperature? Write your new explanation below
4 One full link	The more heat that is released into the atmosphere through infared radiation and stays trapped from the carbon dioxide will make the planet warmer	Good progress. To improve your response return to Step 4.4 to find out what happens to energy from the Sun when it is absorbed by the Earth. Write a new explanation below.

WISE Embedded Assessment Examples

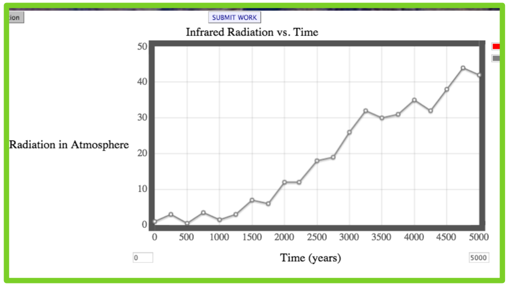


Energy mechanisms: Greenhouse gases and atmospheric temperature

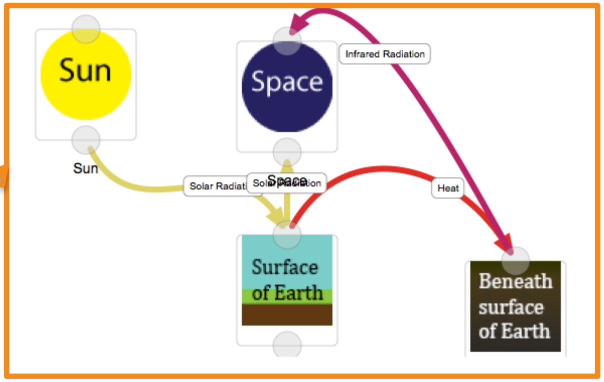


Collaborate with a Partner, or not!

- Explore the greenhouse gases model [Step 1.2 and 1.3]
- Then choose to explore:
- Guidance on Graphing [step 1.4]



- Guidance on a Diagram [step 1.6]

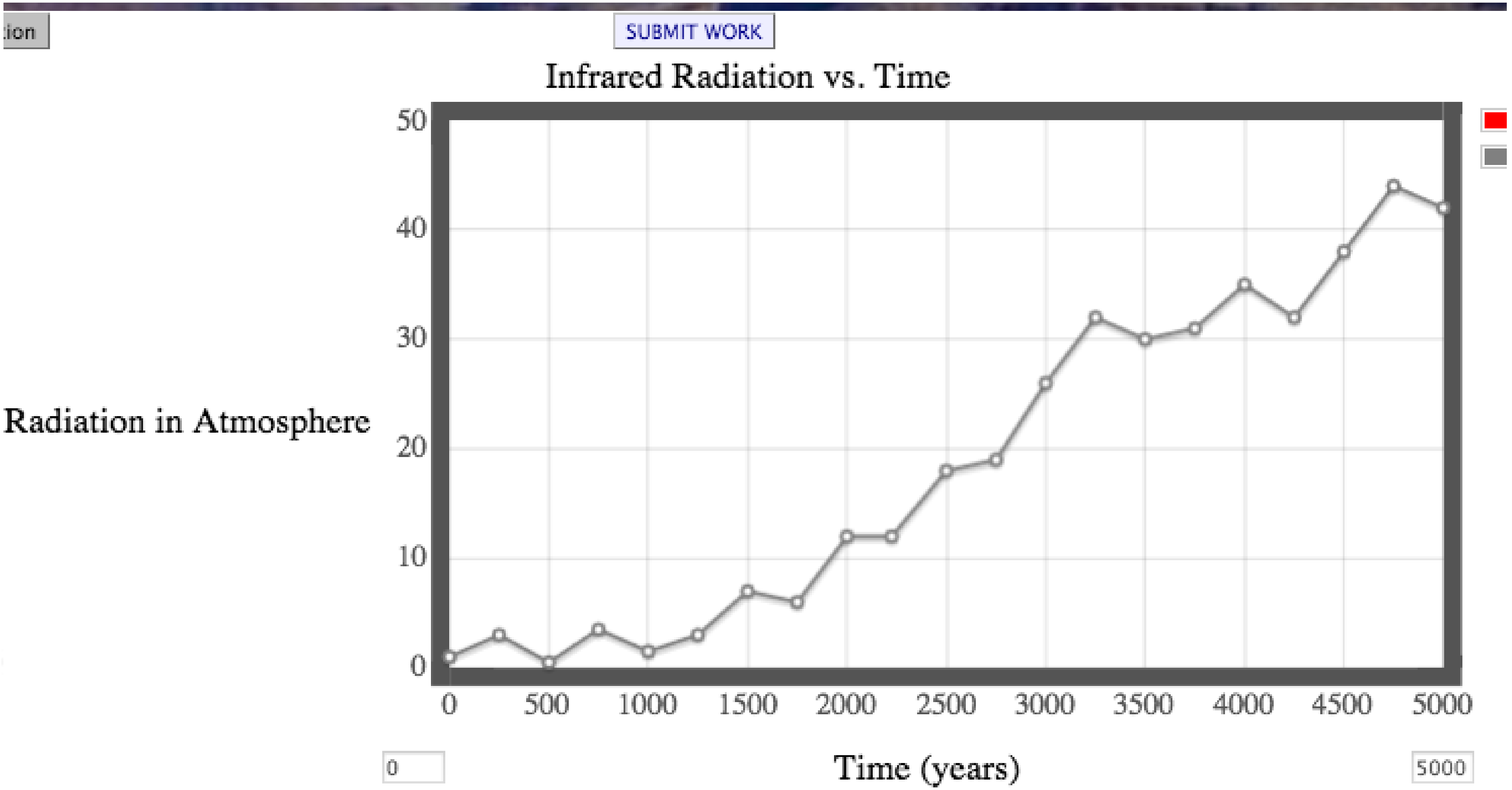


- Guidance on an Essay [steps 1.9 & 1.10]

Burning coal to produce electricity has increased the amount of carbon dioxide in our atmosphere. What possible effect could the increase in carbon dioxide have on our planet?

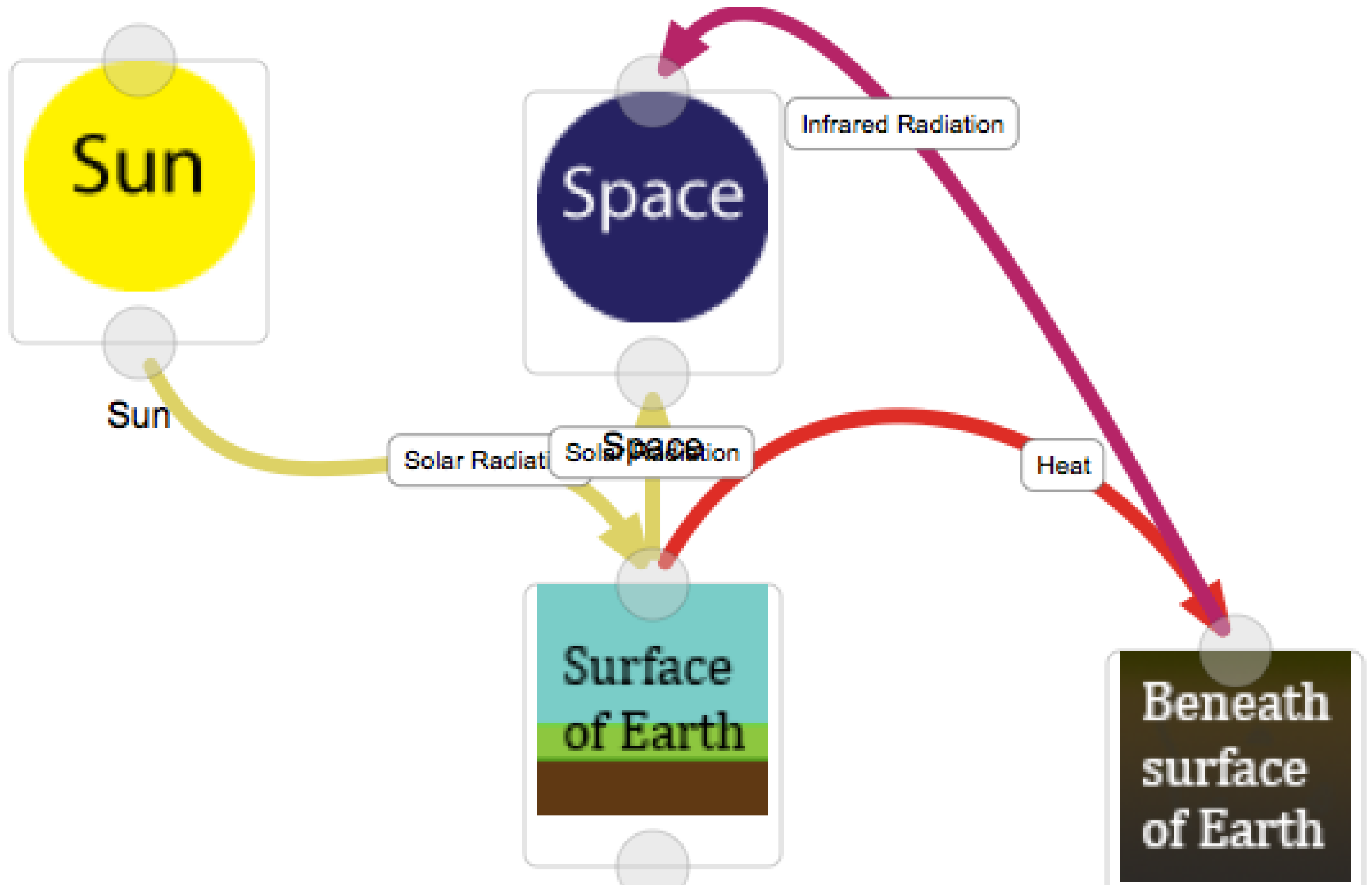
Try Getting Graph Guidance [Step 1.4]
Scroll down to see this graph

Click on the graph to locate a point, then click another point and connect the graph. When you are ready, submit your work.



Try Illustrating Energy Flow [Step 1.6]

Connect the pictures to show how Energy moves between the Sun, the Earth, and Space.



Try Getting Guidance on an Essay [Steps 1.9 & 1.10]

- Burning coal to produce electricity has increased the amount of carbon dioxide in our atmosphere. What possible effect could the increase in carbon dioxide have on our planet?
- In step 1.10 create an essay that you think could be written by a middle school student.
- Then click “Check Answer” to get guidance.
- Read the guidance and think about how this guidance might lead a middle school student to revise the first answer. NOTE: the link to revisit the unit is NOT active.
- Reflect on how this type of automated guidance could help a teacher support a class of 35-40 students all using the global climate unit.

Automated grading and guidance: Natural language processing

- Humans score 1000 student written responses to reflection questions to train the c-rater engine.
- It would take teachers 7 or more years to encounter this many responses
- Automated scores are reasonably accurate [kappa between .7 and .9]
- Partnership designs knowledge integration guidance based on effective teacher guidance

Gerard, L. F., Ryoo, K., McElhaney, K. W., Liu, O. L., Rafferty, A. N., & Linn, M. C. (2015). Automated Guidance for Student Inquiry. *Journal Of Educational Psychology*: **doi:10.1037/edu0000052**.

Teacher Concerns with Essays

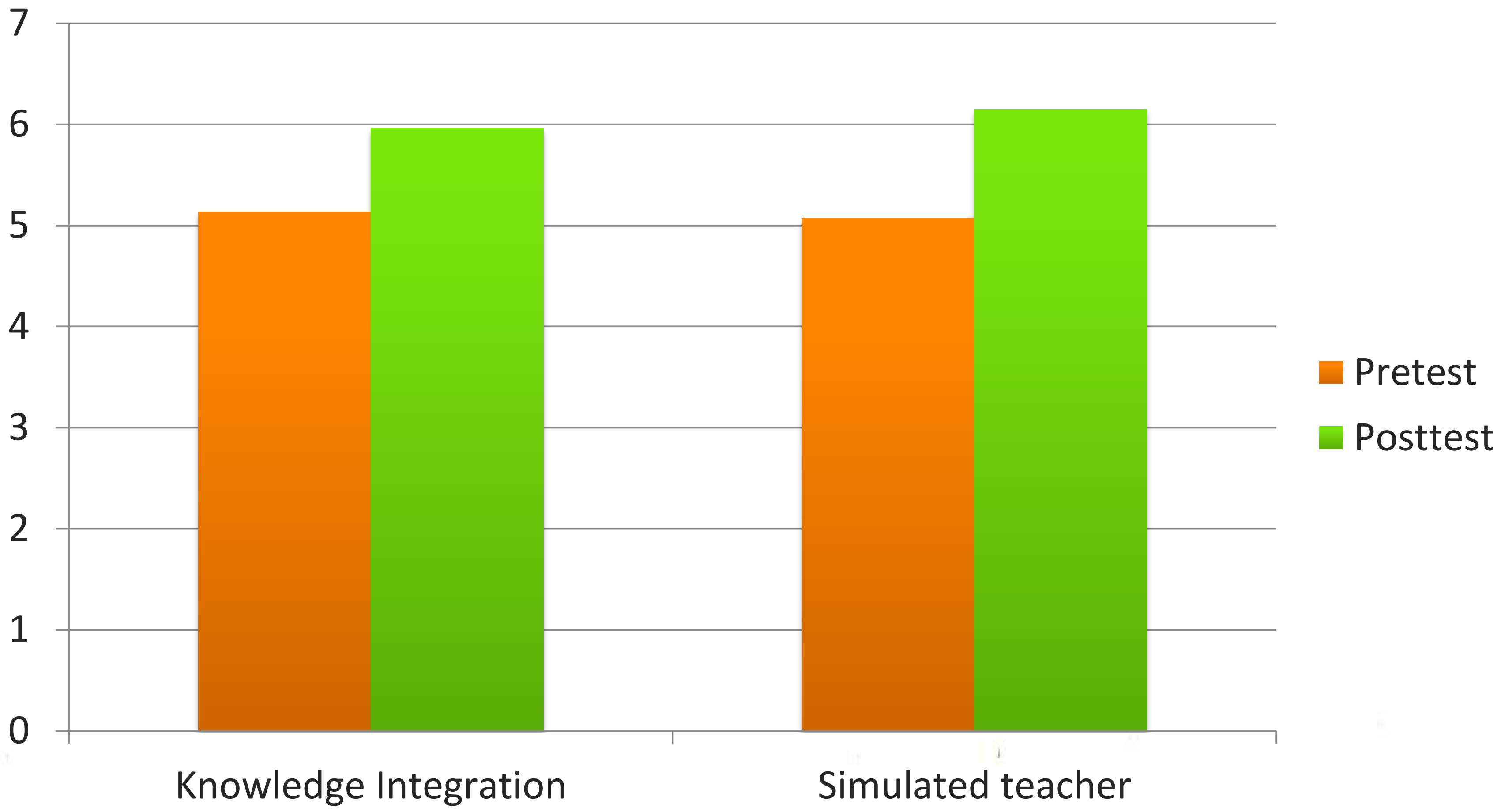
- “I have a hard time knowing what feedback to give them without giving them the answer.”

- “Everyone is asking for something and I can’t get to them.”

Technology as Inquiry Partner

Teachers have only 4-5 class periods to teach complex topics like photosynthesis. They often have difficulty guiding all the students.

Automated KI guidance as effective as expert teacher guidance



Assessment and NGSS

- Embedded assessments can measure NGSS practices

- 1. Asking questions (for science) and defining problems (for engineering)
- 2. Developing and using models [1.2-1.3]
- 3. Planning and carrying out investigations [1.3]
- 4. Analyzing and interpreting data [Graph 1.4; model 1.5]
- 5. Using mathematics and computational thinking [1.4; 1.7]
- 6. Constructing explanations (for science) and designing solutions (for engineering) [Diagram 1.6]
- 7. Engaging in argument from evidence [Essay 1.10]
- 8. Obtaining, evaluating, and communicating information [Diagram 1.6; Collaborating 1.9]

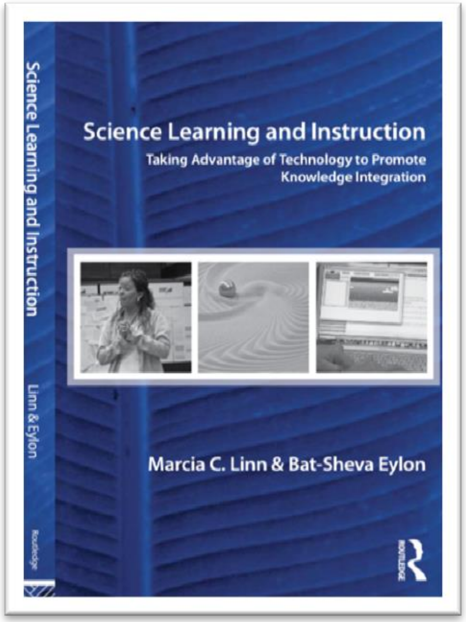
Theoretical Framework

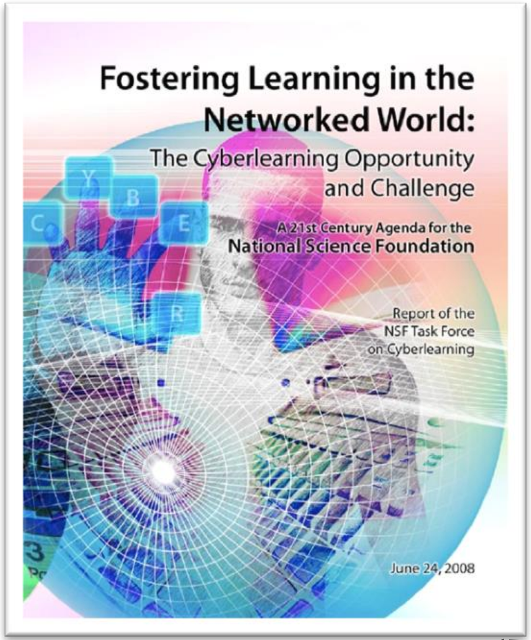
- ***Knowledge integration informs design of instruction, assessment, and professional development***

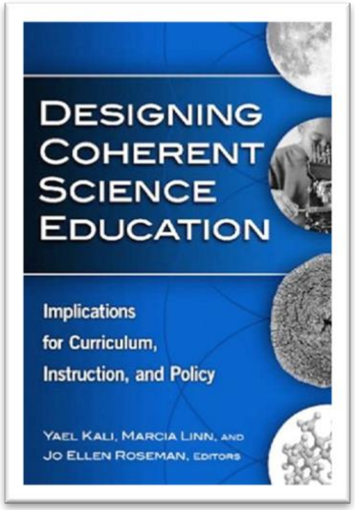
2000 **2004** **2009** **2011 [2015]**

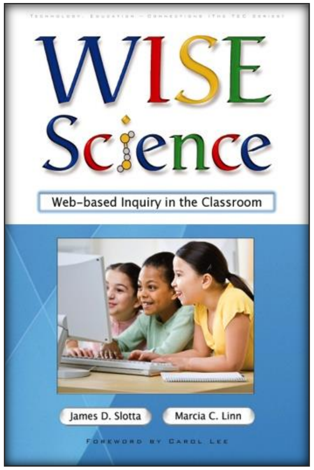
WISE is Free and Available

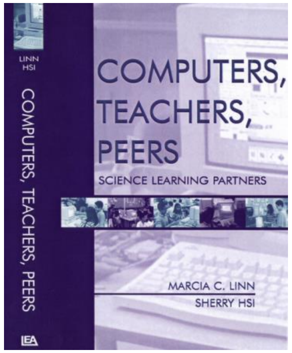
WISE.Berkeley.edu











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For More information about our work

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