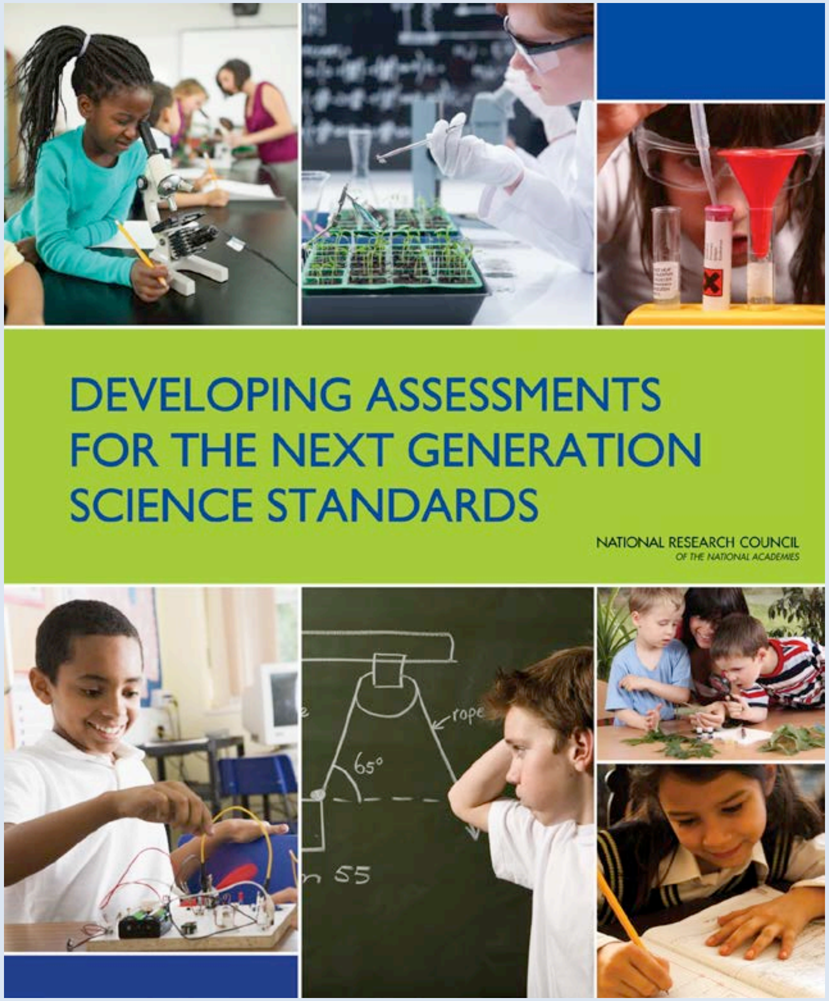
Measuring What Matters:

Opportunities & Challenges in Assessing Science Proficiency

Jim Pellegrino



UIC LEARNING SCIENCES RESEARCH INSTITUTE

Five Relevant Questions for Michigan

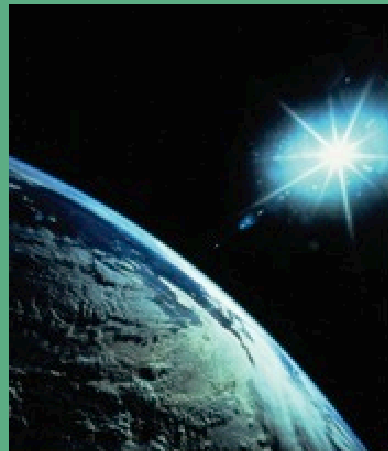
1. What are the conceptions that most people you know, including policy makers, educators, parents, and the public, have about **what it means to know and learn science**?
2. What are the conceptions that most people you know, including policy makers, educators, parents, and the public, have about the **teaching of science**?
3. What are the conceptions that most people you know, including policy makers, educators, parents, and the public, have about the **assessment of science learning**?
4. To what extent do those conceptions **help or hinder** the process of **designing and implementing high quality instruction** that includes assessments of "three-dimensional" science learning as part of normal educational practice?
5. What would it take for a state like Michigan to **design and implement a coherent and balanced science assessment system** tied to contemporary science standards? What are the opportunities as well as the barriers?

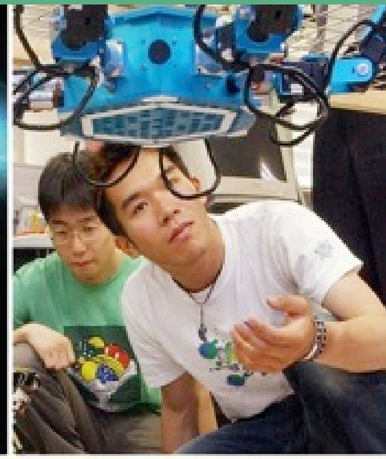
Foci of Today's Discussion

- Defining Competence to Achieve Coherence in Science Education

- NGSS and Instructionally Supportive Assessment

- From NGSS Performance Expectations to Assessments Designed for Classroom Use





A FRAMEWORK FOR K-12 SCIENCE EDUCATION

Practices, Crosscutting Concepts, and Core Ideas

NATIONAL RESEARCH COUNCIL
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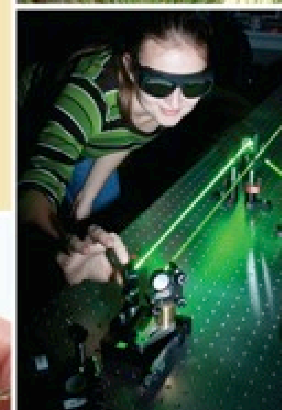

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New Definition of Competence

- The NRC Science Framework has proposed descriptions of student competence as being the intersection of knowledge involving:
  - **important disciplinary practices**
  - **core disciplinary ideas,**
  - **and crosscutting concepts** with
  - **performance expectations** representing the intersection of the three.
- Competence is something that develops over time & increases in sophistication & power as the product of coherent curriculum, instruction & assessment

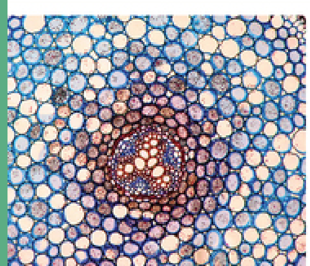
NRC Framework's Goals for Teaching & Learning

- Coherent investigations of core ideas across multiple years of schooling
- More seamless blending of practices with core ideas
- Performance expectations that require reasoning with core disciplinary ideas
  - explain, justify, predict, model, describe, prove, solve, illustrate, argue, etc.

NEXT GENERATION SCIENCE STANDARDS

For States, By States

NGSS Lead States



SCIENCE EDUCATION WILL INVOLVE LESS:	SCIENCE EDUCATION WILL INVOLVE MORE:
Rote memorization of facts and terminology	Facts and terminology learned as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning.
Learning of ideas disconnected from questions about phenomena	Systems thinking and modeling to explain phenomena and to give a context for the ideas to be learned
Teachers providing information to the whole class	Students conducting investigations, solving problems, and engaging in discussions with teachers' guidance
Teachers posing questions with only one right answer	Students discussing open-ended questions that focus on the strength of the evidence used to generate claims

Source: National Research Council. (2015). *Guide to Implementing the Next Generation Science Standards* (pp. 8-9). Washington, DC: National Academies Press. http://www.nap.edu/catalog/18802/guide-to-implementing-the-next-generation-science-standards

Two Major Features of the NGSS

- Built on the idea of Progressions in the Sophistication of Student Understanding - as previously articulated in the NRC Framework
- Include a new “Architecture” with a focus on Performance Expectations that draw from the intersections of disciplinary core ideas, science and engineering practices, and cross-cutting concepts

4-LS1 From Molecules to Organisms: Structures and Processes

How to read the standards »
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Students who demonstrate understanding can:

Students who demonstrate understanding can:

4-LS1-1. **Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.] [*Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.*]

4-LS1-2. **Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** [Clarification Statement: Emphasis is on systems of information transfer.] [*Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.*]

functioning of a natural system. (4-LS1-2) **Engaging in Argument from Evidence** Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Construct an argument with evidence, data, and/or a model. (4-LS1-1)	• Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)	

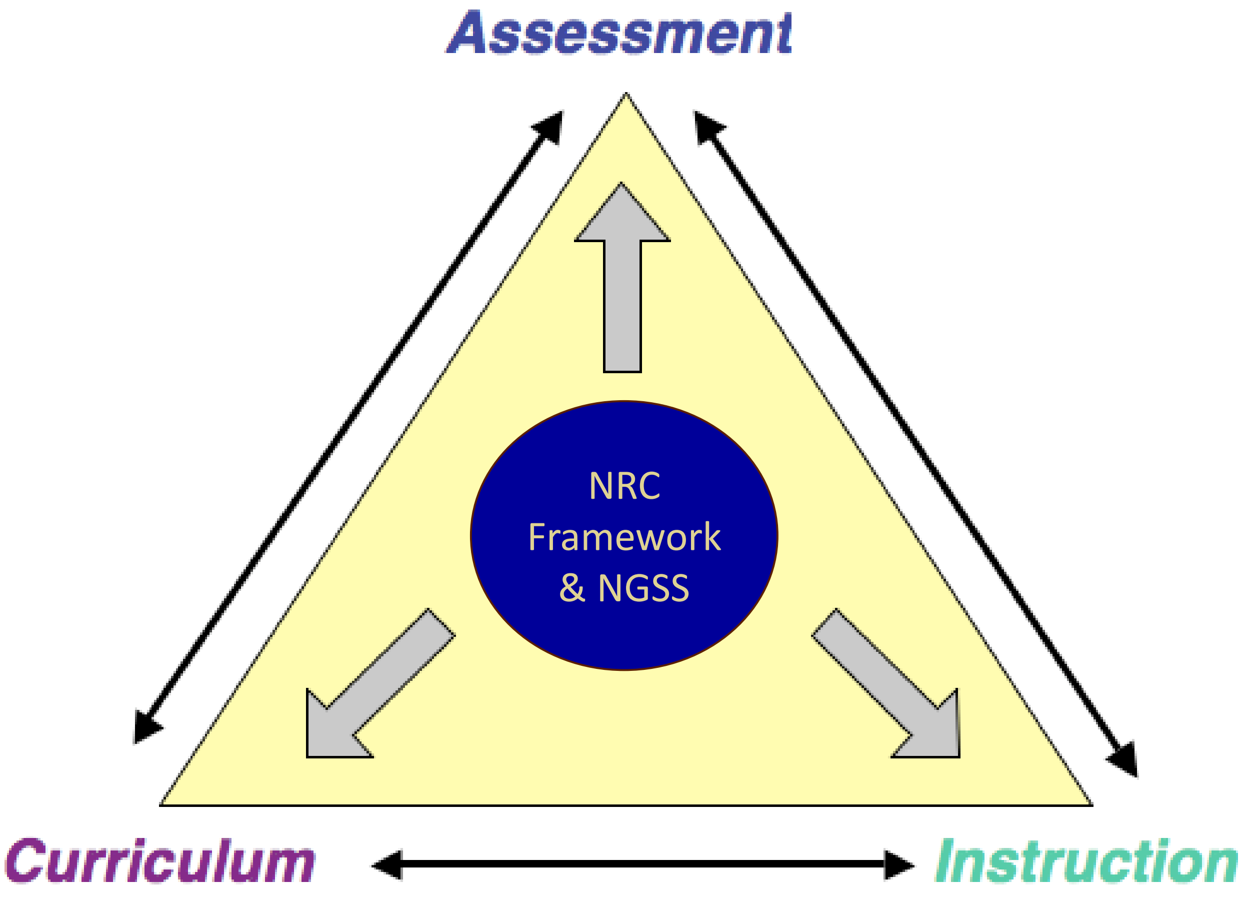
Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:
1.LS1.A (4-LS1-1); **1.LS1.D** (4-LS1-1); **3.LS3.B** (4-LS1-1); **MS.LS1.A** (4-LS1-1),(4-LS1-2); **MS.LS1.D** (4-LS1-2)

Common Core State Standards Connections:
ELA/Literacy -
W.4.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1)
SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-LS1-2)*
Mathematics -
4.G.A.3 Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. *(4-LS1-1)*

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Framework & NGSS as the Basis for Aligning C-I-A



Assessment Designed to Support Instruction

- To develop the skills and dispositions to use scientific and engineering practices to further their learning and to solve problems, students need to experience instruction in which they
  - use multiple practices in developing a particular core idea and
  - apply each practice in the context of multiple core ideas.
- Effective use of the practices will require that they be used in concert with one another, such as in supporting explanation with an argument or using mathematics to analyze data
- Assessments will be critical supports for this instruction.
- The proper design and use of such assessments poses a major conceptual and operational challenge.

Foci of Today's Discussion

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EDUCATION AT THE NATIONAL RESEARCH COUNCIL
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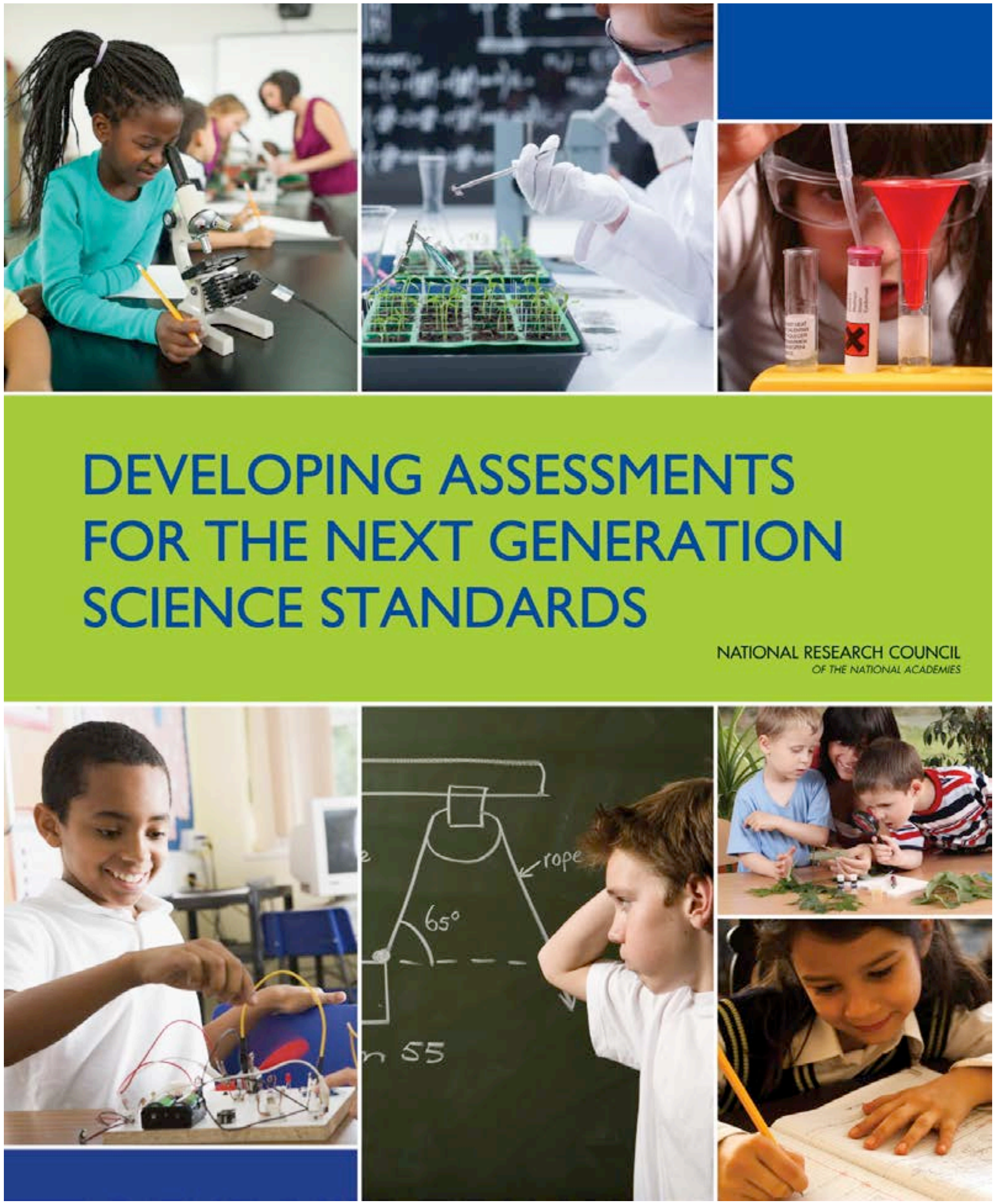


Committee on the Assessment of K-12 Science Proficiency

Board on Testing and Assessment

and

Board on Science Education

National Academy of Sciences

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

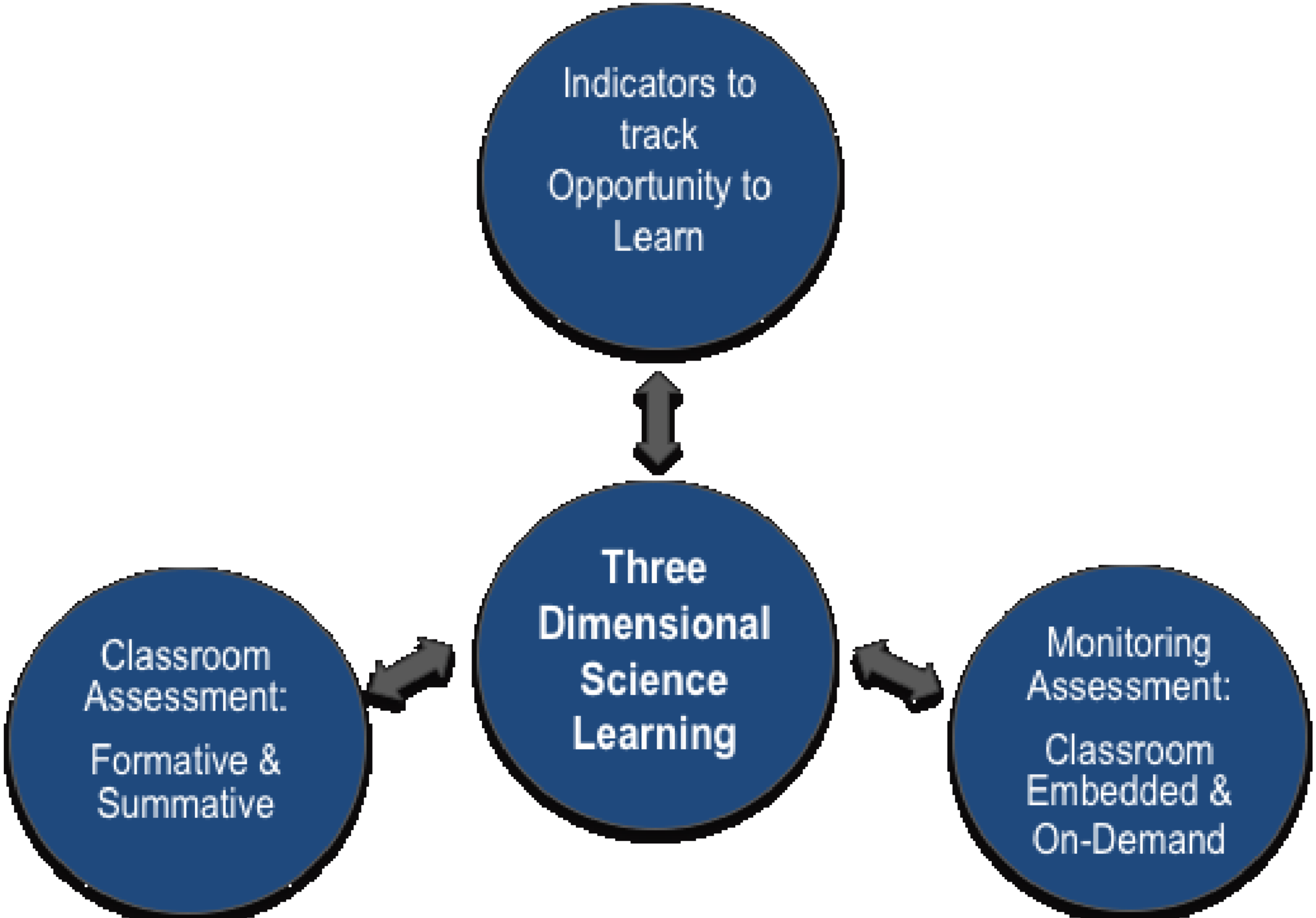
Report's Main Messages

1. Assessment tasks should allow students to engage in science practices in the context of disciplinary core ideas and crosscutting concepts. This poses a significant design challenge.
   - Multi-component tasks that make use of a variety of response formats will be best suited for this.
   - Selected-response questions, short and extended constructed response questions, and performance tasks can all be used, but should be carefully designed to ensure that they measure the intended construct and support the intended inference.
2. Students will need multiple and varied assessment opportunities to demonstrate their proficiencies with the NGSS performance expectations.

Third Critical Message: Build a Coherent System of Assessments

3. A system of assessments will be required and should include classroom assessment, monitoring (large-scale) assessments, and indicators of opportunity to learn.
   - Classroom assessment should be an integral part of instruction and should reinforce the type of science learning envisioned in the framework and NGSS.
   - Monitoring (large-scale) assessments will need to include an on-demand component and a component based in the classroom (classroom-embedded) in order to fully cover the breadth and depth of the NGSS performance expectations.
   - Indicators of opportunity to learn should document that students have the opportunity to learn science in the way called for in the framework and NGSS and that schools have appropriate resources.

Assessment System Components

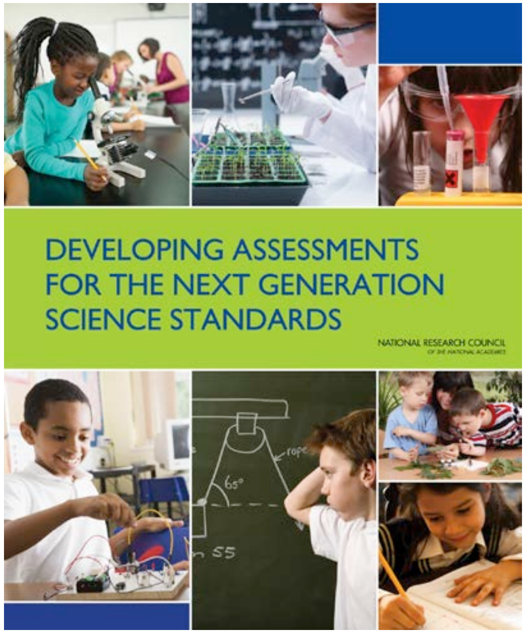


Report's Main Messages (cont.)

4. Implementation should be gradual, systematic, and carefully prioritized, **beginning with classroom assessment** and moving to monitoring assessment.

5. Professional development, adequate support for teachers, and innovative applications of technology will be critical.

Give Precedence to Classroom Assessment



Why Focus on Assessment in the Classroom?

- Instruction that is aligned with the framework and NGSS will naturally provide many opportunities for teachers to observe and record evidence of students' learning.
- Student activities that reflect such learning include
  - developing and refining models;
  - generating, discussing, and analyzing data;
  - engaging in both spoken and written explanations and argumentation;
  - reflecting on their own understanding.
- Such opportunities are the basis for the deployment of assessments of three-dimensional science learning.

Foci of Today's Discussion

- Defining Competence to Achieve Coherence in Science Education
- NGSS and Instructionally Supportive Assessment
- From NGSS Performance Expectations to Assessments Designed for Classroom Use

How do we ***Assess*** toward the PEs?

Assess toward Performance Expectations

Next Generation Science Assessment

The challenge:

How can we create assessments that integrate the three dimensions of the NGSS and help teachers assess student's progress toward achieving the performance expectations?

SRI Education

CREATE for STEM Institute

NSF

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The Concord Consortium

GORDON AND BETTY MOORE FOUNDATION

NGSA Project Goals

Our Project's Overall Goals

Our project is designed to address three main goals:

(1) Construct a comprehensive design model, using an evidence-centered design (ECD) approach, to guide the development of tasks aligned with the NGSS performance expectations

(2) Develop and test technology-based assessment items and rubrics related to these performance expectations,

(3) Develop guidelines and materials for teachers to use these assessments in the classroom for diagnostic and formative purposes.

Project Scope – Focal DCIs for Middle School Science

Physical Science

Matter & Its Interactions

- Structure & properties of matter
- Chemical reactions

Energy

- Definitions of energy
- Conservation of energy and energy transfer

Life Science

From Molecules to Organisms: Structures and Processes

- Organization for matter and energy flow in organisms

Ecosystems: Interactions, Energy, and Dynamics

- Interdependent relationships in ecosystems
- Cycle of matter and energy transfer in ecosystems

Focus on Two Science and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations and designing solutions
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Considering Multiple Crosscutting Concepts

1. Patterns
2. Cause and Effect: Mechanism and Explanation
3. Scale, Proportion and Quantity
4. Systems and System Models
5. Energy and Matter: Flows, Cycles and Conservation

http://nextgenscienceassessment.org/

Next Generation Science Assessment

Developing NGSS-aligned assessments and curricula for the next generation of K-12 students

Home | About | Design Process | Task Portal | Projects | Dissemination

How can science educators effectively support the integrated 3-dimensional learning called for by the NGSS?

A big challenge facing teachers who are shifting instruction to meet the vision of the Framework for K-12 Science Education and the Next Generation Science Standards (NGSS) is how to support students' progress toward achieving the new standards.

The Next Generation Science Assessment (NGSA) group is a multi-institutional collaborative that is applying the evidence-centered design approach to create classroom-ready assessments for teachers to use formatively to gain insights into their students' progress on achieving the NGSS performance expectations.

We are a high-caliber interdisciplinary team with expertise in:

- science disciplinary knowledge and practice,
- science teaching and learning,
- classroom-based assessment,
- technology-enhanced instruction and assessment, and
- K-12 professional development.

Try Our NGSS Tasks

Do you work with students who are making steps toward a set of performance expectations?

Try our online, interactive assessment tasks featuring:

- Videos and simulations
- Authentic and engaging scenarios
- Stamps and drawing tools
- Scaffolds and supports

Learn about the NGSA task portal.

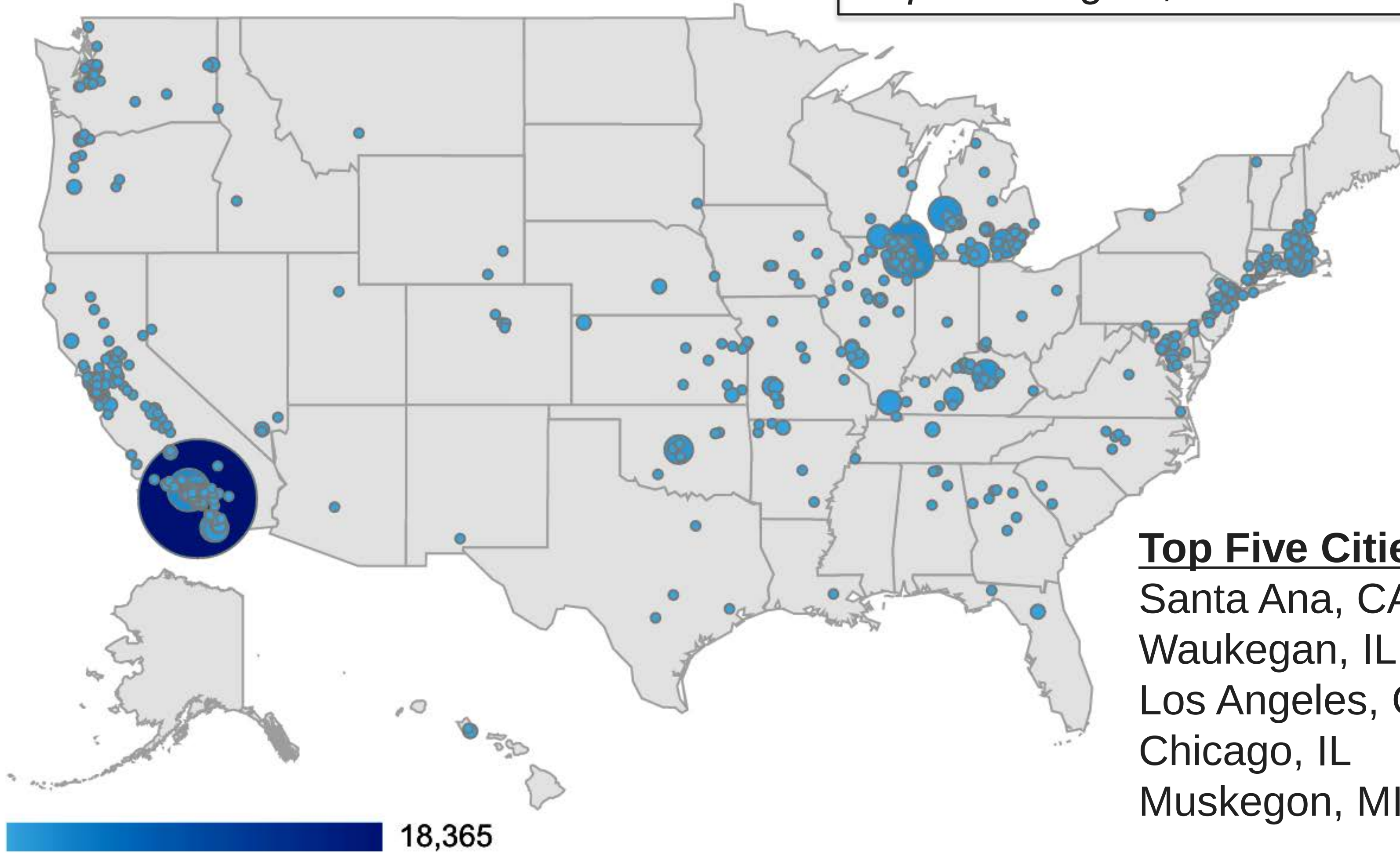
Try the NGSS Tasks

Contact us!

Search

NGSA Online Portal Data

Representing 62,791 Sessions



Top Five Cities

Santa Ana, CA
Waukegan, IL
Los Angeles, CA
Chicago, IL
Muskegon, MI

April, 2017

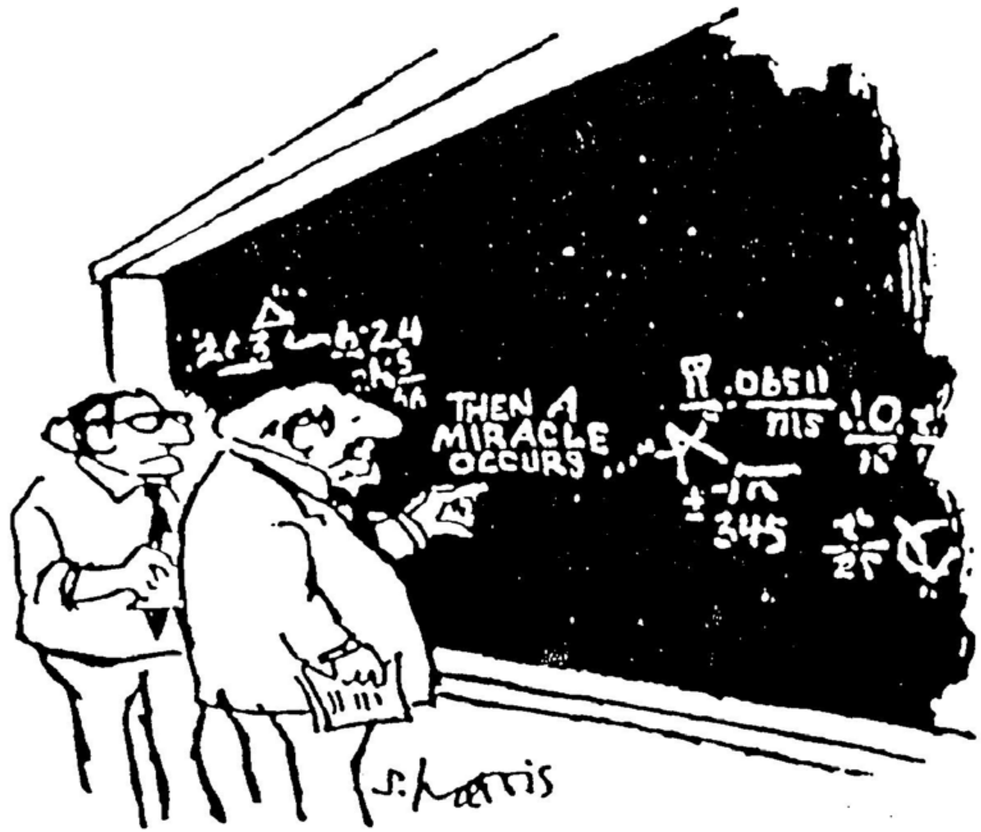
Overview of our Evidence-Centered Design Process

Typical Assessment Design

1 Identify Target Performance Expectations

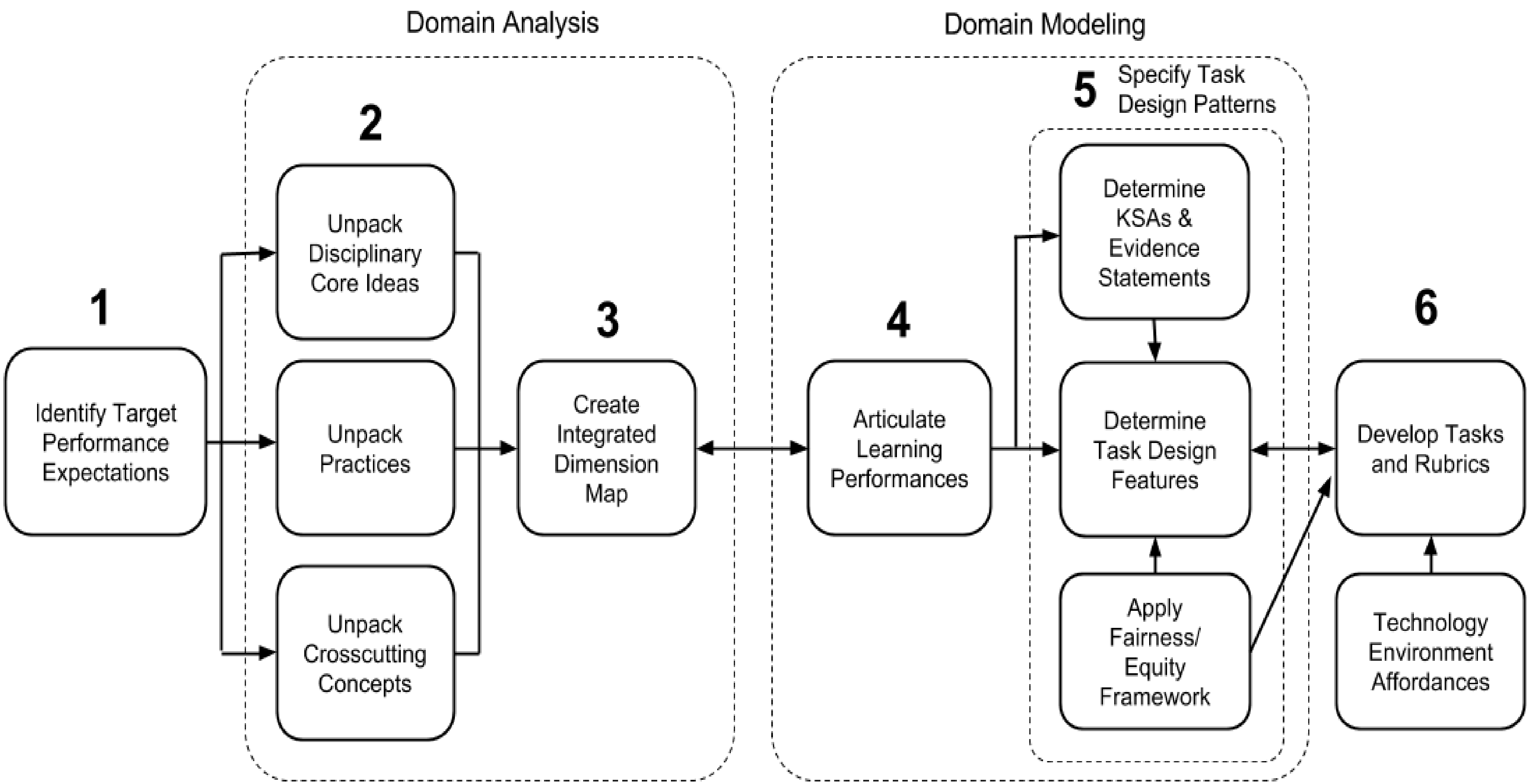
↓

2 Develop Tasks and Rubrics



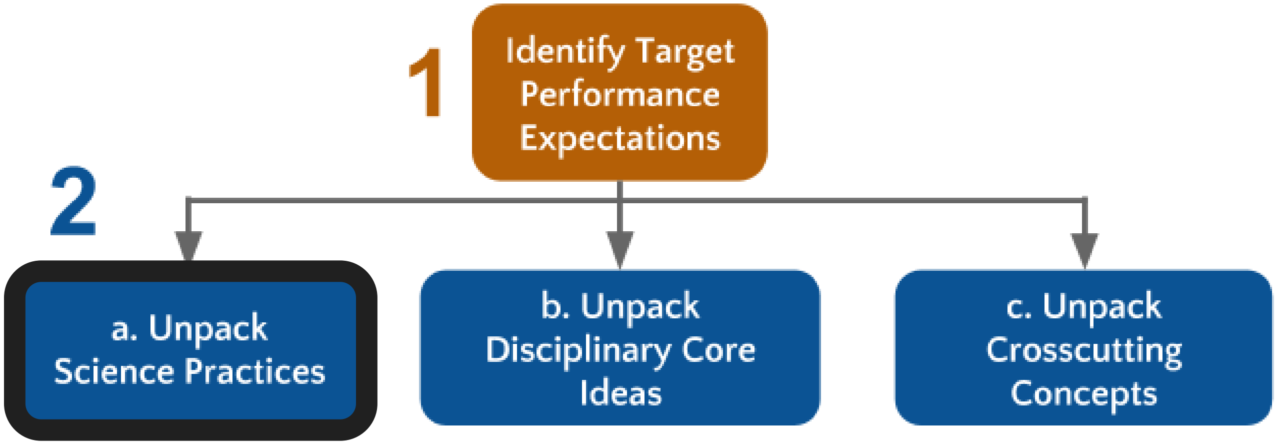
"I think you should be more explicit here in Step Two."

Grand Design Process



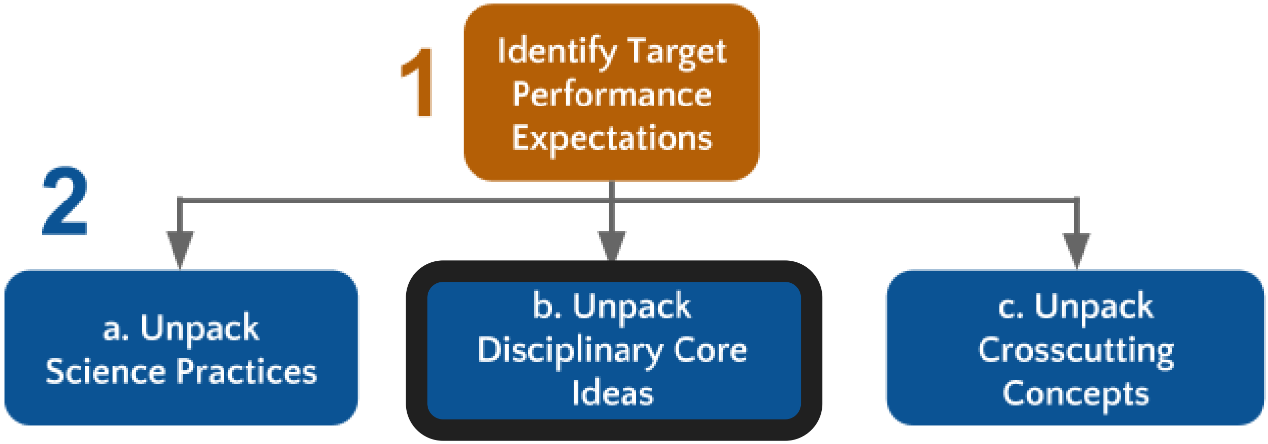
Domain Analysis

NGSA Design Process: Domain Analysis



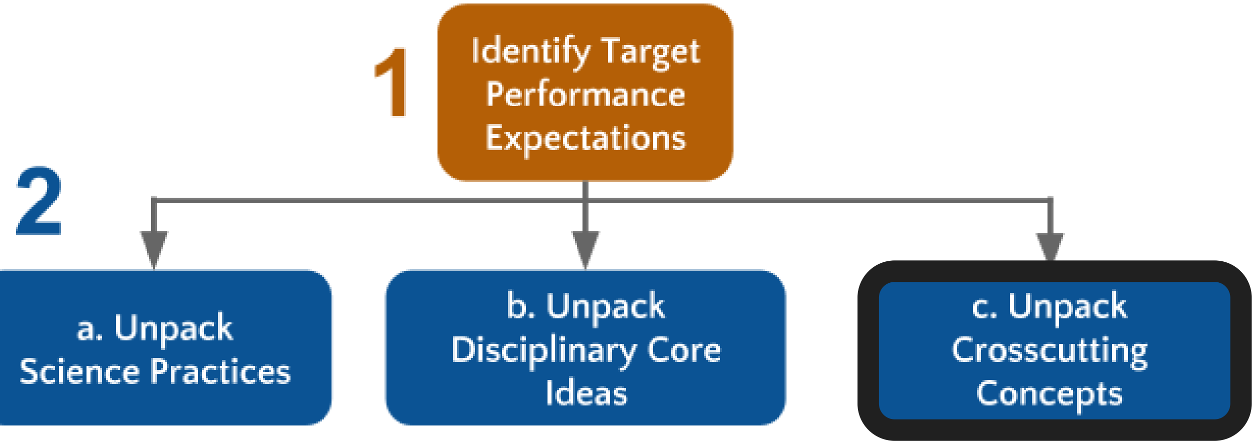
- Describe the practice and its components
- Identify the requisite knowledge and skills
- Specify features of a high level of performance
- Identify intersections with other practices

NGSA Design Approach: Domain Analysis



- Elaborate aspects of a disciplinary idea
- Define assessment boundary
- Describe prior knowledge
- Identify student challenges
- Brainstorm relevant phenomena

NGSA Design Approach: Domain Analysis



- **Describe essential features**
- **Specify features of a high level of performance**
- **Identify intersections with science practices and disciplinary core ideas**

Why Unpack??

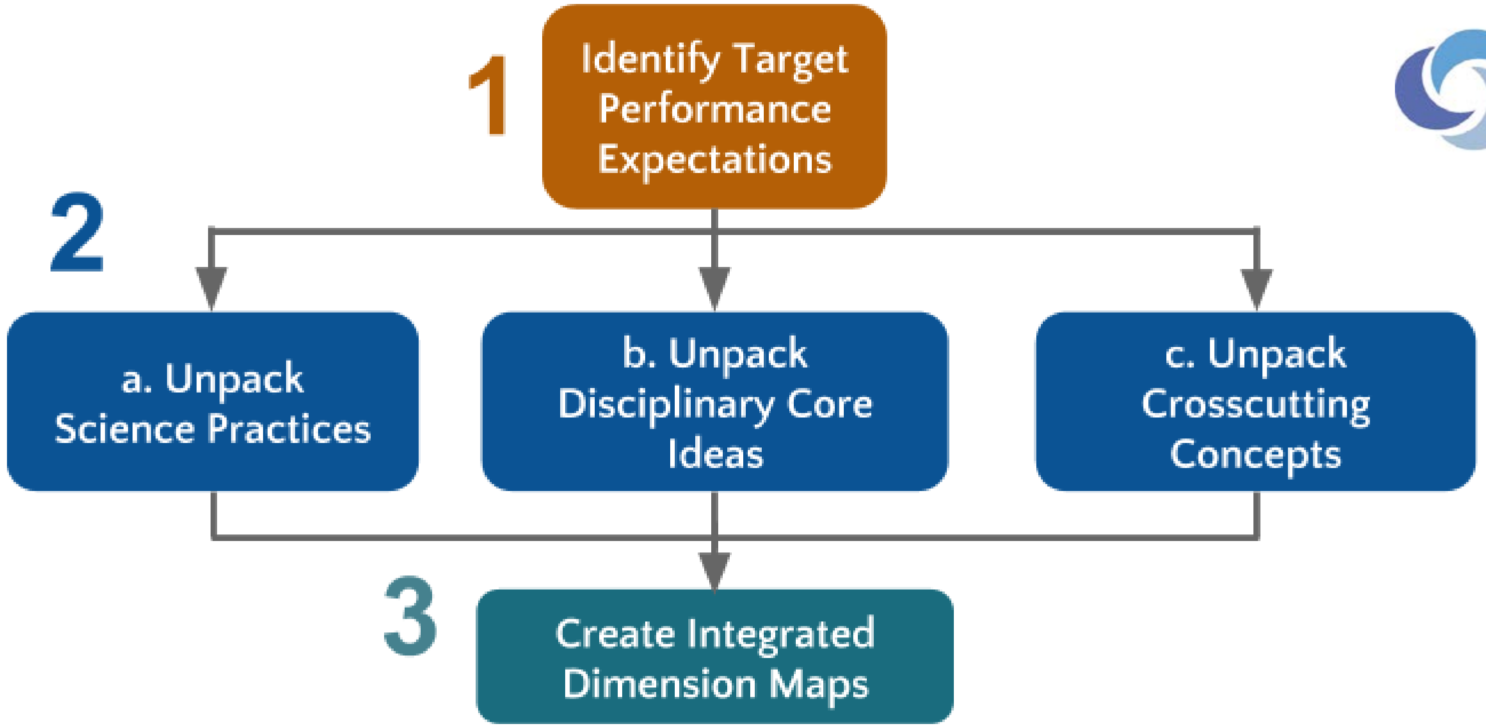
The unpacking process enables one to:

- 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 and apply 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
- Sustain the essential aspects of each dimension
- Sets the stage for constructing learning performances

NGSA Design Approach: Domain Analysis



We draw from the unpacking to lay out the conceptual "terrain" of the PE:

- Lay out the essential Disciplinary Relationships
- Link the Disciplinary Relationships to the crosscutting concepts and practices

Creating Integrated Dimension Maps

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

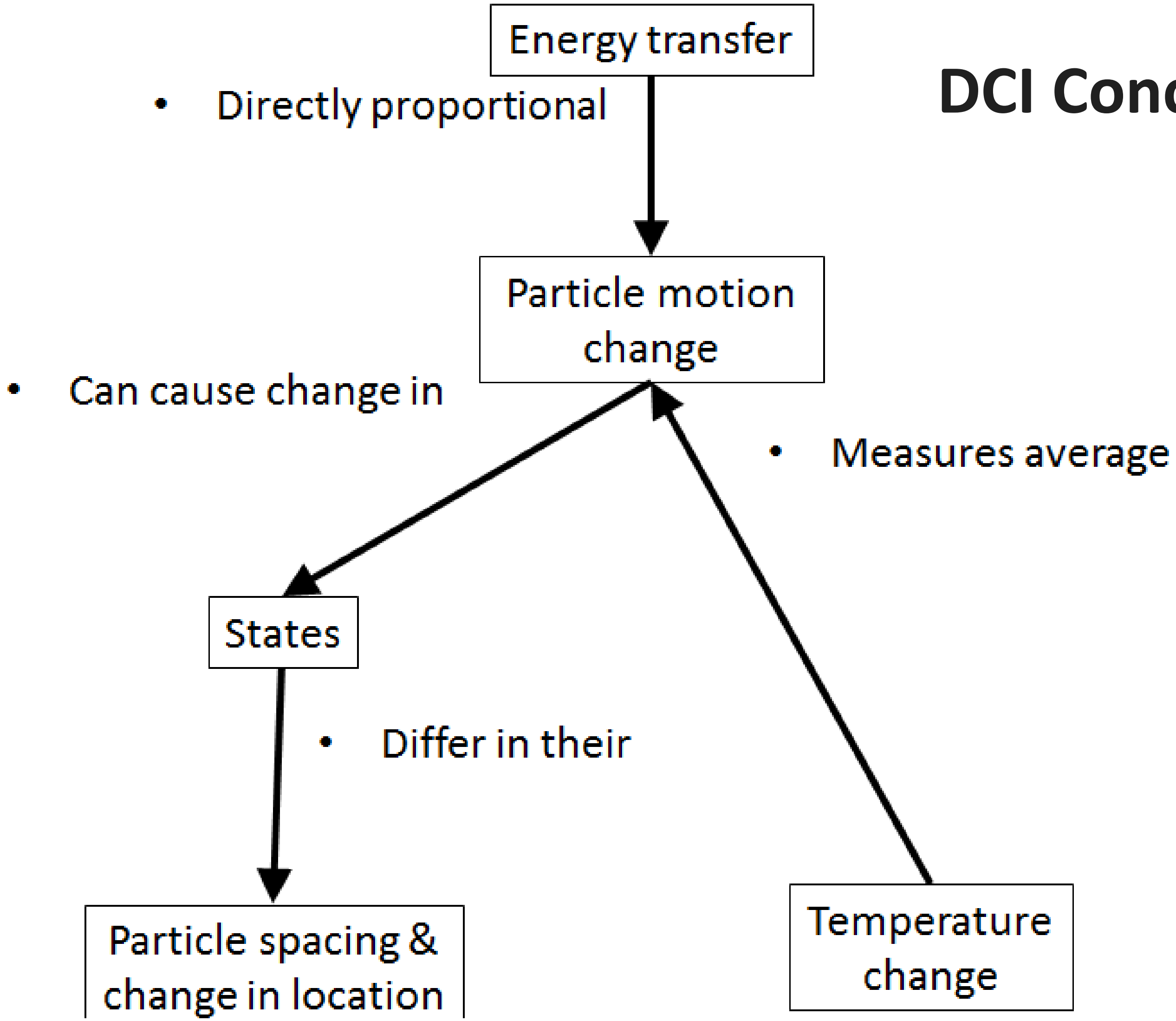
- Illustrates how the 3 dimensions are intended to work together to demonstrate proficiency with a PE
- Shows the possible ways for combining aspects of the 3 dimensions

Creating a map entails:

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

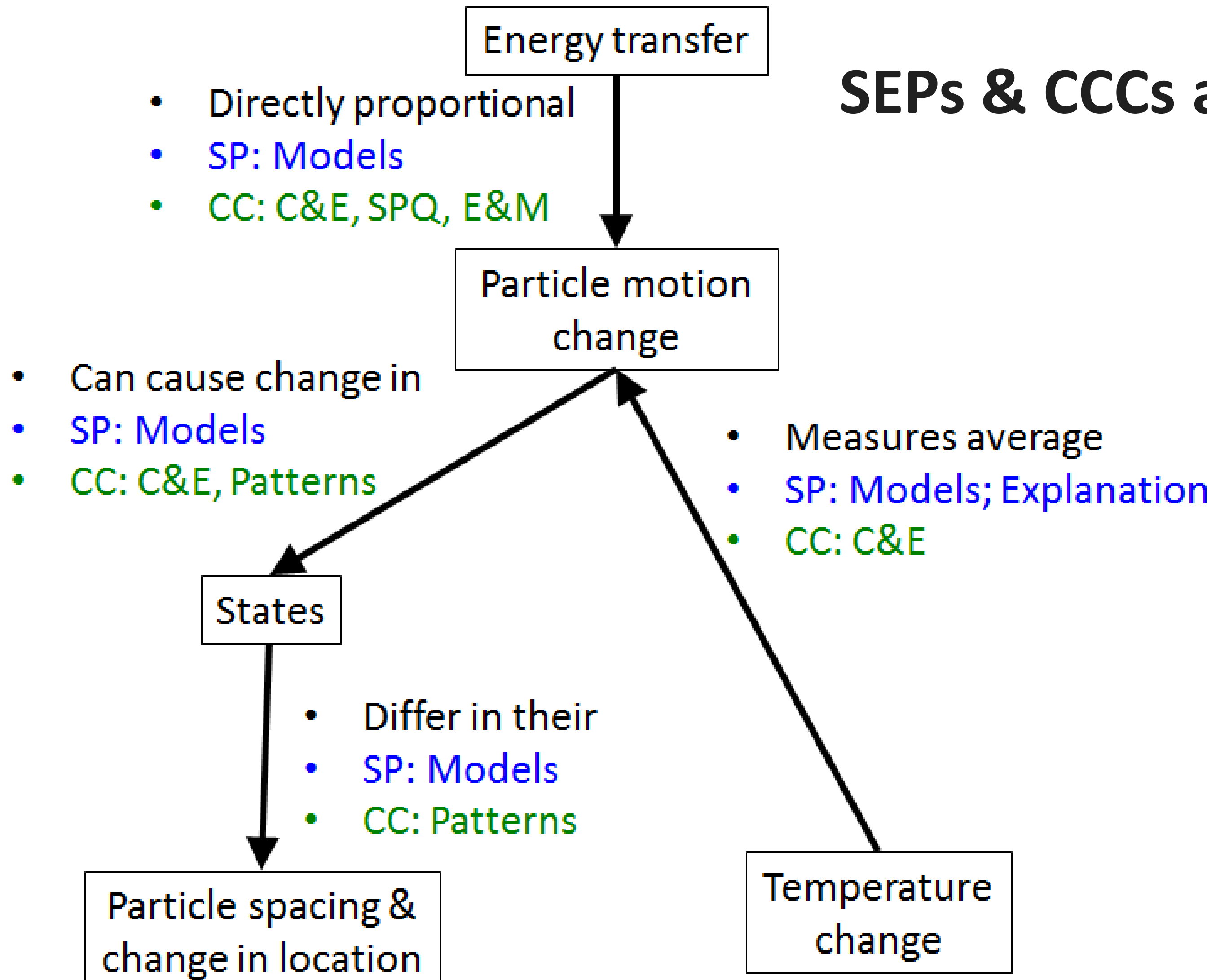
MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

DCI Concept Map



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.

SEPs & CCCs added



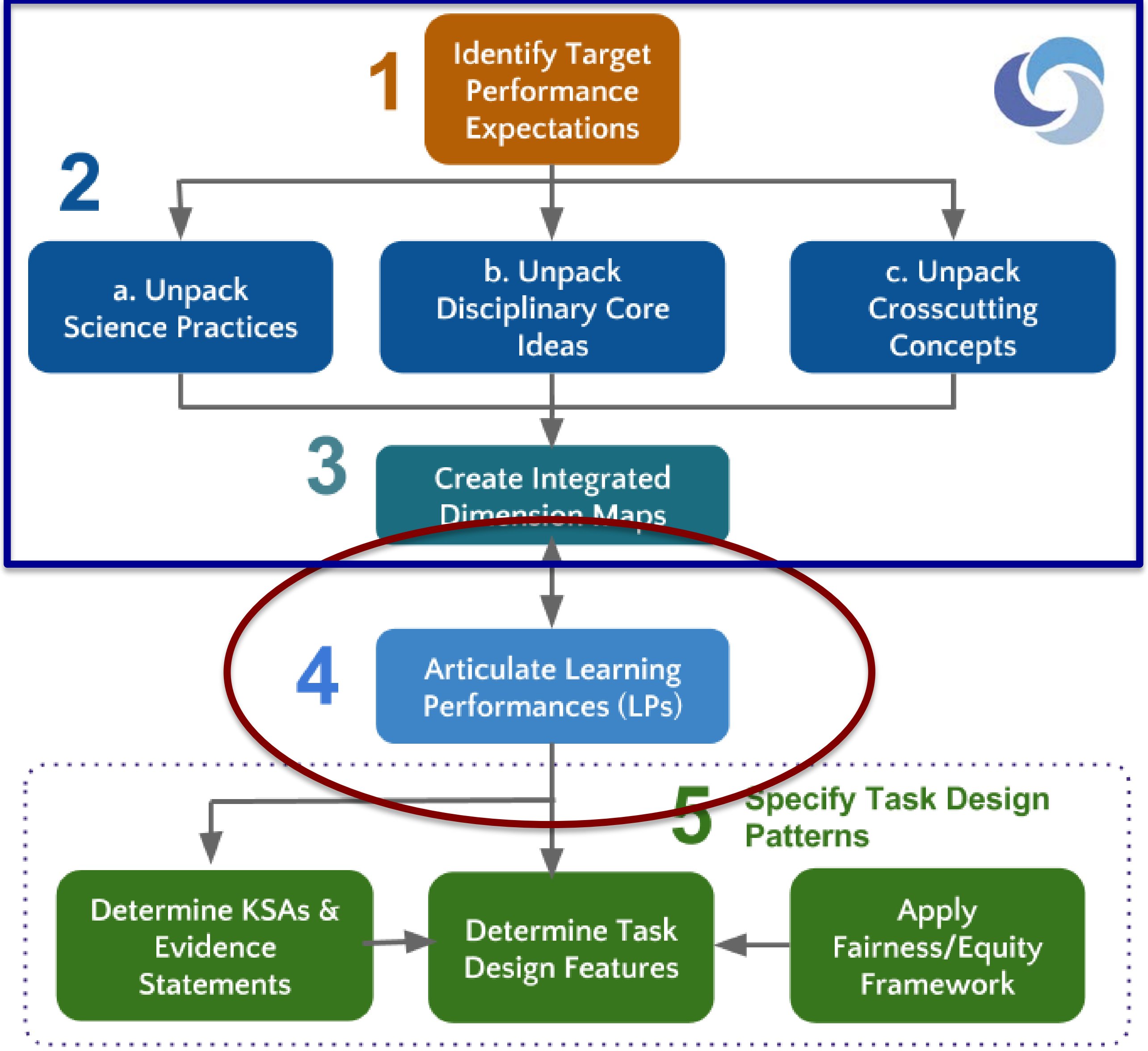
Domain Modeling

NGSA Design Process

Intentional and Explicit

Phase 1: ***Domain Analysis***

Phase 2: ***Domain Modeling***



We define 3-D building blocks called LEARNING PERFORMANCES

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.

- Each PE integrates the 3 dimensions and represents end-of-grade band goals
- Teachers need ways to assess 3-D proficiency and support students' progress toward PEs

We develop what we call: **Learning Performances**

Learning Performances

What is a Learning Performance?

- Knowledge-in-use 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 or executing “naked” procedures

Learning performances build towards a PE

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.

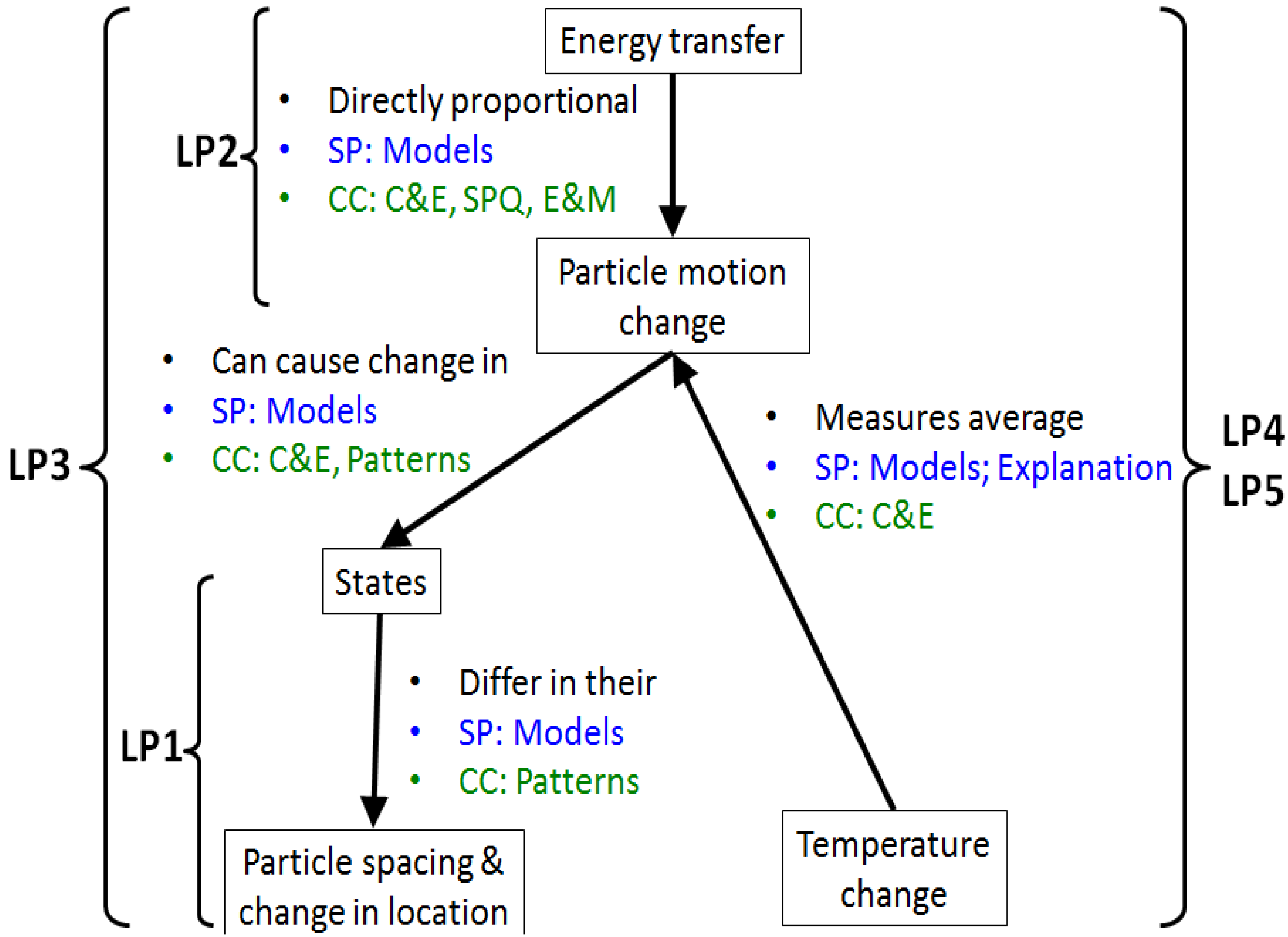
- **LP E-01:** Students evaluate a model that uses a particle view of matter to explain how states of matter are similar to and/or different from each other.
- **LP E-02:** Students develop a model that explains how particle motion changes when thermal energy is transferred to or from a substance without changing state.
- **LP E-03**: Students develop a model to explain the change in the state of a substance caused by transferring thermal energy to or from a sample.

Learning Performances integrate 3 Dimensions

- 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.

DCI	Practice	CCC
PS1.A. Structure and Properties of Matters • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • Transferring thermal energy to/from the samples could increase or decrease kinetic energy of the particles until a change of state occurs. **PS3.A. Definition of Energy** • The temperature of a system is proportional to the average kinetic energy and potential energy per atom or molecule.	**Develop a model** *Model Elements:* • Specify elements of the model (and their attributes) and describe why these elements are necessary *Relationship among Elements:* • Represent the relationships or interactions among model elements and describe why these relationships are important *Correspondence:* • Represent the correspondence between model elements and the target phenomenon or available data	**Cause and Effect** Cause and effect relationships may be used to explain and/or predict phenomena in natural or designed systems. • Identify or describe the cause(s) that lead to the given effect(s) under various conditions (thermal energy) • Identify or describe the effect(s) that result from the given cause(s) under various conditions. (particle motion)

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.



Chemical Reactions

Main PEs

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.

MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

Support PE

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.

- *LP C01:* Students *analyze and interpret data* to determine whether substances are the same based upon characteristic properties.
- *LP C02:* Students *construct a scientific explanation* about whether a reaction has occurred using properties of substances before and after the substances interact.
- *LP C03:* Students *evaluate whether a model explains* that different molecular substances are made from different types and/or arrangements of atoms.
- *LP C04:* Students *evaluate whether a model explains* that a chemical reaction produces new substances and conserves atoms.
- *LP C05:* Students *use a model to explain* that in a chemical reaction atoms are regrouped and why mass is conserved.
- *LP C06:* Students *develop a model* of a chemical reaction that explains new substances are formed by the regrouping of atoms, and that mass is conserved.
- *LP C07:* Students *evaluate whether a model explains* that a chemical reaction produces new substances and conserves mass because atoms are conserved.

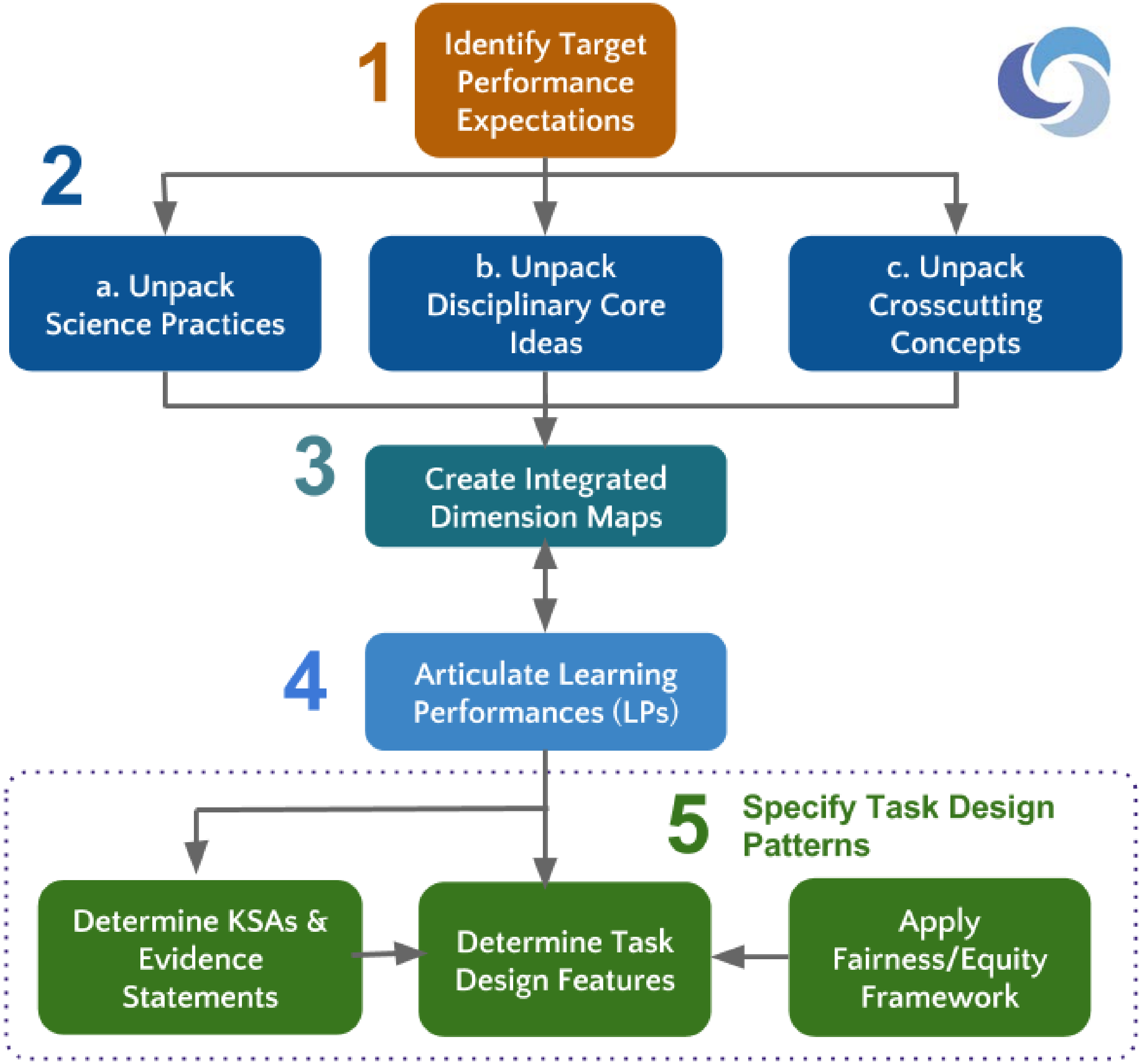
NGSA Design Process

Intentional and Explicit

Phase 1: ***Domain Analysis***

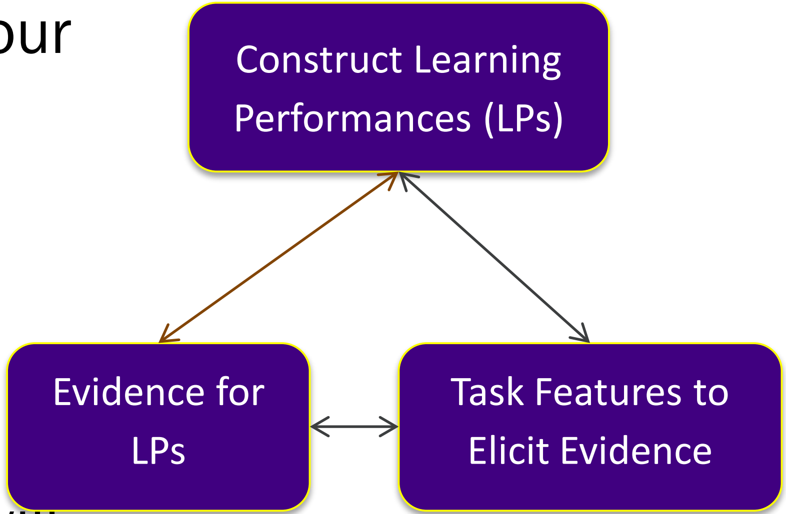
Phase 2: ***Domain Modeling***

Phase 3: ***Create tasks and rubrics***



Assessment as an Argument from Evidence: 3 Connected Questions

- What do we want students to know and be able to do? (Claims described by our learning performances)
- What kinds of evidence will students need to provide to demonstrate proficiency?
- What kinds of tasks / task features will elicit the desired evidence?



When we have logical and coherent answers connecting these three questions, we have an *assessment argument*.

Specify Task Design Pattern for LP

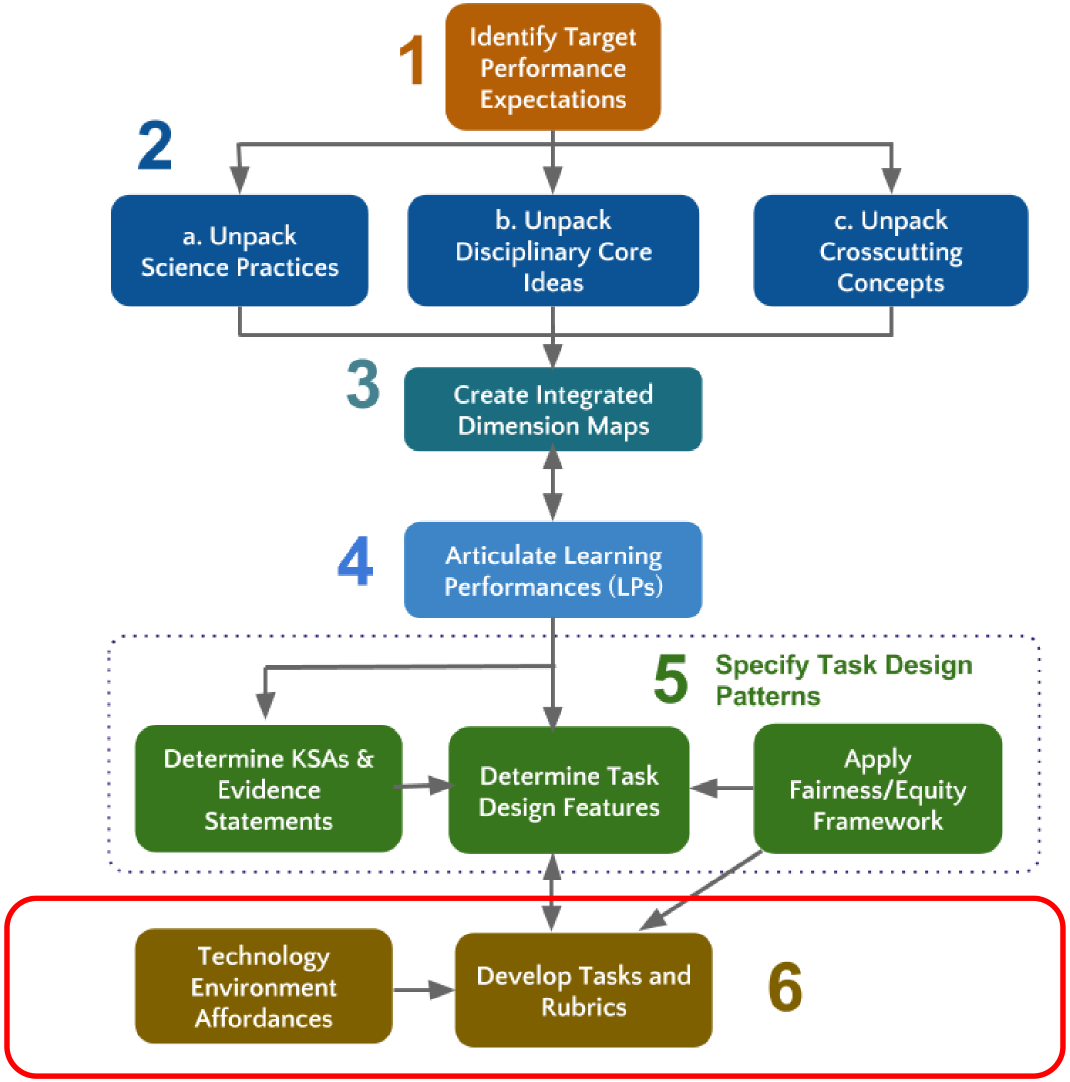
Construct the Assessment Argument
Claim (the Learning Performance)
Focal Knowledge, Skills, & Abilities ("FKSAs")
Additional Knowledge, Skills, & Abilities
Evidence Required to Demonstrate Proficiency
Characteristic Task Features – present in each task
Variable Task Features – present in some tasks

Characteristic Task Features	• Prompt students to develop a model to explain what is observed in the scenario • Prompt students to describe (in text) what the model shows • Provide students with a computer-based drawing tool to develop a model • Provide a scientifically authentic investigation context accessible to students with diverse cultural backgrounds and experiences.* • Use language accessible to students with diverse linguistic abilities*
Variable Task Features	• Types of scenario/phenomenon students are asked to model • Representation of the phenomenon (e.g. video, verbal description, static image) • Modeling/drawing tool features provided for students* • Prompt to include a legend or labels for their model • Scaffolding features to help elicit relevant model features* • Visual aids to support students with diverse linguistic and visual ability*

** Indicates features specifically informed by our fairness assessment framework*

Developing and Evaluating Tasks

Developing Tasks & Rubrics



Tasks built to align to LPs

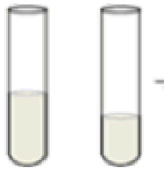
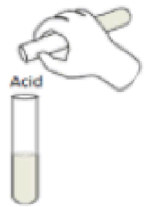
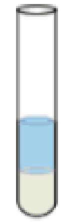
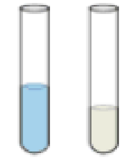
- Claims in the Learning Performances, and their associated evidence statements, are used to identify task characteristics
- One LP will have multiple tasks that can be designed – can be designed to vary in difficulty
- Exemplar responses written for each task, checked against the LP/Task evidence statement
- Multidimensional rubrics are specified for scoring
- Student data are collected to refine task design and scoring rubrics

Shawn had 3 dishes of water at room temperature. She cooled one dish, causing thermal energy to transfer from that dish to the surroundings. She kept the middle dish at room temperature. She transferred thermal energy into the third dish by heating it. Then, Shawn dropped a red-coated chocolate candy into each dish. Watch what happened using the video.

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**

Nami wondered if mixing an acid with an alcohol would cause a chemical reaction. She did the following experiment:

Step 1	Step 2	Step 3	Step 4	Step 5
 Acid Alcohol			 Layer 1 Layer 2	 Layer 1 Layer 2
Measured and tested properties of acid and alcohol at room temperature. Recorded data in Table 1.	Mixed the acid and alcohol in a test tube.	Heated the test tube with the mixture.	After heating, observed Layer 1 and Layer 2 form.	Measured and tested properties of substance in Layer 1 and Layer 2 at room temperature. Recorded data in Table 1.

She measured the boiling point and mass, and calculated the density of the substance, then recorded the data in Table 1.

Question #1

Based on Nami's results in Table 1, write a scientific explanation about whether this experiment had a chemical reaction or not. In your scientific explanation make sure that you:

1. Write a claim stating whether the acid and alcohol chemically reacted.
2. Include evidence to support your claim.
3. Give reason(s) why the evidence you included supports your claim.

Table 1. Data for liquids before and after the experiment

Substance	Density	Boiling Point	Mass
Acid	1.2 g/cm³	100 °C	6.9 g
Alcohol	0.80 g/cm³	98 °C	9.0 g
Layer 1	0.91 g/cm³	82 °C	13.2 g
Layer 2	1.0 g/cm³	100 °C	2.7 g

For a class project, Jaden's science teacher asked him to develop a model to show how energy flows through a natural system that involves a consumer. Jaden chose to use the koala as the consumer in his model. Koalas live in eucalyptus trees and eat mainly eucalyptus leaves. Jaden's model is shown to the right.

Question #1

Describe 2 parts of Jaden's model that show you how energy flows through the system.

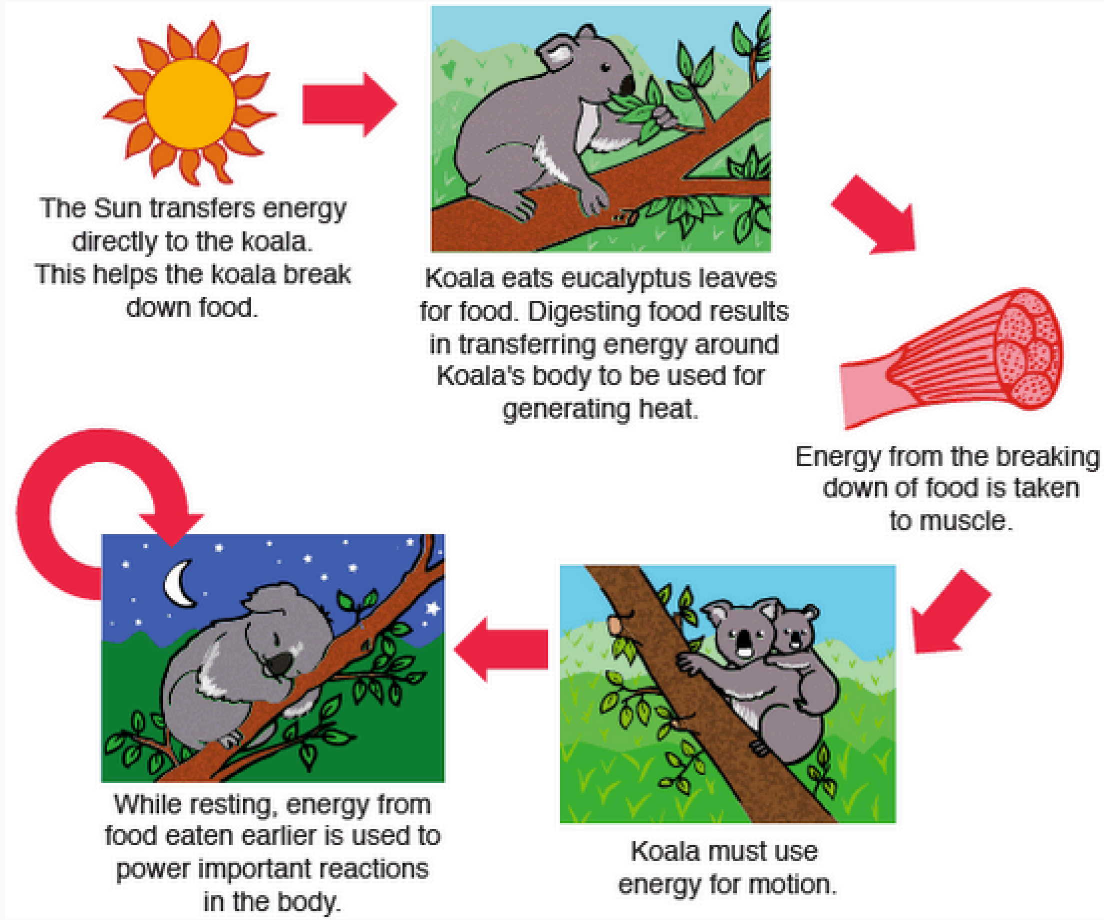
Type answer here

Question #2

What feedback would you give to Jaden to help him improve his model? Take a snapshot of the model and circle 2 parts that need improvement.

Then use the text box to describe improvements you would make to the parts of the model you circled.

Take a snapshot



To what extent and in what ways does this task relate to students making use of the three dimensions of the NGSS?

Claims, Evidence, Tasks & Alignment

- What claim (or claims) about student proficiency do you want to make?
- Which NGSS dimensions are targeted?
- Does a candidate assessment task require access to all three targeted NGSS dimensions in order for students to complete the task?
  - Does the assessment task require students to integrate the three targeted NGSS dimensions?
  - Is the task likely to elicit the desired evidence?
- Does the full task set provide sufficient evidence relative to your overall claim(s) for the assessment?

Some Key Takeaway Points & Implications for Task Design & Alignment for State Assessments

Key Points

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

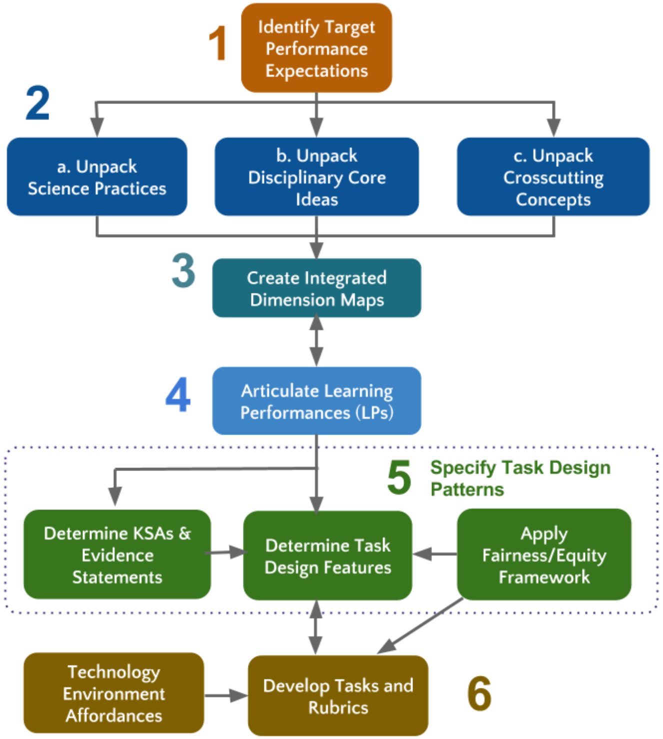
- Integrate aspects of all 3 dimensions of a given performance expectation
- Function in relation to other LPs to identify “what it takes” to make progress toward meeting a performance expectation (or set)
- Provides guidance to assessment designers for creating instructionally supportive tasks

The Value of an ECD Type Process

A systematic process to facilitate consensus about the design principles of tasks (in this case, 3-dimensional classroom assessments)

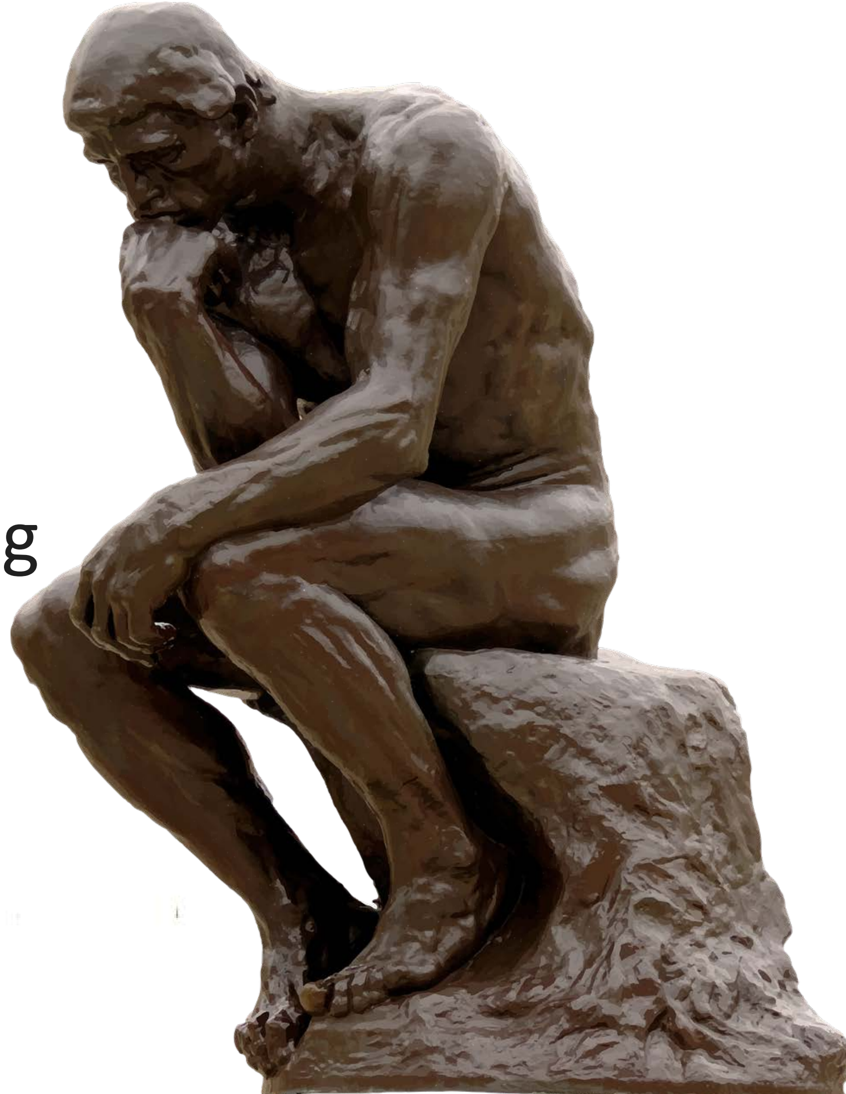
Benefits

- Broadly accessible vision of how to design NGSS assessments
- Documents principled design decisions
- Creates well-aligned tasks that are usable across varied purposes/environments
- Generalizes to other core ideas, crosscutting concepts, and practices



Thoughts, Questions & Concerns

- On unpacking
- Integrated dimension maps
- Creating Learning Performances
- Moving from LPs to Tasks
- Creating Rubrics and Scoring
- Classroom Implementation
- Measurement & Validation
- Application to Large-Scale Assessment Design



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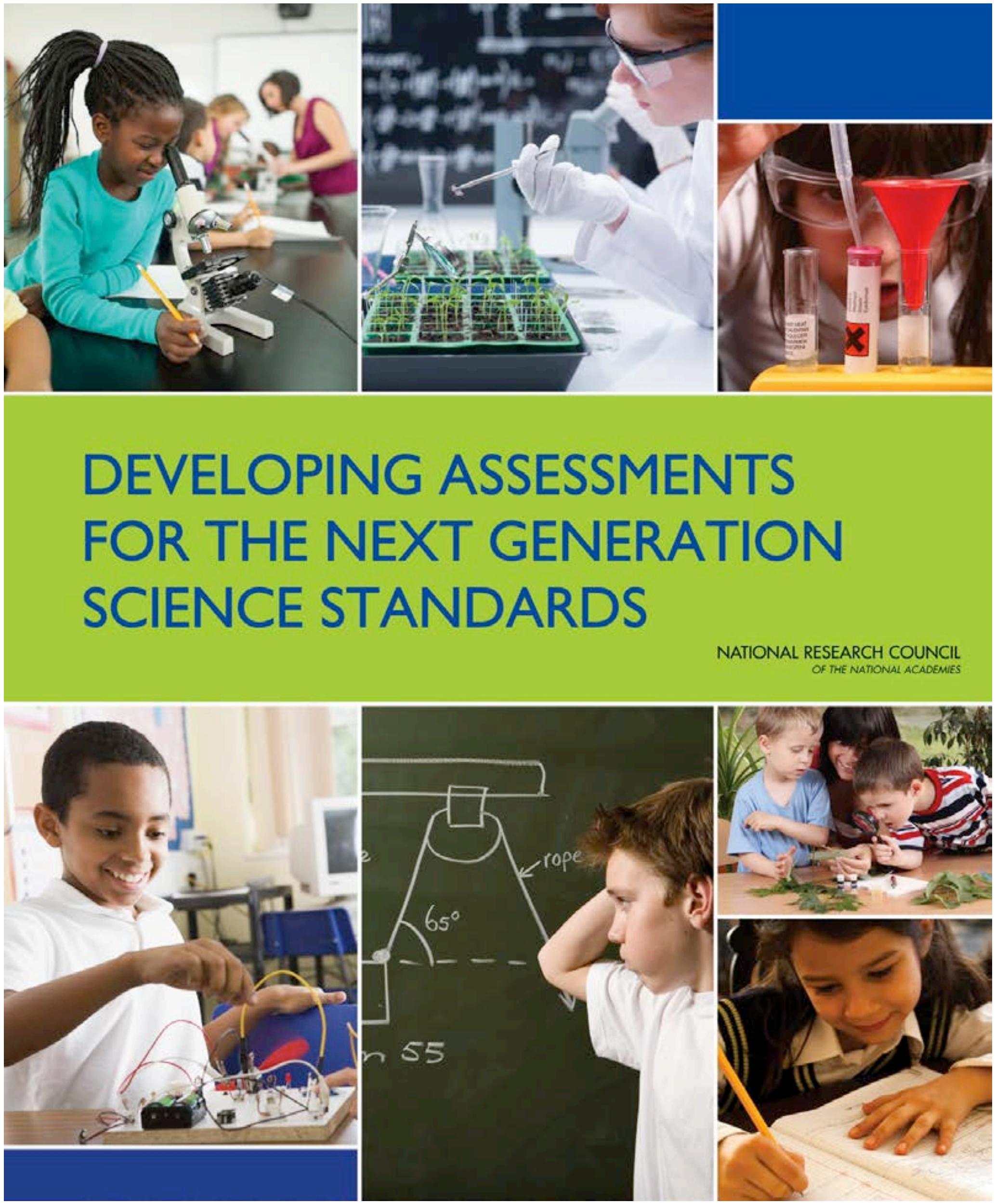

Committee on the Assessment of K-12 Science Proficiency

Board on Testing and Assessment

and

Board on Science Education

National Academy of Sciences

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

Report's Main Messages

1. Assessment tasks should allow students to engage in science practices in the context of disciplinary core ideas and crosscutting concepts. This poses a significant design challenge.
2. Students will need multiple and varied assessment opportunities to demonstrate their proficiencies with the NGSS performance expectations.
3. Build a coherent system of assessments – three system components
   - **(a) classroom; (b) state level monitoring; (c) opportunity to learn**
4. Implementation should be gradual, systematic, and carefully prioritized, beginning with classroom assessment and moving to monitoring assessment.
5. Professional development, adequate support for teachers, and innovative applications of technology will be critical.

Five Relevant Questions for Michigan

1. What are the conceptions that most people you know, including policy makers, educators, parents, and the public, have about **what it means to know and learn science**?
2. What are the conceptions that most people you know, including policy makers, educators, parents, and the public, have about the **teaching of science**?
3. What are the conceptions that most people you know, including policy makers, educators, parents, and the public, have about the **assessment of science learning**?
4. To what extent do those conceptions **help or hinder** the process of **designing and implementing high quality instruction** that includes assessments of "three-dimensional" science learning as part of normal educational practice?
5. What would it take for a state like Michigan to **design and implement a coherent and balanced science assessment system** tied to contemporary science standards? What are the opportunities as well as the barriers?