Three-Dimensional Science Teaching and Learning: *The Work of the Texas Instruments Science Implementation Team*

Live T^3 Webinar
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TI Science Implementation Team

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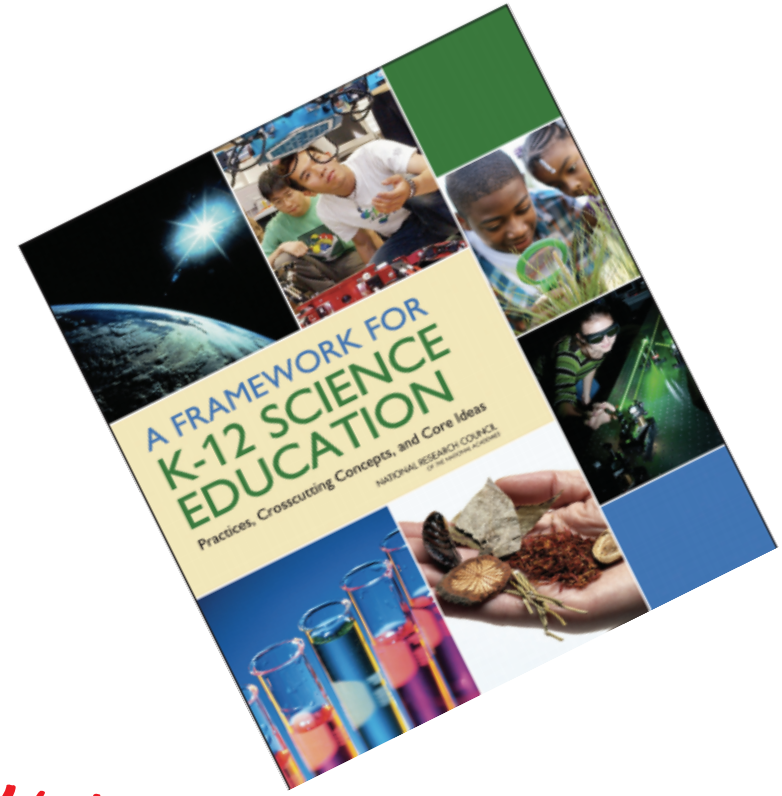
- **Ron DeChristoforo**
  - TI State Policy Director
- **Peter McLaren**
  - NGSS Writing Team Member and National Science Consultant

A Vision For Science Education



"The Framework is designed to help realize a vision for education in the sciences and engineering in which ***(all) students****, over multiple years of school, actively* ***engage in science and engineering practices*** *and* ***apply crosscutting concepts*** *to deepen their* ***understanding of the core ideas*** *in these fields."*

A Framework for K-12 Science Education (NRC, pp 8–9)

The Innovations of the NGSS

1. Three-Dimensional Learning
2. Students engaged in Phenomena and Designed Solutions
3. Engineering and Nature of Science in integrated into science
4. All three dimensions build coherent learning progressions
5. Science is connected to math and literacy

Three Dimensions of the *Framework*

Science & Engineering Practices

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

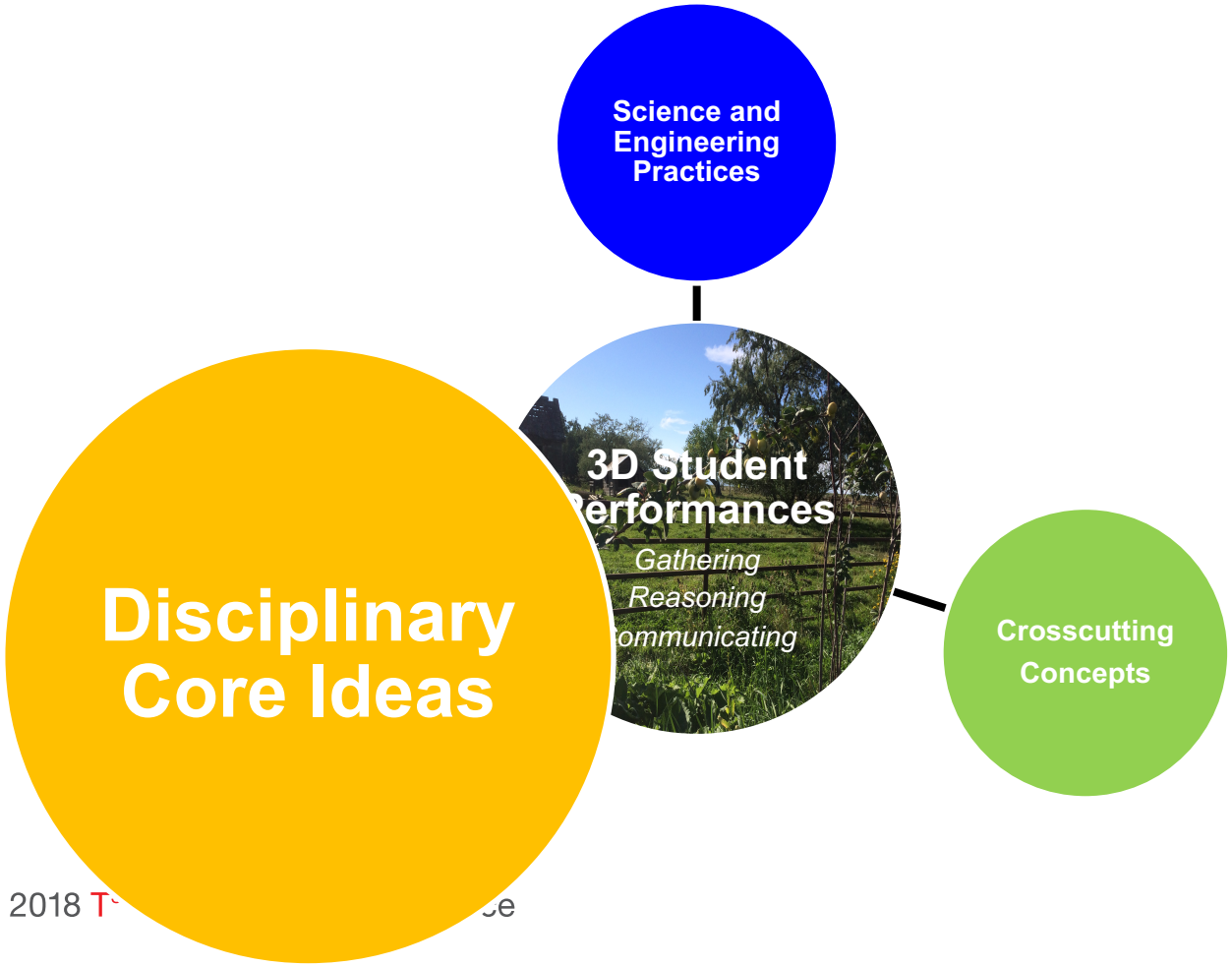
Crosscutting Concepts

1. Patterns
2. Cause and effect
3. Scale, proportion and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

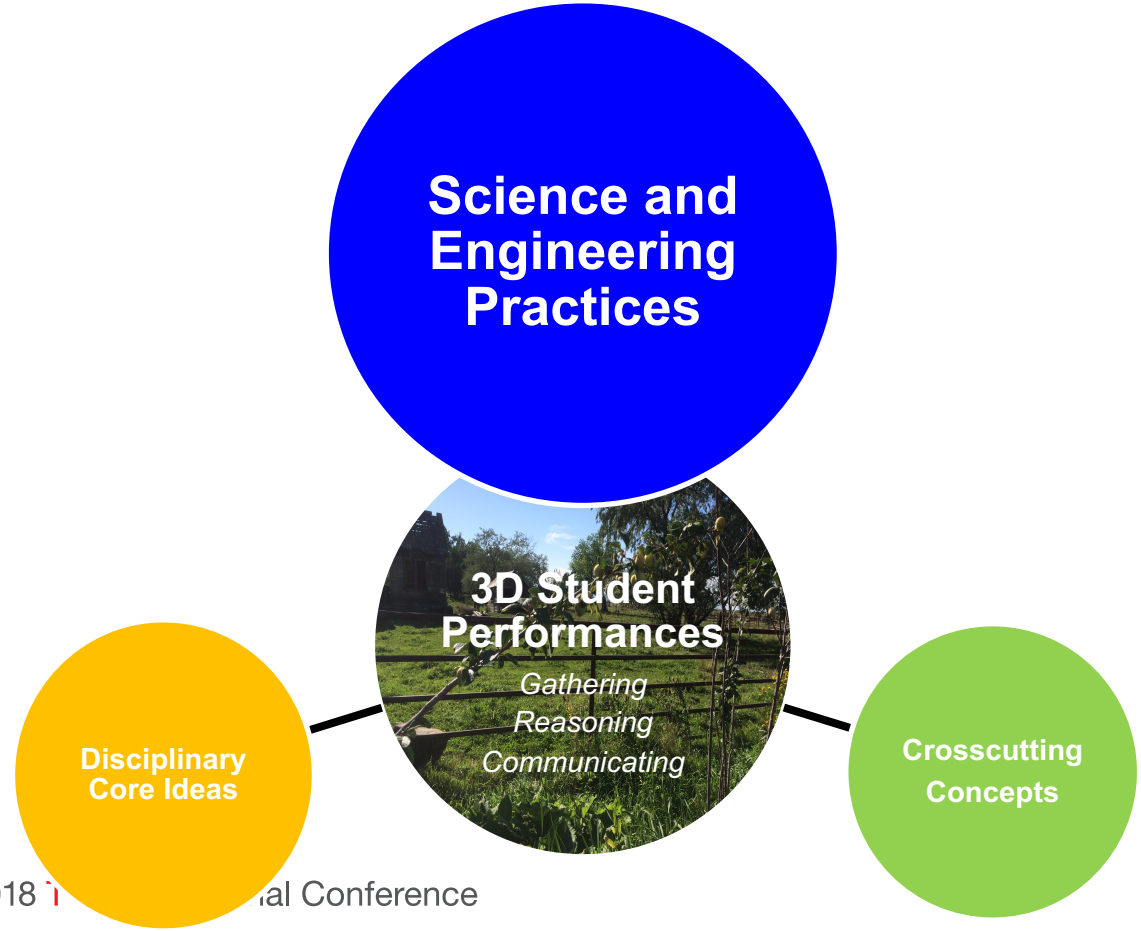
Disciplinary Core Ideas

Life Science	Physical Science
LS1: From Molecules to Organisms: Structures and Processes	PS1: Matter and Its Interactions
LS2: Ecosystems: Interactions, Energy, and Dynamics	PS2: Motion and Stability: Forces and Interactions
LS3: Heredity: Inheritance and Variation of Traits	PS3: Energy
LS4: Biological Evolution: Unity and Diversity	PS4: Waves and Their Applications in Technologies for Information Transfer
Earth & Space Science	**Engineering & Technology**
ESS1: Earth's Place in the Universe	ETS1: Engineering Design
ESS2: Earth's Systems	ETS2: Links Among Engineering, Technology, Science, and Society
ESS3: Earth and Human Activity	

Science Performances are at the Intersection of Student Learning



Science Performance are at the Intersection of Student Learning



Science and Engineering Practices

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

Framework Pages 41-82

CCSS Mathematical Practices

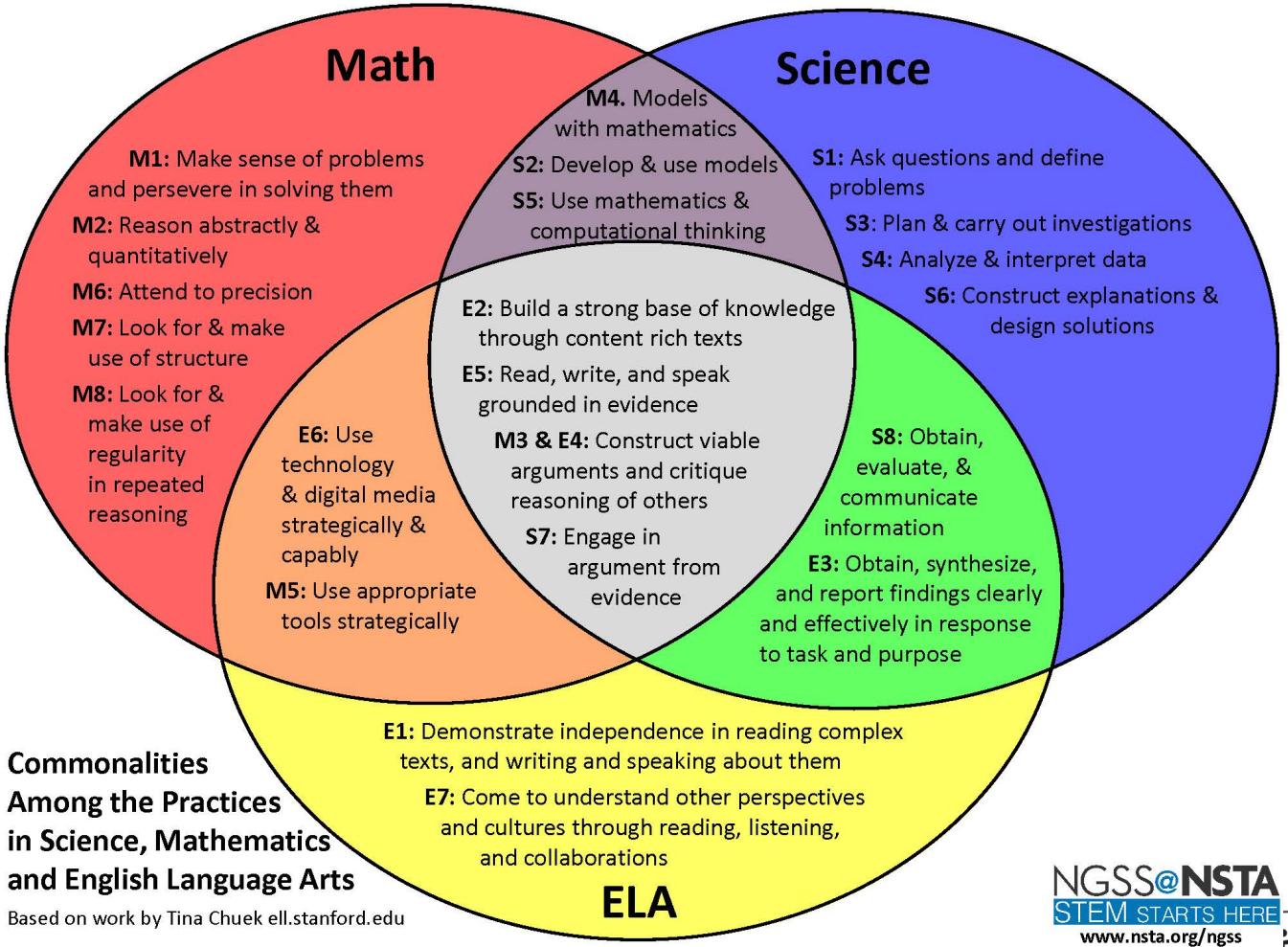
1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
7. Look for and make use of structure
8. Look for regularity in repeated reasoning

Science and Engineering Practices

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

Science and Engineering Practices

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



Commonalities Among the Practices in Science, Mathematics and English Language Arts

Based on work by Tina Chuek ell.stanford.edu

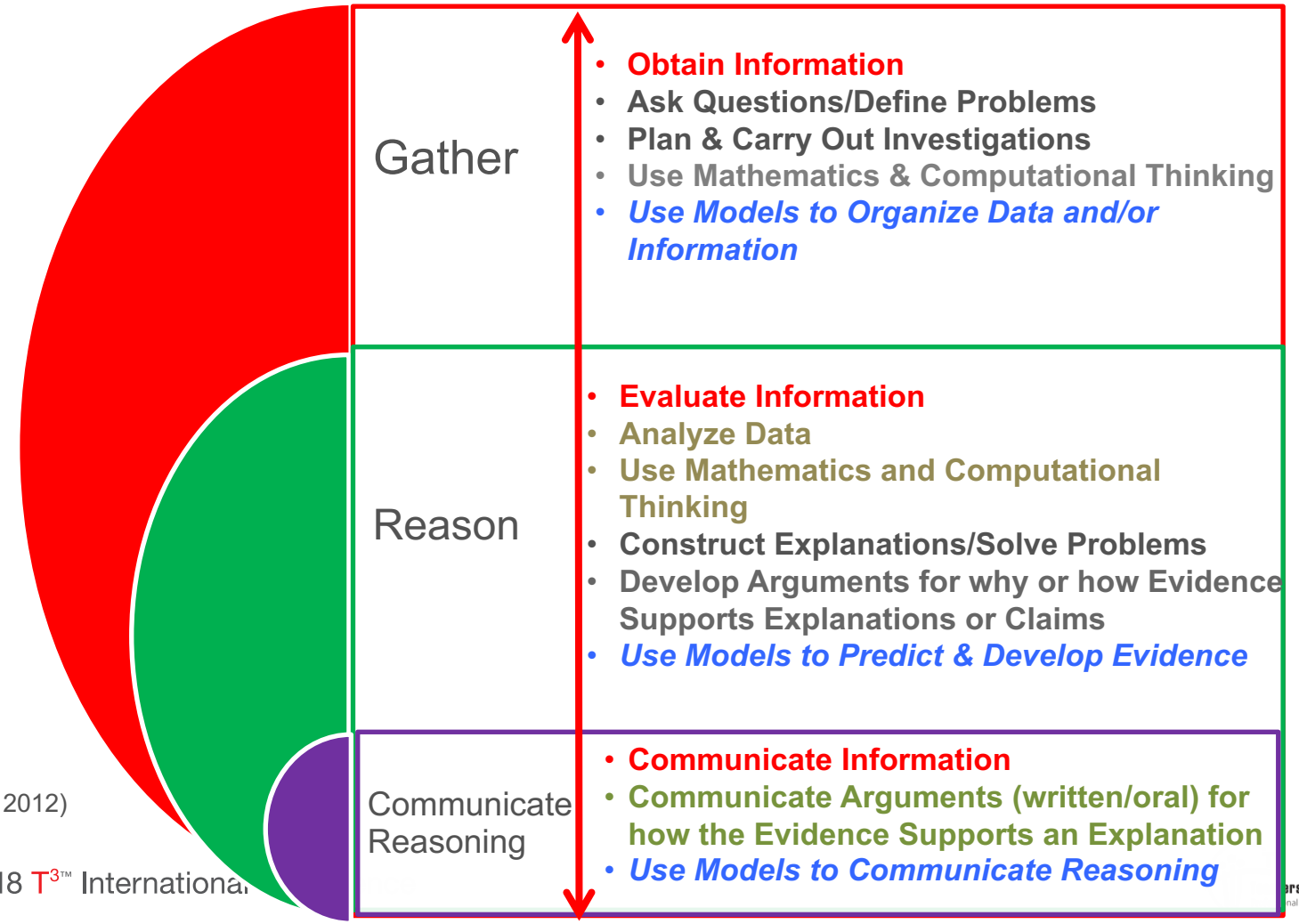
CCSS + NGSS = TI ❤

CCSS Says

1. Make sense of problems, persevere in solving them
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
7. Look for and make use of structure
8. Look for and express regularity in repeated reasoning.

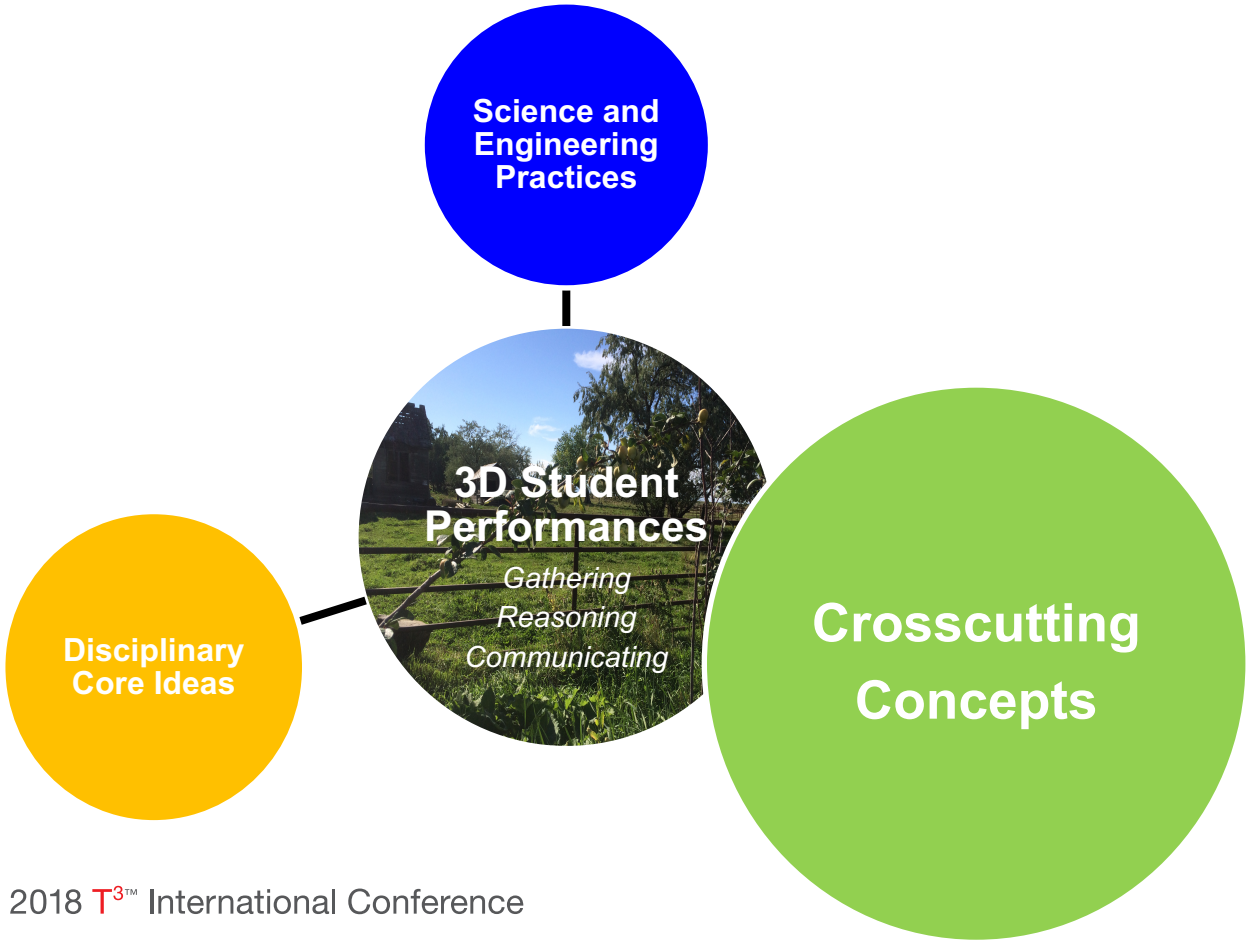
NGSS Says

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



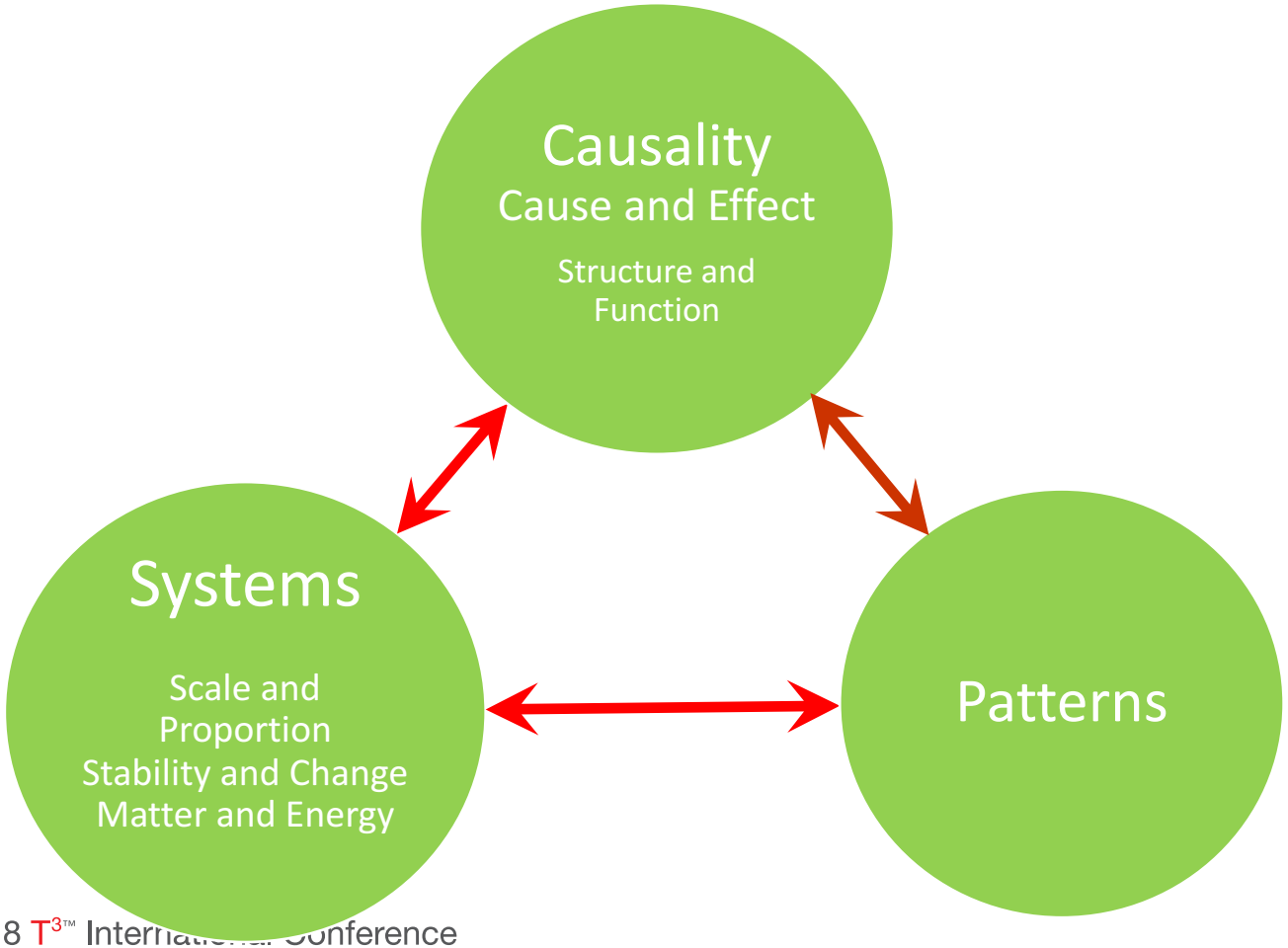
(Moulding, 2012)

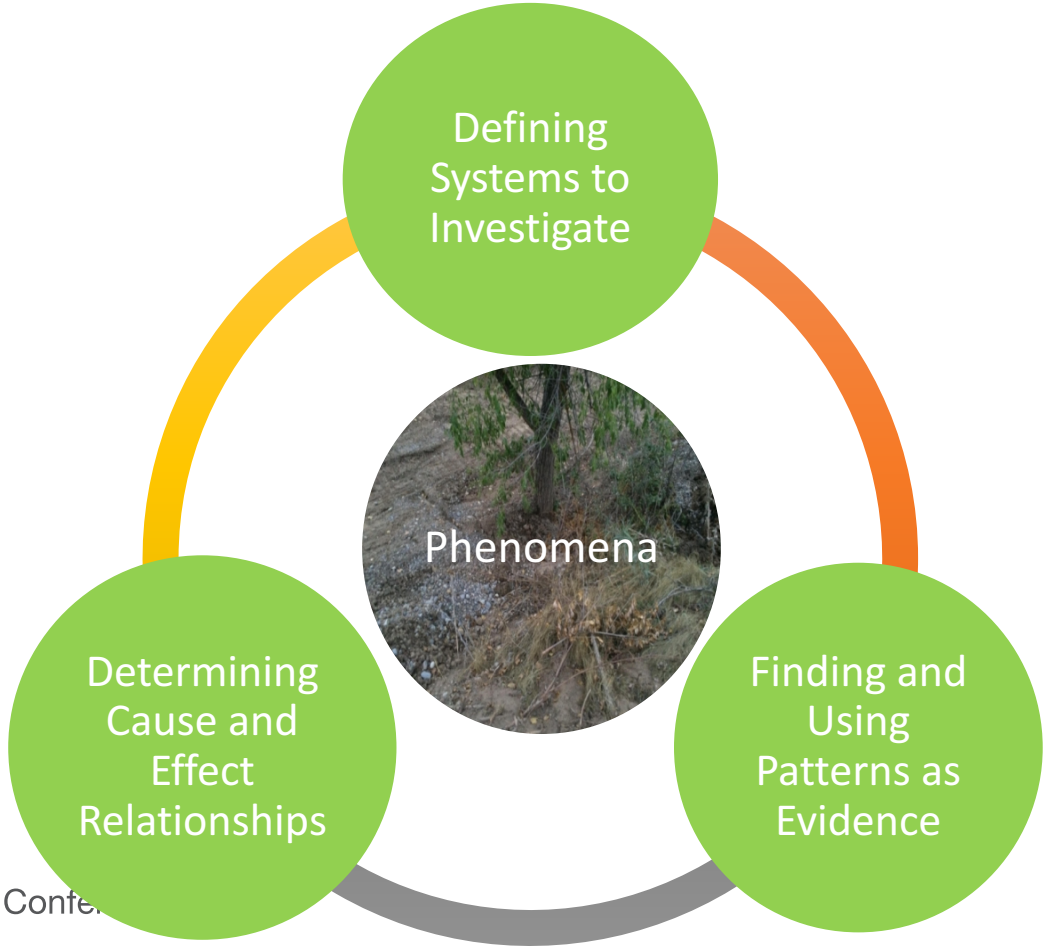
Science Performance are at the Intersection of Student Learning

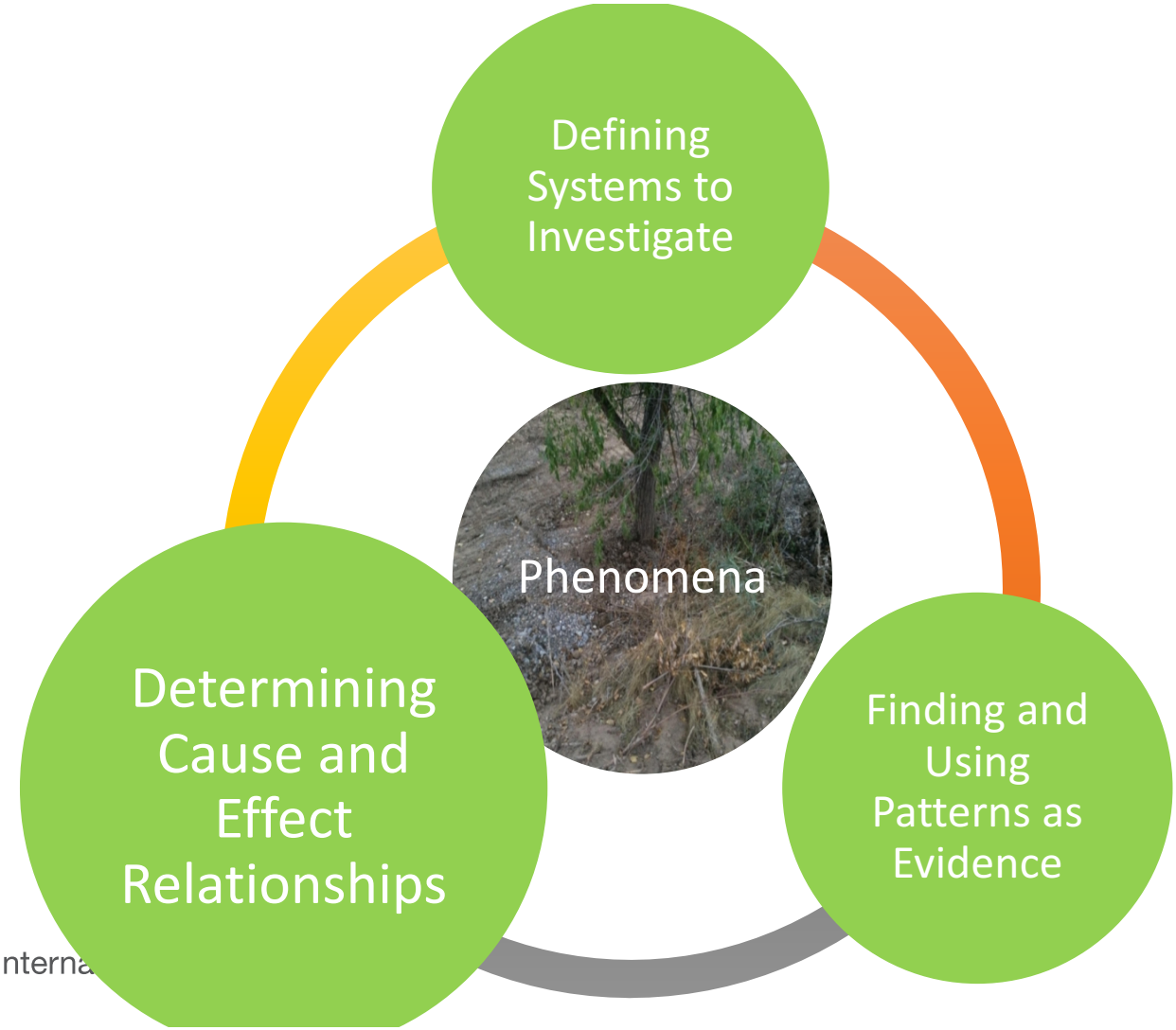


Crosscutting Concepts

1. Patterns
2. Cause and Effect
3. Scale, Proportion, and Quantity
4. Structure and Function
5. Systems and System Models
6. Matter and Energy
7. Stability and Change


Causality
Cause and Effect
Structure and Function
Systems
Scale and Proportion
Stability and Change
Matter and Energy
Patterns


Defining Systems to Investigate
Phenomena
Determining Cause and Effect Relationships
Finding and Using Patterns as Evidence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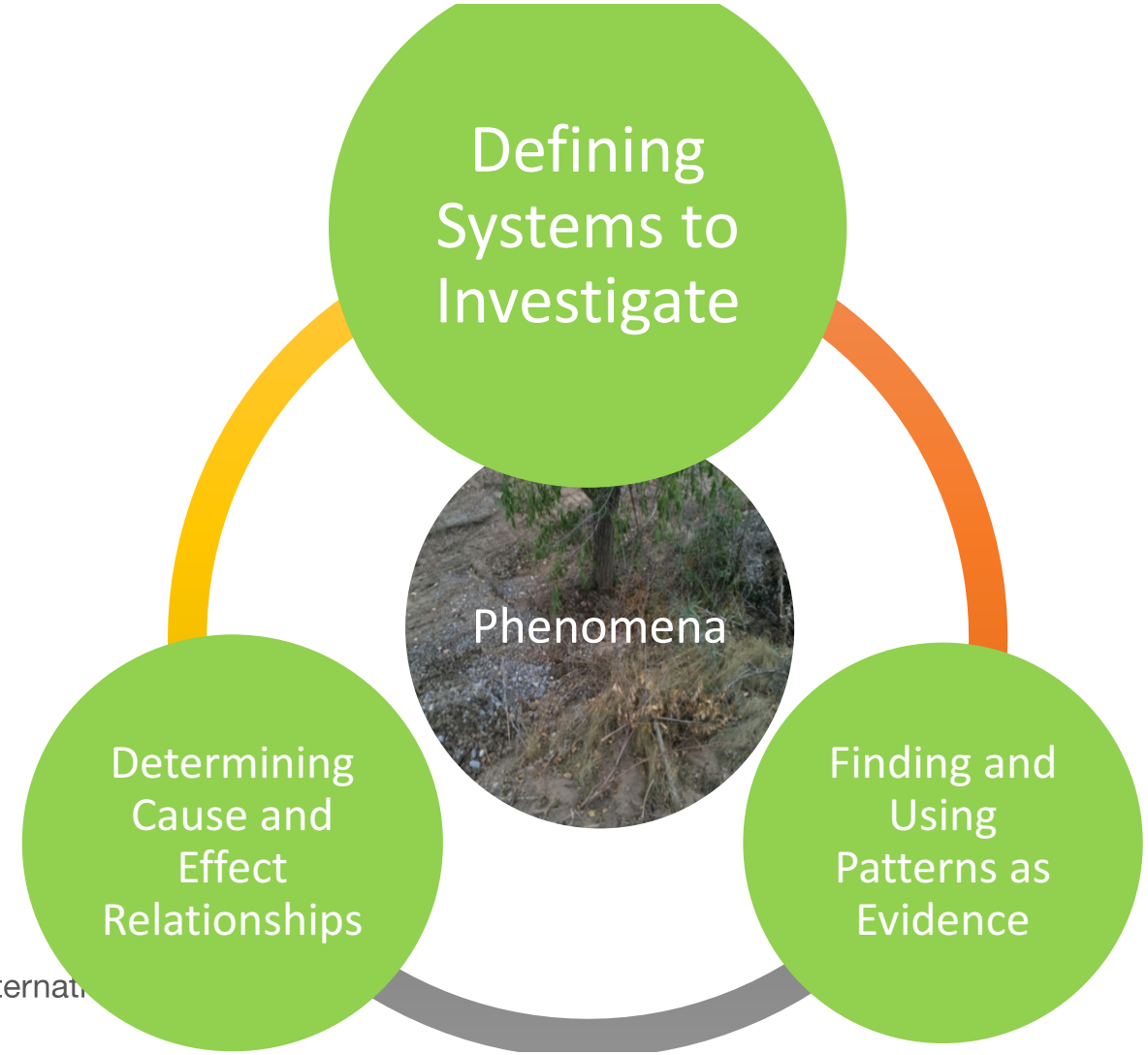
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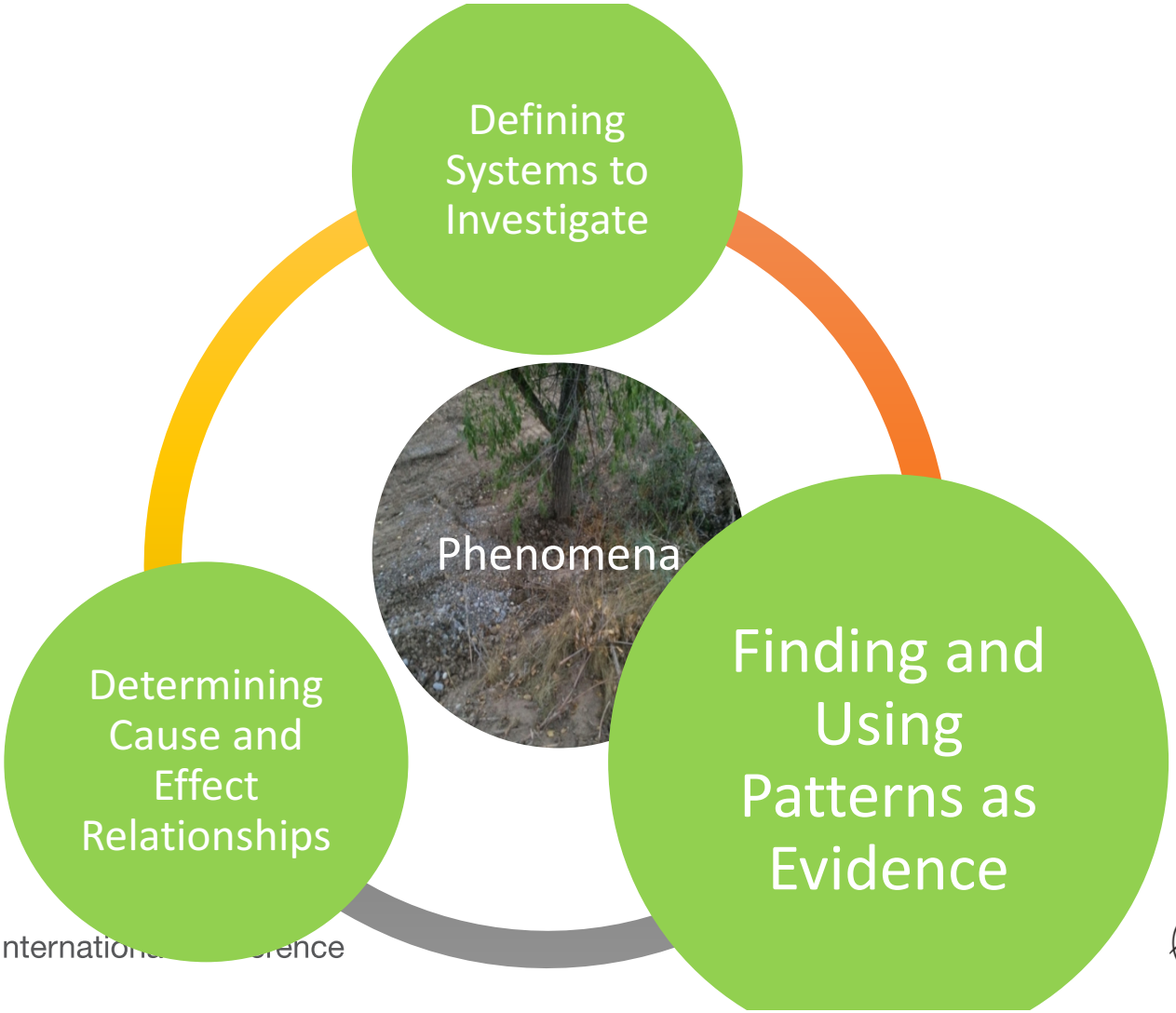

Defining Systems to Investigate
Phenomena
Finding and Using Patterns as Evidence
Determining Cause and Effect Relationships

Why Is The Work of the Science Implementation Team Important?

State of the States: States *Framework* Influenced Science Education Standards

States that have Adopted the Next Generation Science Standards (19 + DC)

NGSS Adopted States (Yr. Adopted)	
• Arkansas (2015) • California (2013) • Connecticut (2015) • Delaware (2013) • District of Columbia (2013) • Hawaii (2016) • Illinois (2014) • Iowa (2015) • Kansas (2013) • Kentucky (2013)	• Maryland (2013) • Michigan (2015) • Nevada (2014) • New Hampshire (2016) • New Jersey (2014) • New Mexico (2017) • Oregon (2014) • Rhode Island (2013) • Vermont (2013) • Washington (2013)

Influence of the *Framework for K12 Science Education* on State Science Standards

***S**tates that have **A**dapted the **NGSS** (SANGSS)* Alabama Georgia Idaho[13] Indiana[1] Louisiana[5] Massachusetts[2] Mississippi[6] Missouri Montana	Nebraska[9] New York Oklahoma South Carolina South Dakota Tennessee[11] Utah[3] West Virginia[4] Wisconsin[15] Wyoming[10]
In Development Using the Framework and the NGSS: Colorado[12] North Dakota	Pennsylvania Ohio[14]
States That Have Not Revised Their Standards Alaska Arizona Florida Maine	Minnesota[7] North Carolina Texas Virginia[8]

1. Though the standards were influenced by the Framework they are not integrating three-dimensions
2. Massachusetts does not use crosscutting concepts in their standards.
3. On April 12, 2018 Utah authorized the development of K-5 and HS Standards "using the NGSS as their primary source".
4. One MS ESS standard had a word change (not recognized as a NGSS state by Achieve INC)
5. Adopted March 8, 2017
6. Mississippi Adopted new standards based on the Framework in May, 2017
7. Minnesota is scheduled to revise their standards for science in 2018.
8. Virginia is anticipating revision in 2018 and will be using the *Framework* and the NGSS to inform the revision process
9. Adopted September 8, 2017
10. Adopted September 23, 2016
11. Adopted October, 2016
12. Colorado's Academic Standards for Science are anticipated to be presented for adoption in June, 2018. The earliest any effective change will occur would be July 1st, 2018.
13. Idaho adopted their Science Standards on February 22, 2018 with full inclusion of human-caused climate change
14. Ohio anticipates adoption of their proposed standards in the Winter of 2018
15. Wisconsin adopted in November, 2017.

The Problem

So What's th

Teachers Need Instructional Materials NOW!!!

What’s Different?

The TI Adaptation Process

Teachers use the “Coaching Template” where the right-hand side of the template identifies what the student is doing and the left-hand side identifies what the teacher is doing.

Working backward from the DCI, what Performance Expectation or Standard would the the lesson best be aligned?

Ts ask the question "By looking at the focus of the lesson, what Disciplinary Core Idea(s) would be supported by this lesson?”

Begin redesign by identifying a phenomenon or problem to which the students will focus.

Ts select a lesson that they have used with demonstrated student success

The TI Adaptation Process

Ts design a student performance to assess student learning of the lesson.

Using the Coaching Template Ts list potential evidence (look fors) of the students engaging in a practice.

Ts design prompts using crosscutting concepts to provide structure for students' reasoning of the phenomena.

Using the Coaching Template, Ts plan how Ss will engage in practices to engage them in gathering, reasoning, and communicating.

Teacher Name: *Stacy Thibodeaux*

Target Grade(s): *9-11*	**LESSON TITLE:** *Making Ice Cream!*
Topic: *States of matter, freezing/melting point of water, colligative properties of matter*	

Performance Expectation(s) (STANDARD) from State Standards or NGSS:

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.]

Note to Teacher – Students do not need to know about vapor pressure, Raoult's Law, or molality and molarity. Students will build upon in their understanding from this conceptual approach.

Lesson Objective(s)

- Ss will collect temperature data during the freezing and melting of water.
- Ss analyze graphs to determine the freezing and melting temperatures of water.
- Ss determine the relationship between adding a solute to a solvent and its effect on the freezing point of the solution

Lesson Body:

This lesson is a lab investigation into the freezing and melting points of water/ice. Students will use the data collected to determine the effect of a solute (salt) on the motion of the water molecules during freezing.

Phenomena

Adding salt to ice will make it cold enough to make ice cream. *https://www.youtube.com/watch?v=_Zt1EuIEhvw*

What Are the Students Doing?

Gathering:

- Ss watch video "Homemade Ice Cream in 5 Minutes"
- After watching the video Ss ask questions to determine how adding salt caused the ice to become "colder"
- *Ss in groups of 2, will conduct an investigation into the freezing and melting point of water and collect data using DataQuest 18A*

Reasoning:

- Ss analyze the data from their investigation to observe any patterns within the data
- Ss will collaborate to use data from investigation to develop a model to explain what is happening at the molecular level when salt is added to the ice bath.
- Ss, as a class, will argue from evidence derived from their own investigations and models to critique and question the other student models.
- Ss, as a class, will collaborate to construct an explanation from evidence for how salt causes ice to lower its freezing point as a class consensus.

Communicating:

- Ss individually develop an explanation from evidence for why the freezing point of water is lowered when salt is added.
- Ss use a model to explain the phenomena of freezing point depression.

Assessment of Student Learning -

Freezing point depression is the phenomenon that describes why adding a solute (in this case salt) to a solvent (in this case water) results in the lowering of the freezing point of the solvent. When a substance starts to freeze, the molecules slow down due to the decreases in temperature, and the intermolecular forces start to take over. The molecules will then arrange themselves in a pattern, and thus turn into a solid. For example, as water is cooled to the freezing point, its molecules become slower and hydrogen bonds begin to "stick" more, eventually creating a solid. If salt is added to the water, the Na^+ and Cl^- ions attract to the water molecules and interfere with the formation of the large network solid known as ice. In order to achieve a solid, the solution must be cooled to an even lower temperature.

Phenomena

Adding salt to ice will make it cold enough to make ice cream. *https://www.youtube.com/watch?v=_Zt1EuIEhvw*

What Is the Teacher Doing?

- *NOTE: Ts may elect to have Ss actually make ice cream.*

Gathering:

Ts will look for the following evidence when students are asking questions:

- Ss questions arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information
- Ss pose questions that are testable and relevant
- Ss ask questions to determine relationships between variables

Ts will look for the following evidence when students are Planning and conducting an investigation

- Ss make careful observations that generate evidence
- Ss recognize patterns in observations and data
- Ss collect data and generate evidence to answer scientific questions. Discuss and compare observations with other Ss observing the same events.

Ts will look for the following evidence when students are Analyzing and Interpreting Data:

- Ss use tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
- Ss compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
- Ss evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Reasoning:

Ts will look for the following evidence when students are: Developing and/or using multiple types of models

- Ss provide mechanistic accounts and/or predict phenomena and move flexibly between model types based on merits and limitations.
- Ss apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Ts will look for the following evidence when students are: Arguing from Evidence

What Is the Student Doing?

Gathering:

- *Ss watch video "Homemade Ice Cream in 5 Minutes"*
- *After watching the video Ss ask questions to determine how adding salt caused the ice to become "colder".*
- *Ss in groups of 2, will conduct an investigation into the freezing and melting point of water and analyze the data from their investigation to observe any patterns within the data (using DataQuest 18a)*

Reasoning:

- Ss will collaborate to use data from investigation to develop a model to explain what is happening at the molecular level when salt is added to the ice bath.
- Ss, as a class, will argue from evidence derived from their own investigation to critique and question the various student models.

DRAFT

Using Crosscutting Concepts as Prompts

Suggested Questions to Initiate Class Discussion:

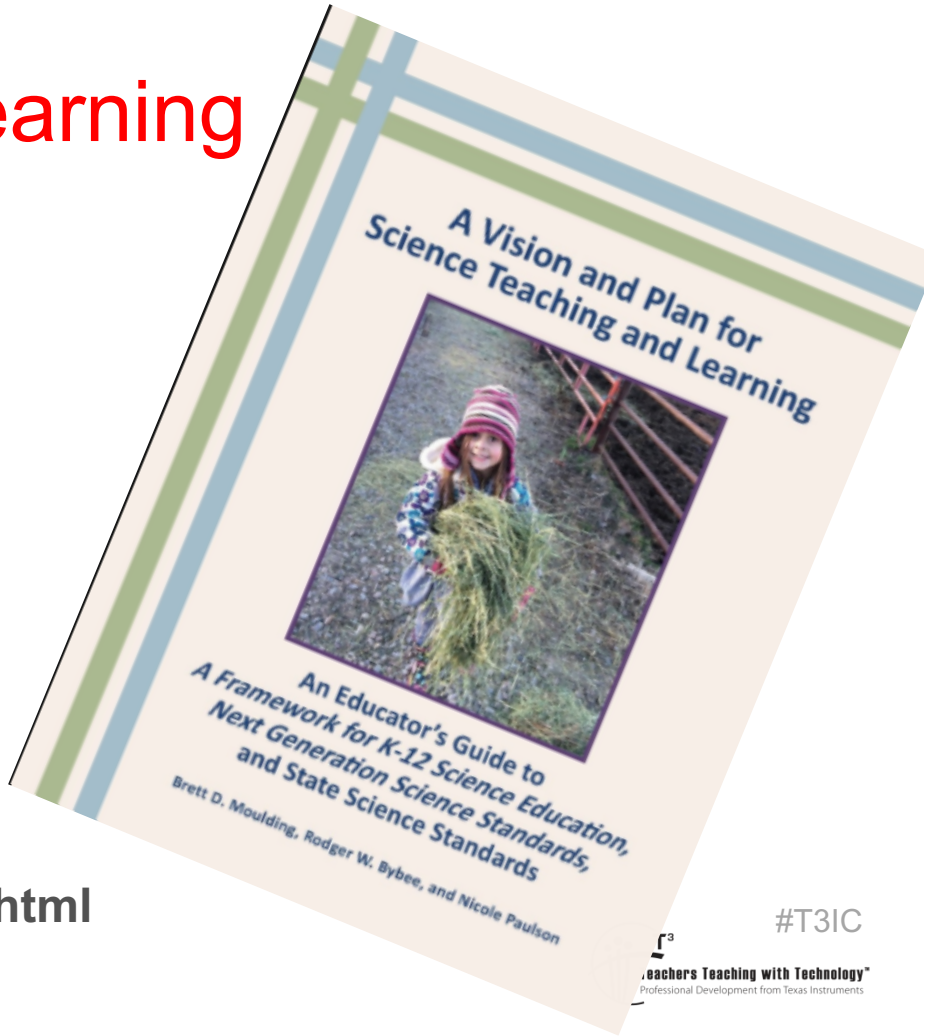
Q: What caused the ice to change in temperature so they the ice cream mixture would freeze?
Q: What are the key parts of the system that you observed in the video?
Q: How do the different components of the system interact?
Q: What effect would another solute, besides salt, have if it were added to the ice water bath?
Q: What patterns in the graph are observed as the test tube is in the water bath?
Q: What patterns are observed in the relationship between the mean (average) temperature and the freezing point?
Q: How does the pattern change when salt is added to the water bath?
Q: What is going on at the molecular level in the test tube? In the salt-ice bath?

A Vision and Plan for Science Teaching and Learning

One of the important texts used to help identify look-fors in this process.

- » Appendix C: Expected Student Performances Specific to the Practice
- » Appendix D: Crosscutting Concepts Matrix

Available at http://pestl.org/sciencebook.html



Outcomes

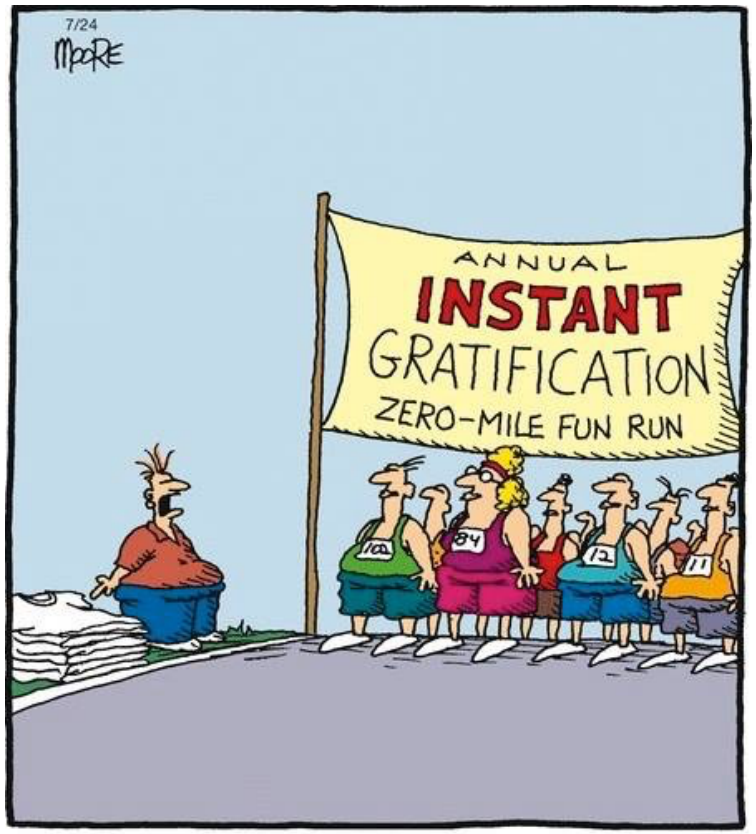
By having teachers reflectively and collaboratively adapt lessons using the process described TI believes that educators will:

» gain a deeper understanding of the instructional shifts required by *Framework-Influenced Standards*

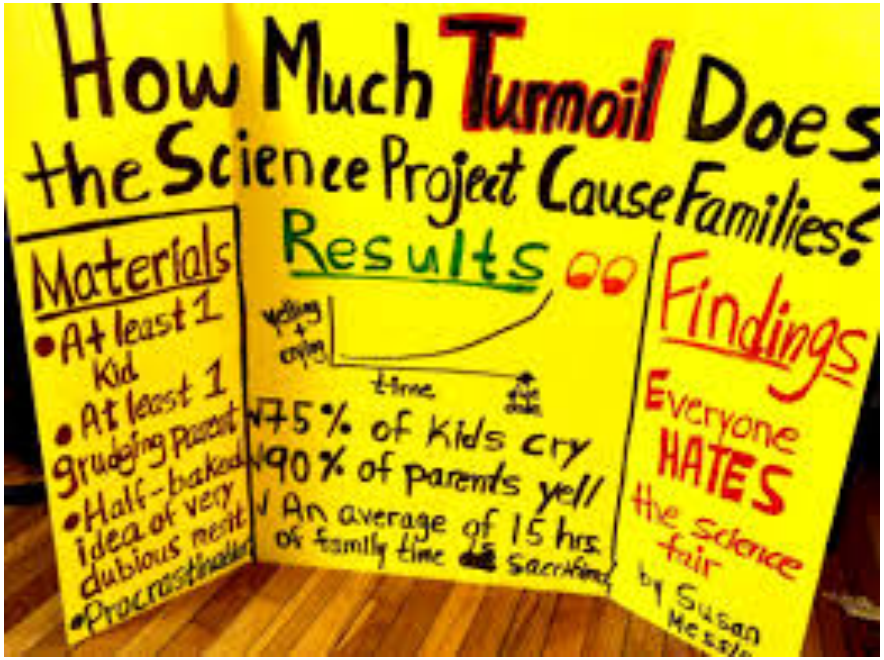
» gain experience by designing lessons that fully integrate the disciplinary core ideas, science and engineering practices, and crosscutting concepts of the *Framework*

» Have a better understanding of the types of evidence (look-fors) students will demonstrate when they are engaged with a three-dimensional lesson.

» Contribute to the instructional materials chasm…Be Part Of The Solution!



"Runners to your mark. Get set. Go! ... OK, come get your T-shirts."


How Much Turmoil Does
the Science Project Cause Families?
Materials
•At least 1 Kid
•At least 1 grudging Parent
•Half-baked idea of very dubious merit
•Procrastination
Results
time
75% of Kids cry
90% of parents yell
An average of 15 hrs of family time sacrificed
Findings
Everyone HATES the science fair

Questions?

Have a Joe DiMaggio Day

Thank You!!!

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@peterjmclaren

Jeff Lukens, T3 International Educator