Designing Instruction with 2019 MN Science Standards

Shifting pedagogy to build curiosity and engagement

Thomas Meagher, PhD
District STEAM Education Coordinator ISD761
Owatonna, MN 55060
Lecturer, Science/STEM Education
University of Minnesota-Twin Cities
drthomasmeagher.weebly.com

Jacob Jensen
6th & 7th Grade Science Teacher
ISD761
Owatonna, MN 55060

Get your copy of the presentation and follow along!

Type in this short URL on your laptop, to participate in the collaborative Jamboard, and for future reference.

http://bit.ly/MnCOSEStorylinestandards

Goal

- Learn strategies and resources for curriculum planning for facilitating science curriculum work in your district or school.

Agenda

- Quick background on the three dimensions of science learning
- Shifts in approaches to curriculum
- General and science specific models for curriculum planning
- Engage in some common strategies and tools for curriculum planning

What's our background with new MN science standards?

How do you feel about teaching middle school science?

What's important for your students to learn in science?

What are you hoping for with the new science standards?

Let's see what people think, Jan-June birthdays share 1st, one minute then switch!

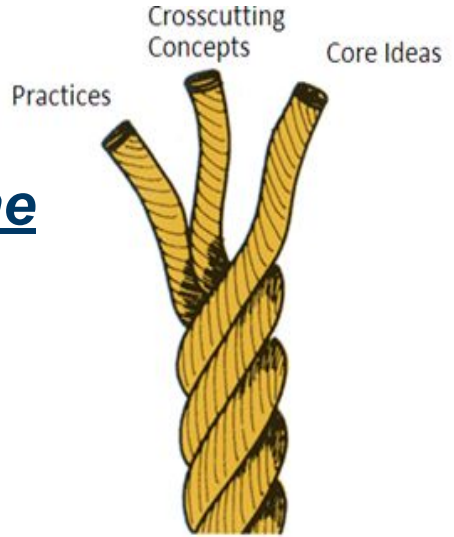
A New Vision for Science Instruction

Less	More
Rote memorization of facts and terms	Facts and terms learned as needed while developing explanations and designing solutions using evidence
Learning ideas disconnected from questions about phenomena	System thinking and modeling to explain phenomena
Teacher providing information to the whole class	Students conducting investigations, solving problems and engaging in discussions
Teachers posing questions with one right answer	Students discussion open-ended questions
Students reading textbooks to answer questions	Students gathering information from multiple sources
Cookbook labs or hands-on activities	Multiple investigations driven by student questions
Worksheets	Students writing journals, report and media presentation to explain and argue
Oversimplification for students perceived as less able	Provision of support for sophisticated science for all

2019 MN Science Content Standards & 3D Learning

Three dimensions for learning are intertwined:

1. **Scientific and Engineering Practices (SEP)**
2. **Crosscutting Concepts (CC)**
3. **Disciplinary Core Ideas (DCI)**
4. **Learning progresses with all 3 dimensions**
   a. **Students explore & explain *phenomena***
   b. **Learning moves through a coherent *storyline***
   c. **Coordination with ELA and math standards**



Why teach science using phenomena?

Quick practice in notice, wonder & explore

Trigger imagination and wonder using ***Phenomena***: “A an intriguing fact, event or situation that is unusual, unexpected, complex or difficult to explain, or understand.

Dimension 1: Science and Engineering Practices

Skills that all students learn with increasing complexity over time.

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 and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

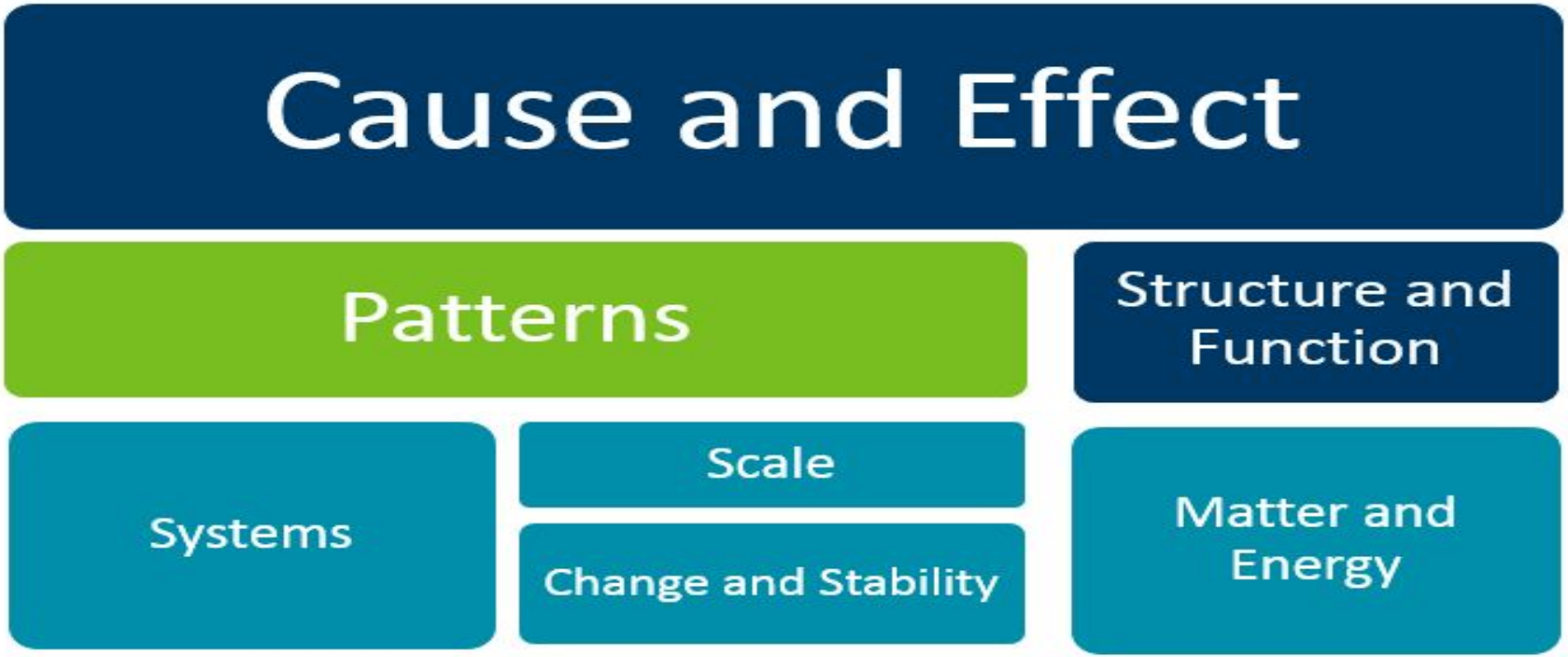
Strong in current MN Standards

In MN Literacy Standards in Science (ELA standards)

New approaches for MN

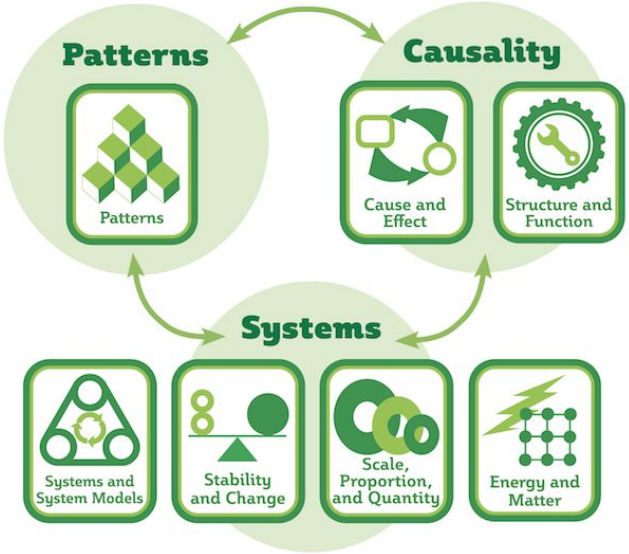
Dimension 2: Crosscutting Concepts

Concepts that are foundational for all academic & science disciplines



What patterns, systems or changes do observe?

Use Crosscutting Concepts to connect content



CCs help focus teaching on ***Deep Thinking*** to develop growth mindsets in students.

Include skills, processes and content from other fields into lessons.

Provide connections for other content teachers to participate and apply to their lessons.

Provide means by which students can transfer what they are learning to other important areas of their schooling, interests or personal life.

Transfer in Learning

How to ***STEAM*** your classroom

STEAM ***is a way of teaching and learning:***

Have students study classwork ***Scientifically***

Incorporate ***Technology***

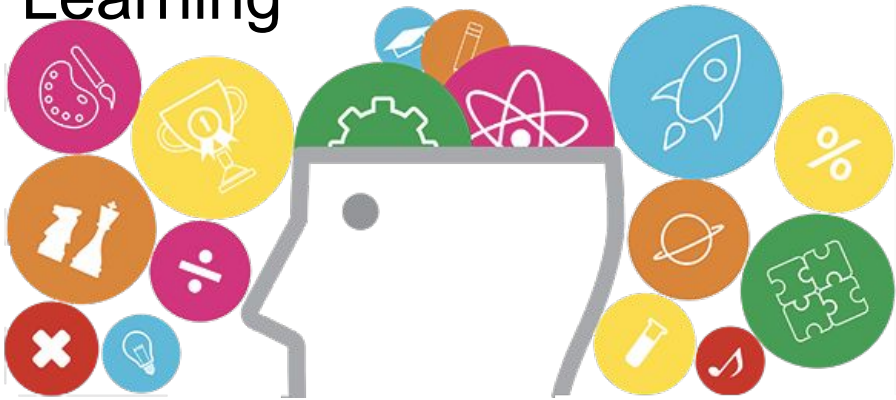
Allow students to ***Engineer*** solutions to real problems

Engage ***Artistic*** creativity

Mathematical analysis of information and data is essential to understanding the modern world

S+T+E+A+M =

Learning



Dimension 3: Disciplinary Core Ideas

Physical Sciences

- PS1: Matter and its interactions
- PS2: Motion and stability: Forces and interactions
- PS3: Energy
- PS4: Waves and their applications in technologies for information transfer

Life Sciences

- LS1: From molecules to organisms: Structures and processes
- LS2: Ecosystems: Interactions, energy, and dynamics
- LS3: Heredity: Inheritance and variation of traits
- LS4: Biological evolution: Unity and diversity

Earth and Space Sciences

- ESS1: Earth's place in the universe
- ESS2: Earth's systems
- ESS3: Earth and human activity

Engineering, Technology and Applications of Science

- ETS1: Engineering design
- ETS2: Links among engineering, technology, Science, and society

Reading the 2019 MN Science Standards & Benchmarks

- The Benchmarks are the essential **content** to be taught, the Strands and Standards are the **pedagogy** for how to teach the content.
- The strands and standards are the same K-12, however they increase in complexity with age and skill development.
- The benchmarks are not published in a specific order, creating the order is up to us, by writing units. (Storyline development can help)

How we should teach the concept

Content to be taught

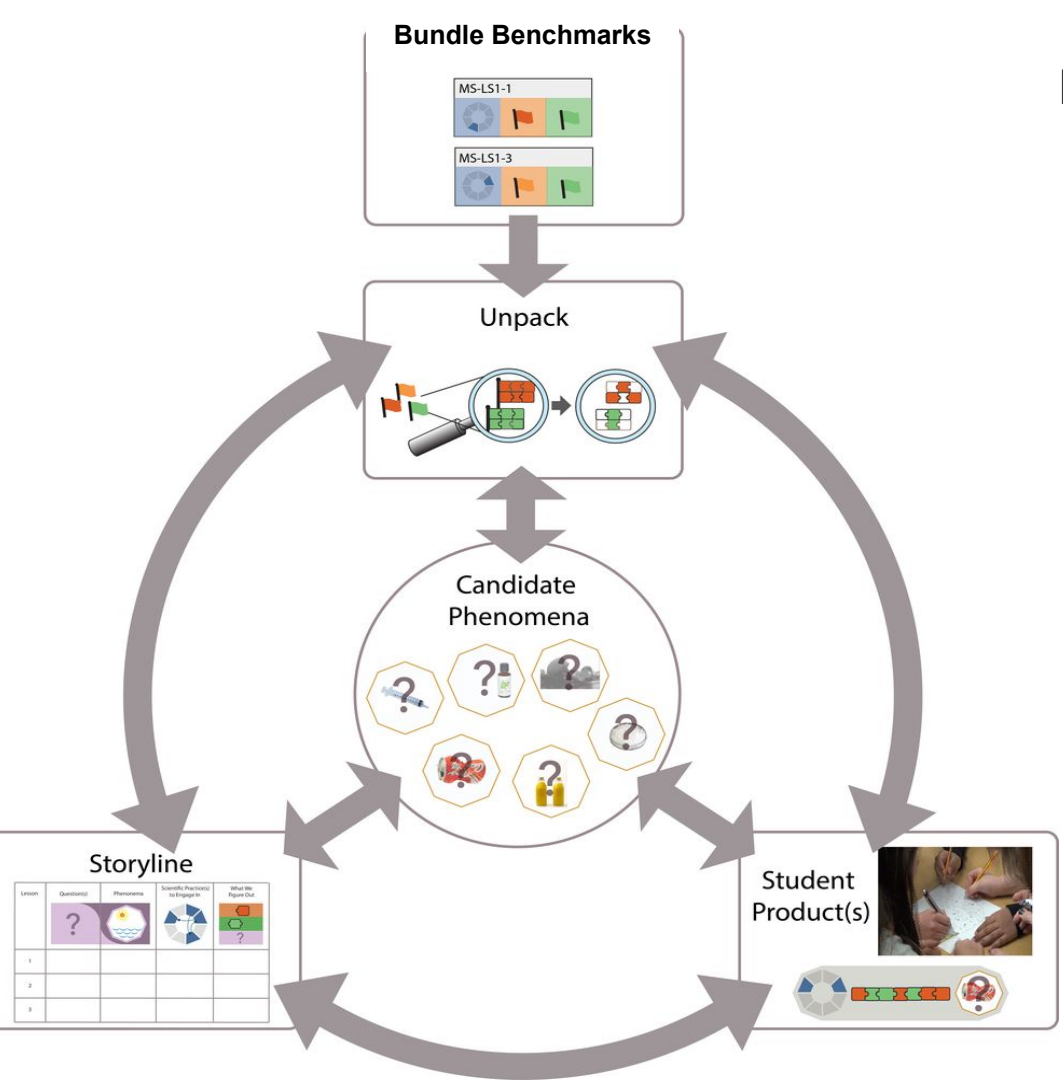
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	LS: Evolution: Unity and Diversity	7L.3.2.1.4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. (SEP: 6, CC: 2, DCI: LS4) *Emphasis is on using simple probability statements and proportional reasoning to construct explanations.*

Phenomena to explore

Next steps you can do now

Plan on shifting well known lessons:

- From lecture & memory recall to discussion & problem solving
- Provide opportunities for exploration & investigation
- **Allow for mistakes & failure**
- Plan for team, small group and large group discussions
- Provide feedback that encourages growth & development
- Shift question techniques to be more ORID focused
- Design units using storyline techniques



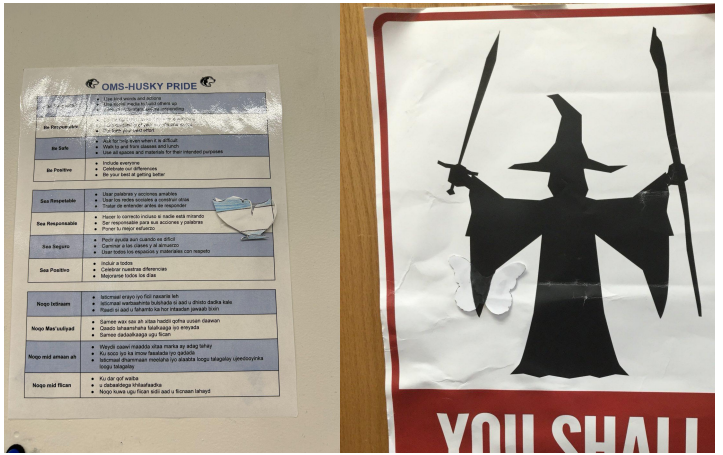
How Phenomena & Storylines drive science teaching

Designing storylines:

1. Bundle Benchmarks
2. Identify Enduring Understandings
   "I can…"
3. Write Essential Questions
4. Identify Phenomena to explore with students
5. Order Learning Experiences
6. Create Assessments

Changes in pedagogy, as much as content

- Designing units should be focused on coherent and sequential scientific ***storylines*** that tie key ideas and ways of learning together.
- **What would you teach first to last?**
  - Opening that catches attention & piques curiosity
  - Middle that has a problem to be solved
  - End with resolution
  - Where does the story lead next? (connections?)
- Perspectives of science instruction:
  - Big picture to small
  - Personal small impact to Big picture



- **Use specific subject area/grade benchmarks (DCIs) & organize in way to tell a “scientific story”.**

Organizing new benchmarks into units

Developing new science units based on storylines:

- Categorize grade level benchmarks into disciplinary specific groups:
- Earth Science, Life Science, Physical Science, MS Science
- Choose one group of benchmarks and organize them into a large unit by ordering the the concepts in such a way as makes an effective story for student learning.
- Online participants can use this Jamboard

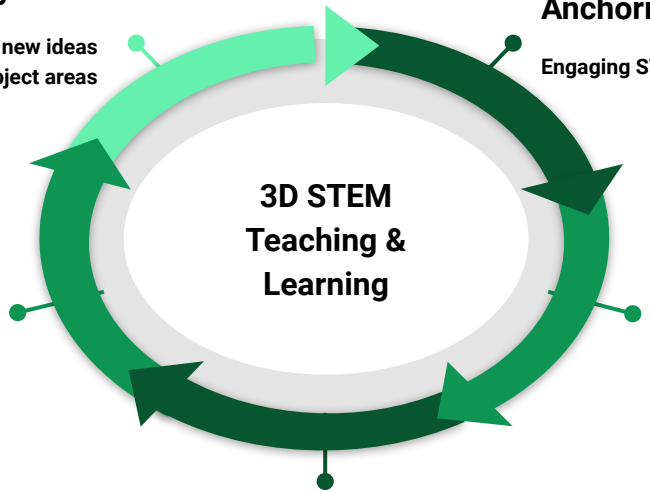
Lesson plan design: Storylines build cohesion

Where does the story lead?

Students make connections to new ideas and other subject areas

Anchoring Phenomena

Engaging STEM Experience



Putting the pieces together

Students construct understanding of what they've studied

Essential Questions

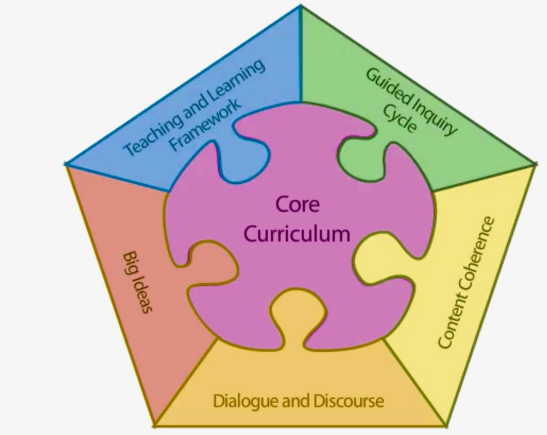
Students explore essential questions that guide research

Students explore learning

Students are engaged in 3D learning

Concerns for writing your own materials vs. adopting

- Coherence of story matters and is difficult to do
- It takes time to develop, test, and revise high quality curriculum.
- Teachers are wonderful deliverers of curriculum, but are not prepared to write curriculum.
- Adopted curriculum has the risk of teachers blindly following the materials



However,

- Going through curriculum planning processes helps teachers understand benchmarks and learning goals better, and makes them better prepared to select instructional materials.
- Instructional materials can be used in the planning process.

Planning begins with storylining

Group 3-5 into a storyline that can “capture their attention” lead to a conflict or challenge to be resolved and a resolution that shows how science concepts can explain how the world works or relevant to their lives

Let’s take a look at the 2019 MN benchmarks for your grade level, either related to this lesson or to an area of interest to your team.

Write the first part of the benchmark into the shared file: Storyline template

Put benchmarks into an order that allows your team to tell the “story” of this bigger science topic.

Owatonna 6th Grade Science Storyline Standards

Owatonna 7th Grade Science Storyline Standards

Techniques for designing a science storyline

Using the 5 question methods to guide design

1. **How do we kick off investigations in a unit?**
2. **How do we work with students to motivate the next step in an investigation?**
3. **How do we help students use practices to figure out pieces of the science ideas?**
4. **How do we push students to go deeper and revise the science ideas we have built together so far?**
5. **How do we help students put together pieces of the disciplinary core ideas and crosscutting concepts?**

Techniques for designing a science storyline:

Building the classroom culture for inquiry & investigation:

a. Provide experiences that demonstrate key phenomena,
b. Allow students to collect their own data and record observations
c. Provide real data from measurement tools or websites, weather, temperatures, etc
d. Use notebooks for recording their learning
e. Model creation on paper, whiteboards, poster paper or 3D
f. Small group or team discussion (**Ambitious Science Teaching**)
g. Publish student/team/group work: ***"School as museum"***

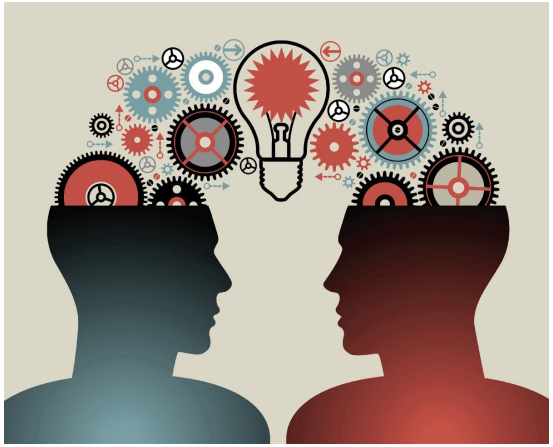
- **We figure out the science ideas.**
- **We figure out where we are going at each step.**
- **We figure out how to put the ideas together over time.**

Essential Questions & Learning targets continued

- If each benchmark has two essential questions to explore, and there are 3 benchmarks in this unit, expect to teach 6-7 lessons minimum. The focus of each lesson can vary from: (5E Lesson design)
- **Engagement**
  - (Demonstration, video, hands-on “tinkering”)
- **Exploration**
  - (Investigation, data collection, diagramming)
- **Elaboration**
  - (Reading non-fiction text, video, online simulations)
- **Explanation**
  - (Writing, explaining evidence, defending ideas & improving designs)
- **Evaluation**
  - (Formative and or summative assessments, product creation, quizzes)

Balancing skill development with conceptual understanding

- ***Transfer of learning*** refers to learning in one context and applying it to another, i.e. applying knowledge or skills to new situations.
- This helps answer the questions of “why are we learning this?”
- When designing lessons balance academic time spent on skill development/practice & application of new knowledge.
- Assessments should target: understanding, transfer & science/engineering skills.



Preparing for the new standards

- The largest changes are in pedagogy, focus on having students explore
- View and Study NGSS videos: Teaching Channel, ngss.nsta.org, Bozeman Science
- Build a phenomena list to pull examples from: Wonder of Science, NGSS phenomena, Project phenomena, and many others
- Explore the documents where NGSS has outlined the curriculum and prepared it for building storylines:
  - NGSS Storylines: https://www.nextgenstorylines.org/

Curriculum planning processes - General

Understanding by Design	MDE Standards Portal (under development)
Identify desired results	Standards alignment
Determine acceptable evidence	Scope and Sequence
Plan learning experiences and instruction	Unit Planning
Plan with end goal of “transfer” of knowledge	

Curriculum planning processes - Science specific

5 Tools and Processes (A PD model)	Ambitious Science	Next Generation Science Standards (not in a sequence)
Plan a unit of instruction	Identify big ideas	Analyze Performance Expectations
Plan classroom Assessments	Select anchoring event and essential questions	Bundling
Develop a conceptual flow	Sequence learning activities	Storylines (+ essential questions) Phenomena
Design learning sequences	Building student voice and arguing from evidence	Assessments Evidence Statements
Develop performance tasks	Learning is constructivist	

Lesson Plan Templates

Three Dimensional Learning Plan Template - Wonder of Science

3 Dimensional 5E Lesson Plan Template (in folder)

Gather, Reason, Communicate Lessons

Questions?