Planning for New Science Standards Series

Workshop II:
Practices, Strategies, and Tools for the Next Generation Science Classroom

Arkansas Department of Education
with support from the
K-12 Alliance/WestEd

Survey

- Link to Pre-Survey:
  https://www.surveymonkey.com/s/Two-DayNGSS_PreSurvey

- You will be asked to enter your identifier in order to match your pre and post surveys.
- Your identifier is comprised of 6 digits:
  – initials of your first and last name
  – and your two-digit birth month
  – and two-digit birth date.
- Example: Tabitha Smith took the survey. Tabitha's birthday is July 23. Tabitha Smith’s identifier is: TS0723

Housekeeping

- Practice Professionalism
- Practice Technology Etiquette (phones, laptops, etc.)
- Practice Active listening (avoid sidebars, distractions)
- Honor Agenda (times and topics)

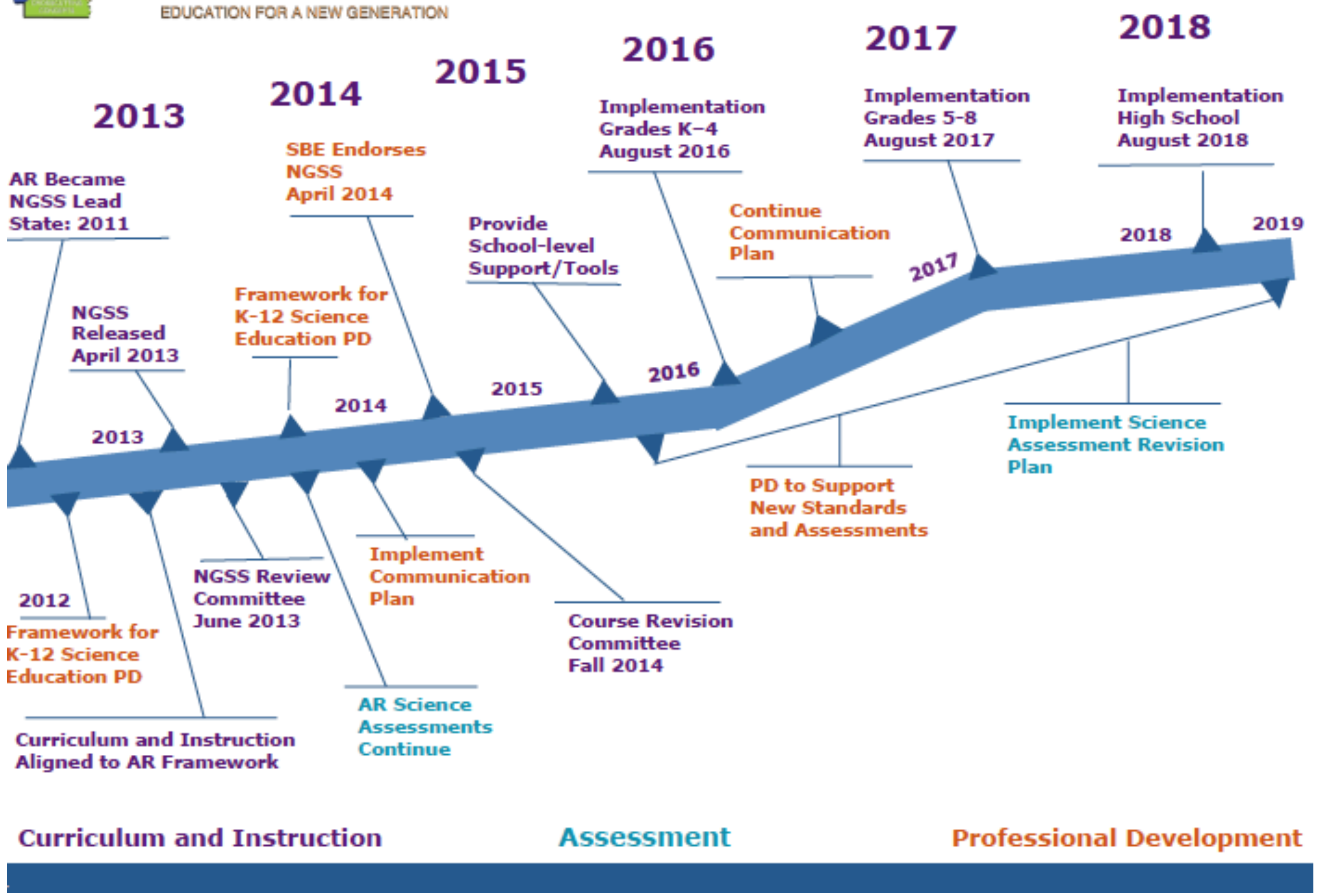
“Make it work” and “Positivism”

Status of New Science Standards

- 2011 - Arkansas was a lead state in the development of the Next Generation Science Standards (NGSS)
- 2013 – Final NGSS released
- 2014 – State Board of Education endorses the use of NGSS as the basis for our new state science standards

ARKANSAS
K-12 SCIENCE STANDARDS
EDUCATION FOR A NEW GENERATION

Science Standards Timeline

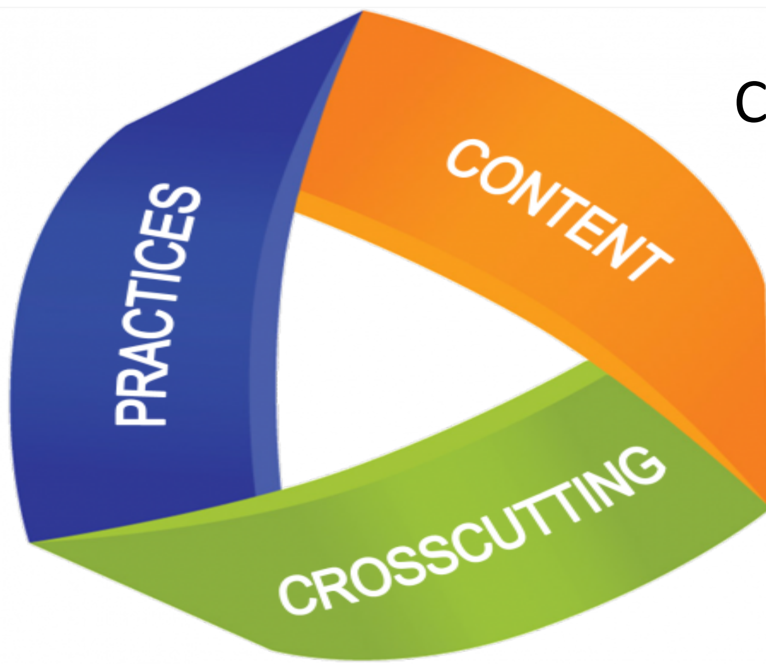


Outcomes

- Recognize the relationship between
  - Disciplinary core ideas (DCIs)
  - Science and Engineering Practices (SEPs)
  - Crosscutting Concepts (CCCs)
- Develop a Conceptual Flow to guide changes in instruction and assessment
- Complete a Phenomena, Question, Practice (PQP) Chart
  - determine best practices aligned to DCIs and PEs

Next Generation Science Standards: 3D Learning

Science and engineering



Core ideas in the discipline

Concepts across disciplines

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
- Develop a model to describe phenomena. (MS-LS2-3)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2)

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
- Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4)

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems
- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)
- Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2)

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

LS4.D: Biodiversity and Humans
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (*secondary to MS-LS2-5*)

ETS1.B: Developing Possible Solutions
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary to MS-LS2-5)*

Crosscutting Concepts

Patterns
- Patterns can be used to identify cause and effect relationships. (MS-LS2-2)

Cause and Effect
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)

Energy and Matter
- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

Stability and Change
- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4),(MS-LS2-5)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)

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Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-LS2-3); **MS.LS1.B** (MS-LS2-2); **MS.LS4.C** (MS-LS2-4); **MS.LS4.D** (MS-LS2-4); **MS.ESS2.A** (MS-LS2-3),(MS-LS2-4); **MS.ESS3.A** (MS-LS2-1),(MS-LS2-4); **MS.ESS3.C** (MS-LS2-1),(MS-LS2-4),(MS-LS2-5)

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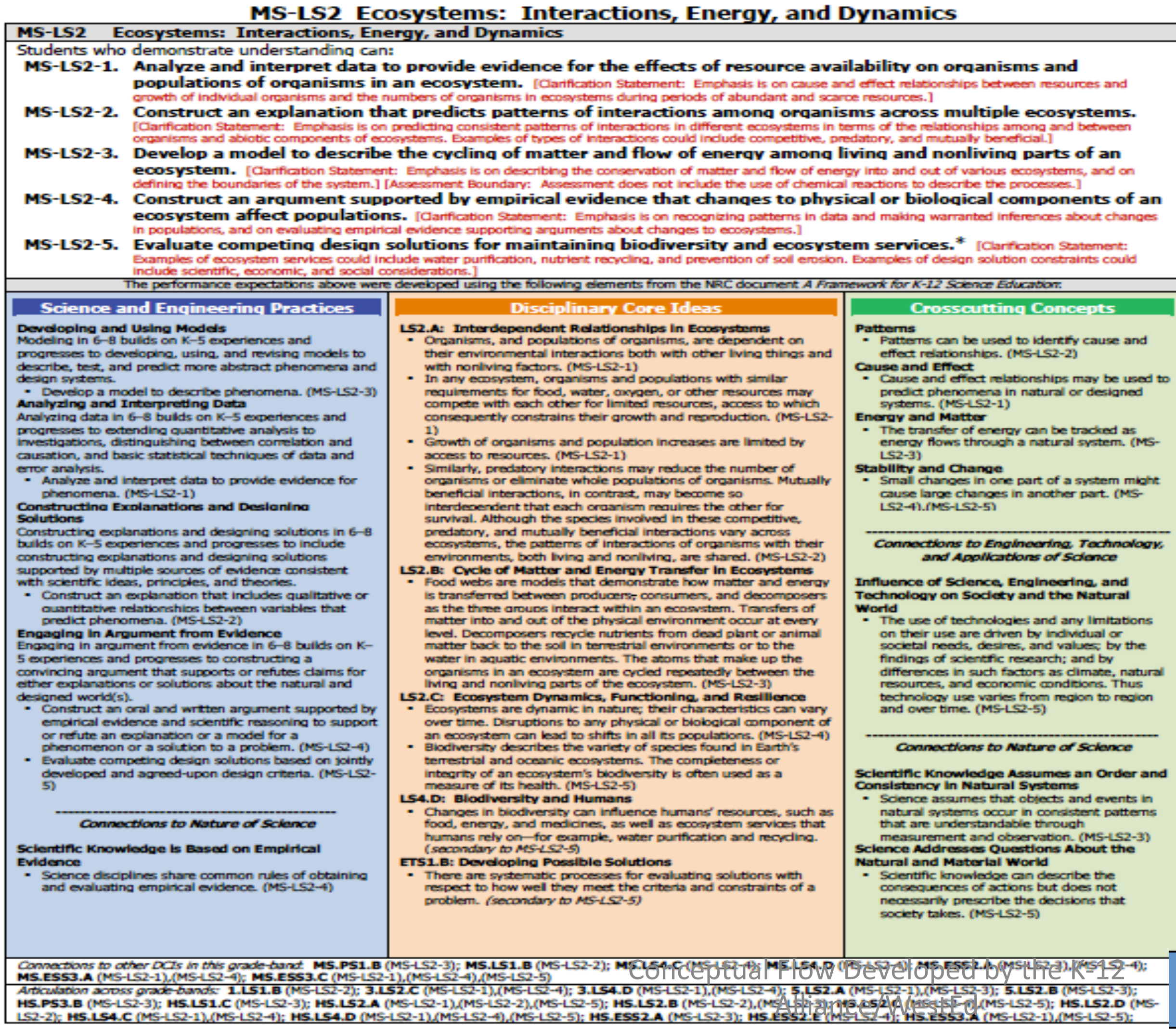

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Performance Expectations

Foundation Boxes
SEP
DCI
CCC

Connections within NGSS and to CCSS

Scientific and Engineering Practices

- Asking questions and defining problem
- Developing and using models
- Planning and carrying out investigations.
- Analyzing and interpreting data
- Using mathematics and information and computer technology
- Developing explanations and designing solutions
- Engaging in argument
- Obtaining, evaluating, and communicating information

Crosscutting Concepts

- Patterns
- Cause and effect: mechanism and explanation
- Scale, proportion and quantity
- Systems and system models
- Energy and matter: flows, cycles and conservation
- Structure and function
- Stability and change

Three-Dimensional Learning

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem

Three-Dimensional Learning Dissected

Analyze and interpret data to provide evidence for

the effects of

resource availability on organisms and populations of organisms in an ecosystem.

NGSS Dissection Task

Identify and Highlight the

- Practice in the PE in blue
- DCI in the PE in orange
- CCC in the PE in green

Identify and Underline the

- Clarification statement

Identify and Circle

- Assessment Boundary

Translating NGSS into Classroom Practice

How People Learn

- Prior Knowledge
- Conceptual Frameworks
- Metacognition

(Bransford et al., 2000)

Conceptual Framework Tool

NGSS

Classroom Instruction

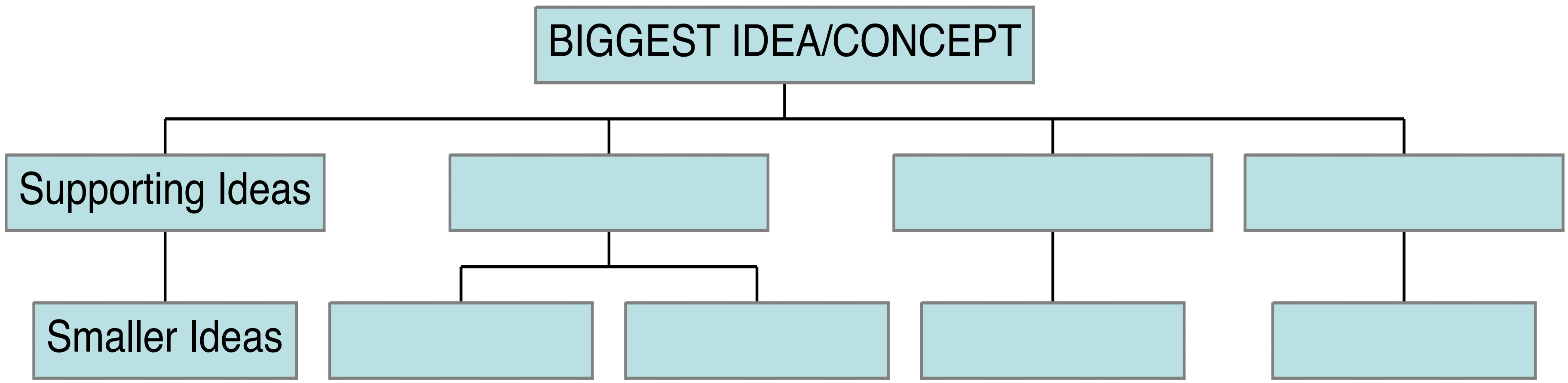
Tool A: Conceptual Flow

- Details the important concepts
- Identifies an instructional sequence
- Identifies important concepts for assessment of student understanding
- Serves as a tool for evaluation of instructional materials

(DiRanna, Osmundson, Topps, Gerhardt, Barakos, Cerwin, Carnahan, Strang, 2008)

Conceptual Flow Developed by the K-12 Alliance/WestEd

Conceptual Flow Diagram



Conceptual Flow Developed by the K-12 Alliance/WestEd

Individual Pre-think

- Answer the prompt in a paragraph using complete sentences.
    - Do NOT create a bulleted list of phrases
- Write about the content ("what" students should know, not how they will show they know it).

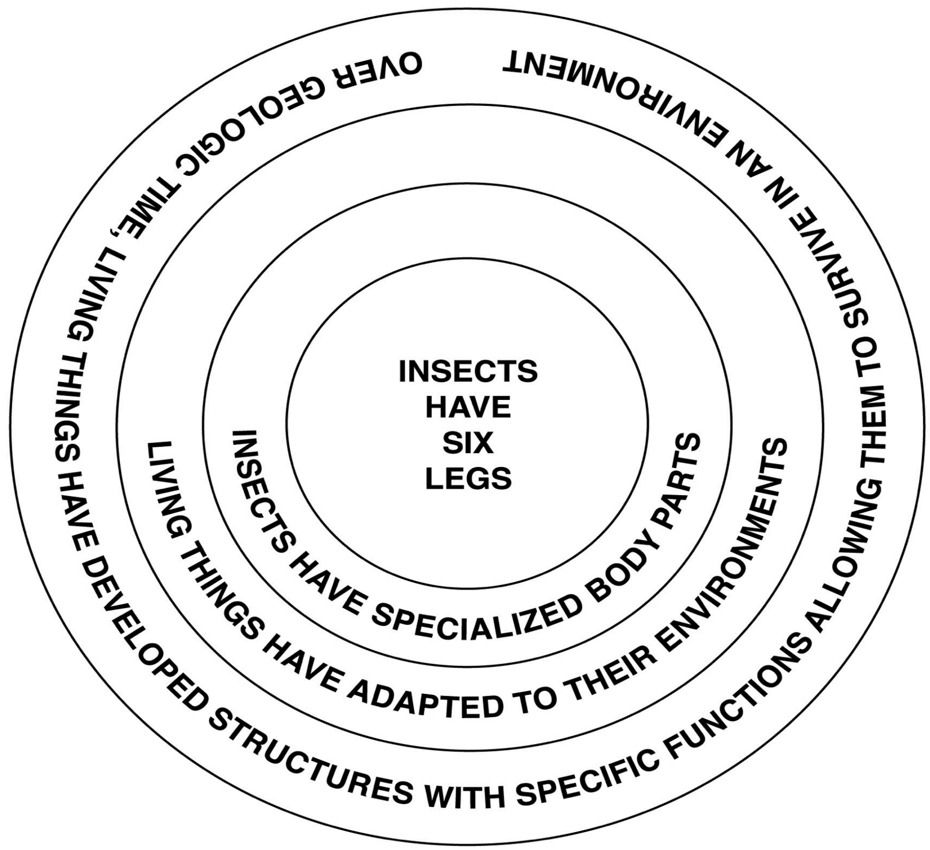
Conceptual Flow Developed by the K-12 Alliance/WestEd

Quick Write Prompt

What should an exiting middle school student know about interactions in an ecosystem?

Conceptual Flow Developed by the K-12 Alliance/WestEd

Factoid to Overarching Idea: Nesting



Conceptual Flow Developed by the K-12 Alliance/WestEd

Facts and Concepts

Facts

- Facts or definitions are pieces of information.
- The focus is on verifiable and discrete details.
- In teaching, facts are often presented without making connections to the big ideas in science.

Concepts

- Concepts are over-arching ideas that clearly show the relationships between facts.
- They are frequently abstract.
- In teaching, concepts are often presented with connections to the real world and to the big ideas of science.

Mark an “F” or “C” to indicate a fact or concept in your quick write.

“Concepts” to Yellow Post-its

<u>Individually</u>

- Transfer your statements marked “C” for concepts to a medium sized yellow post-it.
- Use complete sentence from your quick write.
- One concept per post-it.

“Concepts” to Yellow Post-its

Group

- Compare concepts and negotiate a BIG idea that represents your concepts.
- Write the BIG Idea on a Large Yellow Post-it and place at the top of your paper.
- Organize remaining concepts under the BIG idea (supporting ideas)

“Facts” to Post-its

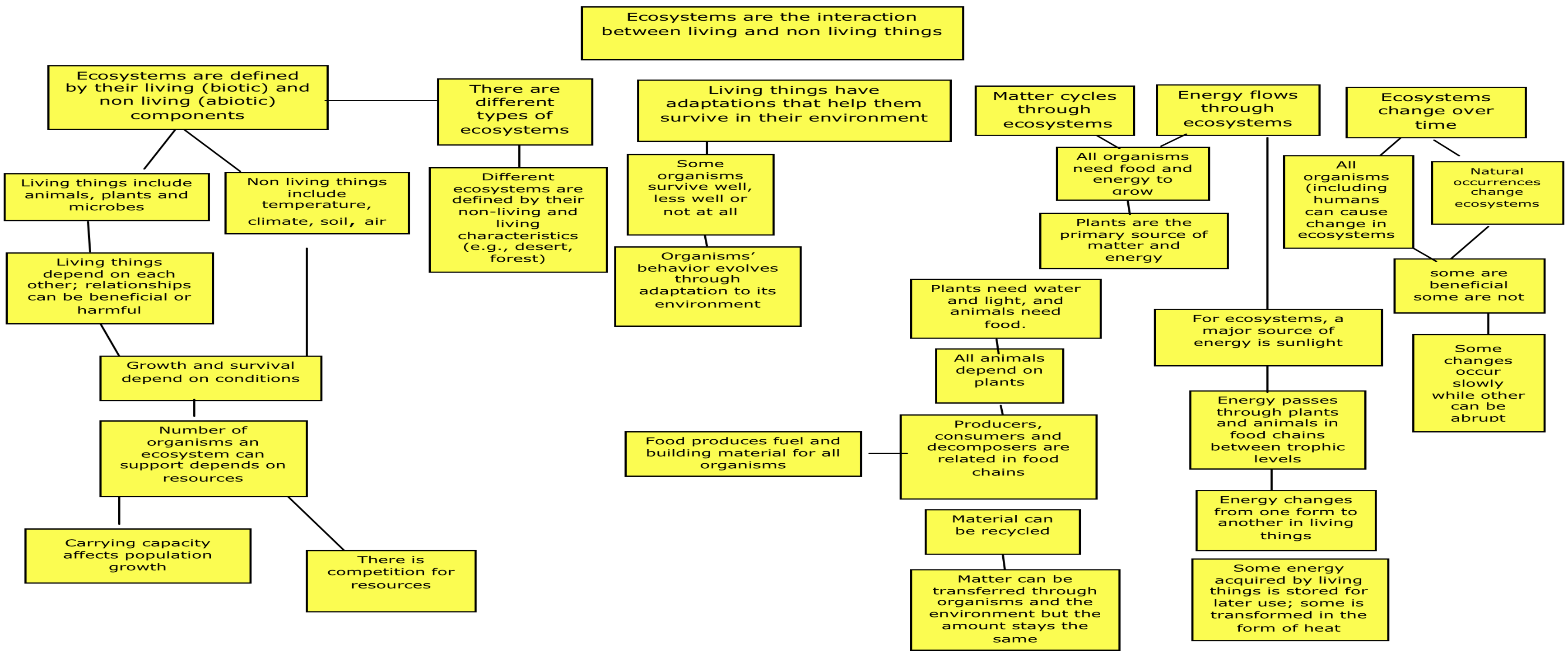
Individually

- Transfer your statements marked “F” for facts to a small sized yellow post-it.
- Use complete sentence from your quick write.
- One fact per post-it.

Group

- Place small ideas under corresponding supporting idea
- Review your “story” reading left to right and top to bottom.
- Move the stickies so that the instructional order makes the most sense.

Collaborative Conceptual Flow



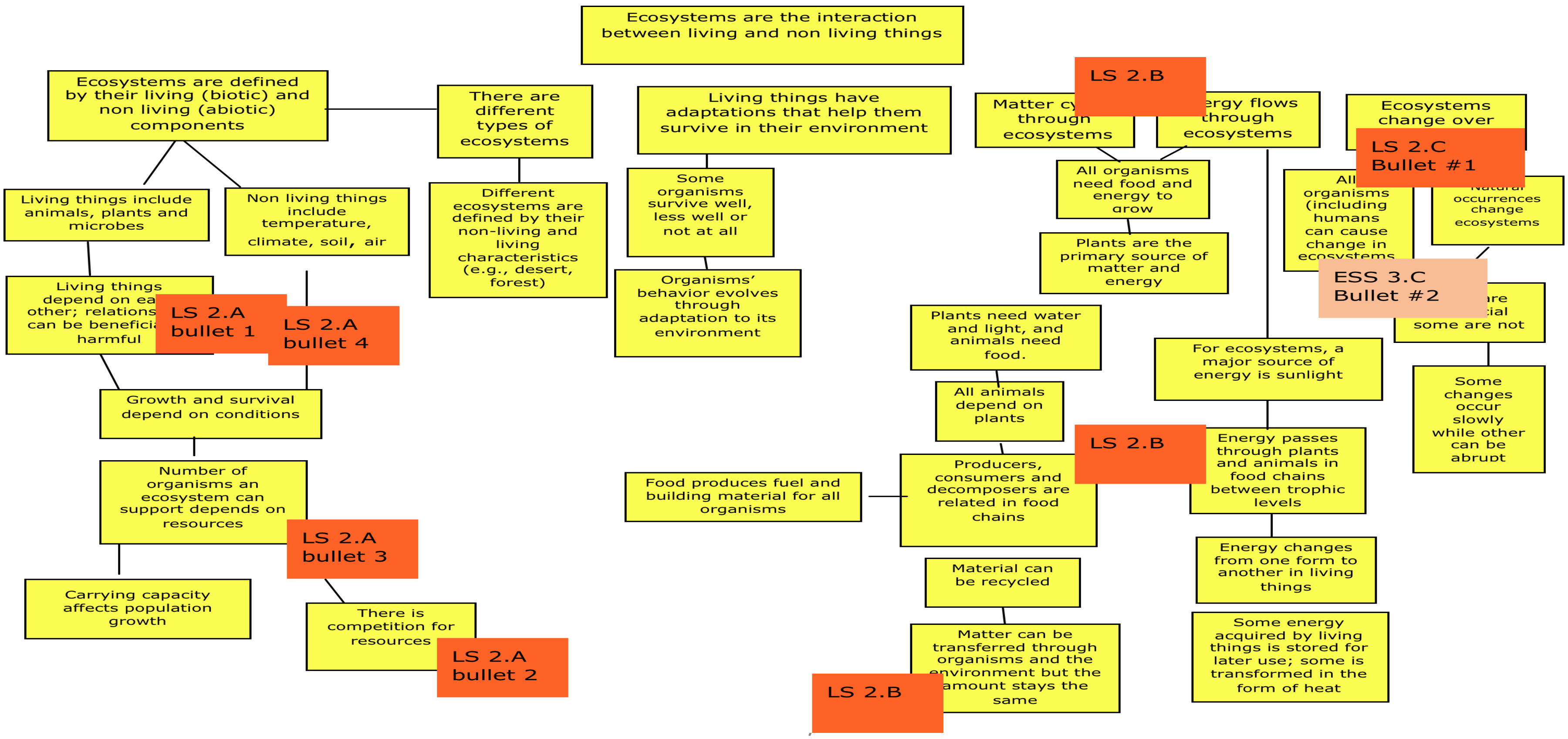
Conceptual Flow Developed by the K-12 Alliance/WestEd

Content Check

- Read Core Idea LS2 – Ecosystems: Interactions, Energy and Dynamics found on pages 150-155 of the Framework for K-12 Science Education
- Are there any ideas on your conceptual flow which should be deleted?
- Are there other content ideas that should be added to your conceptual flow?
- Write additional content on appropriate size yellow sticky-note and put on the CF

Conceptual Flow Developed by the K-12 Alliance/WestEd

Example of DCI Match

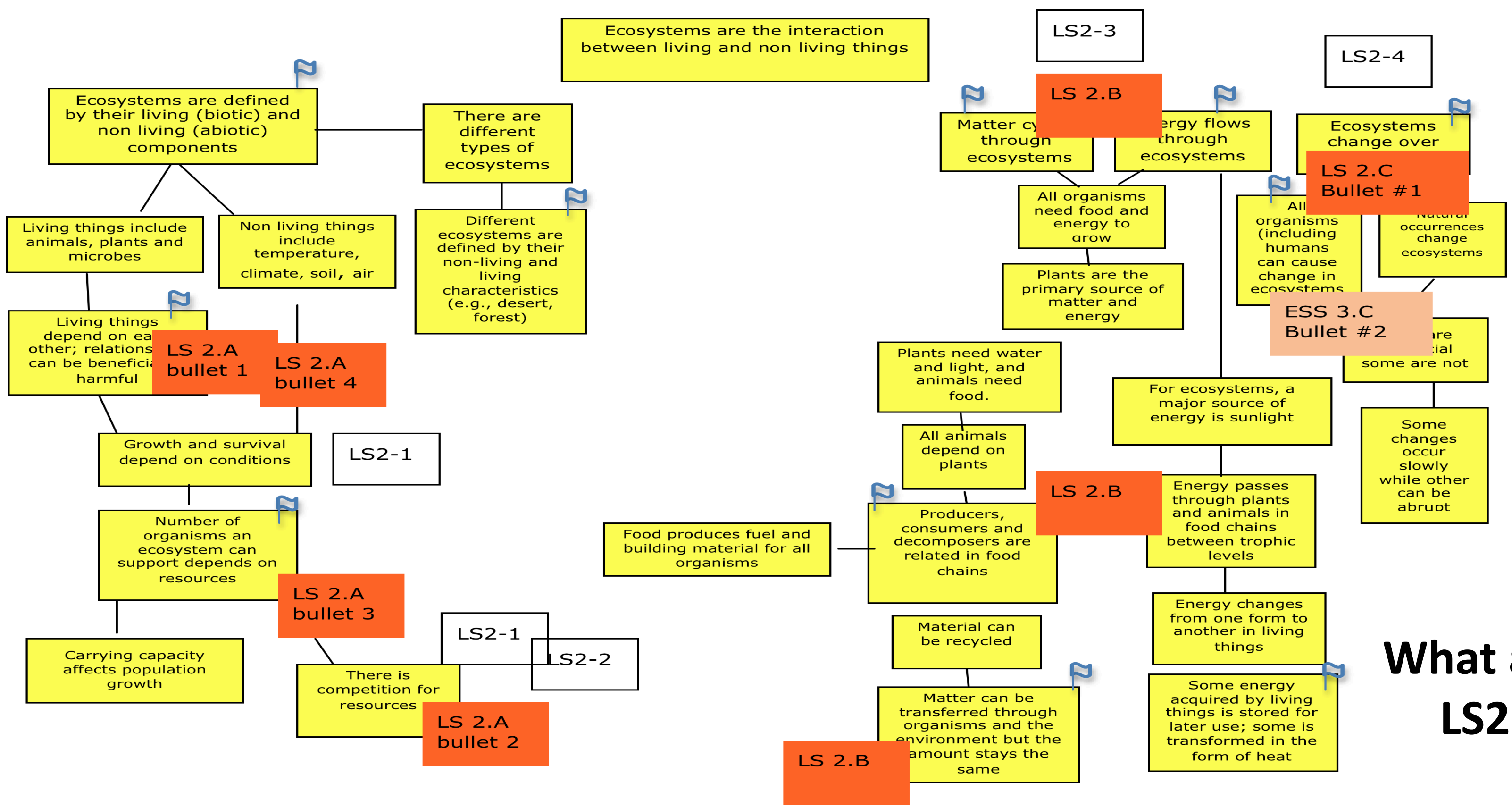


Aligning **DCIs** with the Conceptual Flow

- Read the **DCIs** for the topic.
- Where are the DCIs on your conceptual flow? Write the DCI number and bullet on a **orange** sticky note and post on the flow where you find a match.
- Are there DCIs that are not in your flow? Should they be? Add if appropriate.
- Remember to check DCIs in other content areas

Conceptual Flow Developed by the K-12 Alliance/WestEd

Example PE Match



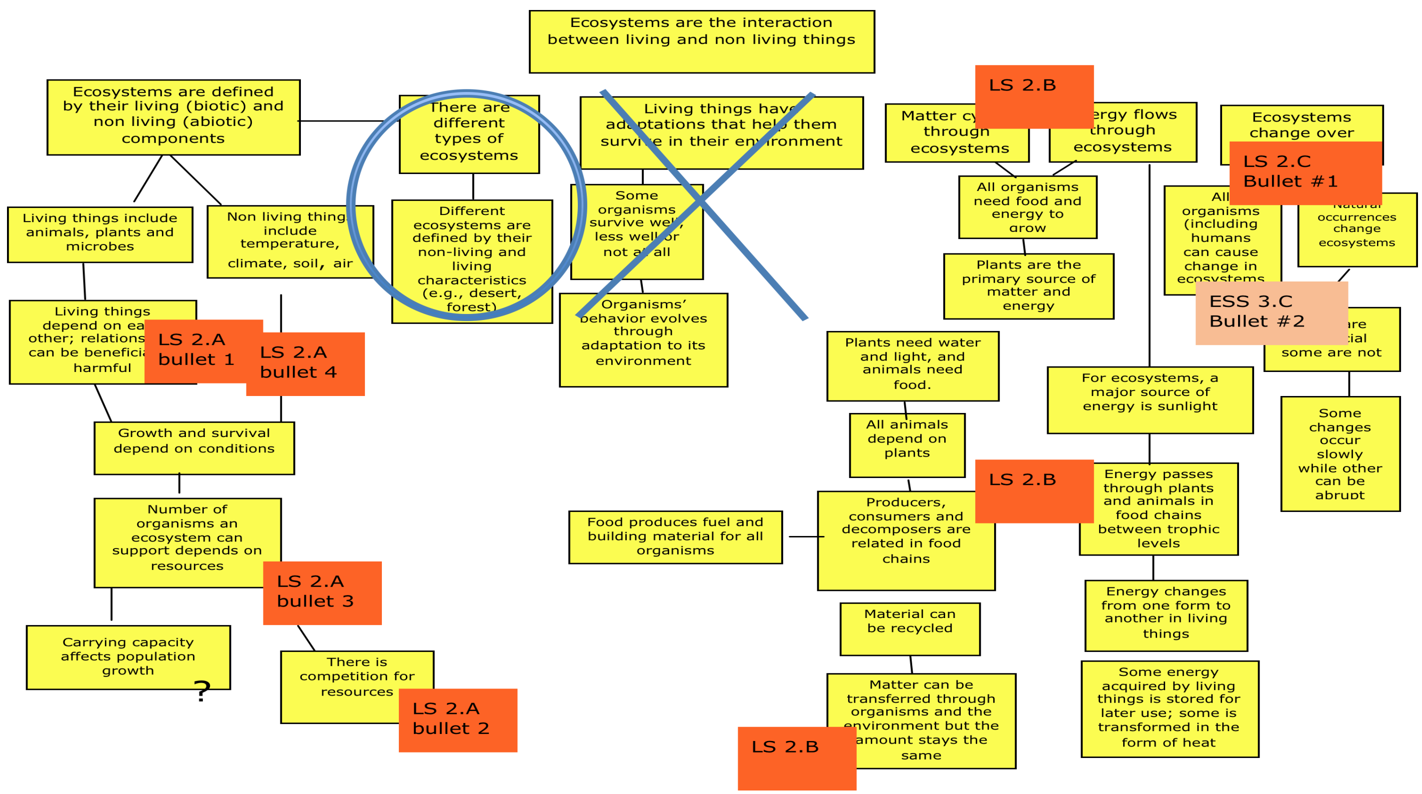
What about LS2-5?

Aligning Performance Expectations (PEs) with a Conceptual Flow

- Review the PEs from MS-LS2; if they appear on your conceptual flow, flag with a small sticky note
- If the PEs are not on your flow, where would you add them?

Conceptual Flow Developed by the K-12 Alliance/WestEd

Example CF Edit



Assessment

- Discuss the types of assessment that will be needed to gauge understanding of these standards.
- In your groups, review the AR Grade 7 Released Item
  - What is this item assessing?
  - How will assessment need to change?
- Formative vs. Summative

Pause and Write

- List at least 2 things you are sure about in the conceptual flow process.
- What is something you are wondering about in the conceptual flow process?

PQP Chart

Performance Expectation:				
DCI	**(Natural) Phenomena**	**Driving Question**	**Practice**	**Crosscutting Concepts**

Enter Selected DCI and PE from Conceptual Flow

PE: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem				
DCI	**(Natural) Phenomena**	**Driving Question**	**Practice**	**Crosscutting Concepts**
LS2.A Organisms dependent on interaction of LT and NLT… Similar needs, competition.. Growth limited by resources..				

What is a Phenomena?

A. An event that can **NOT** be explained through science.

B. A fact that is explained in simple terms.

C. An extraordinary super natural event or person.

D. An event or fact that can be observed and studied.

Brainstorm Phenomena

- Related to the specific DCI
- Related to student background/interest
- Natural phenomena possible to observe in your immediate surroundings OR for which you can obtain **data** (though classroom experiences, the Internet, texts, etc.)
- Use Arkansas-specific examples where feasible

Example: (Natural) Phenomena

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LS2.A Organisms dependent on interaction of LT and NLT… Similar needs, competition.. Growth limited by resources..	*Invasive Species* • *zebra mussels taking over CA lakes (and Great Lakes)* • *kudzu growing all over the south* • *starlings* • *changing meadow or pasture to star thistle*			

Develop Driving Questions

The Question:

- "Marries" DCI with an interesting phenomenon; they are often "why" questions
- Guides student investigation, experiment, or activity, often over multiple days of instruction
- Leads to depth of student understanding (higher order thinking)

Example: Driving Questions

PE: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem				
DCI	**(Natural) Phenomena**	**Driving Question**	**Practice**	**Crosscutting Concepts**
LS2.A Organisms dependent on interaction of LT and NLT… Similar needs, competition.. Growth limited by resources..	*Invasive Species* • *zebra mussels taking over CA lakes (and Great Lakes)* • *kudzu growing all over the south* • *starlings* • *changing meadow or pasture to star thistle*	• Why do zebra mussels proliferate and push out other species? • Why are there so many zebra mussels in the great lakes? • Where did they come from? • Why have they survived so well where others haven't? • What do zebra mussels eat? • What eats zebra mussels? • What pH levels are optimal for zebra mussels?		

Practices to Support Learning

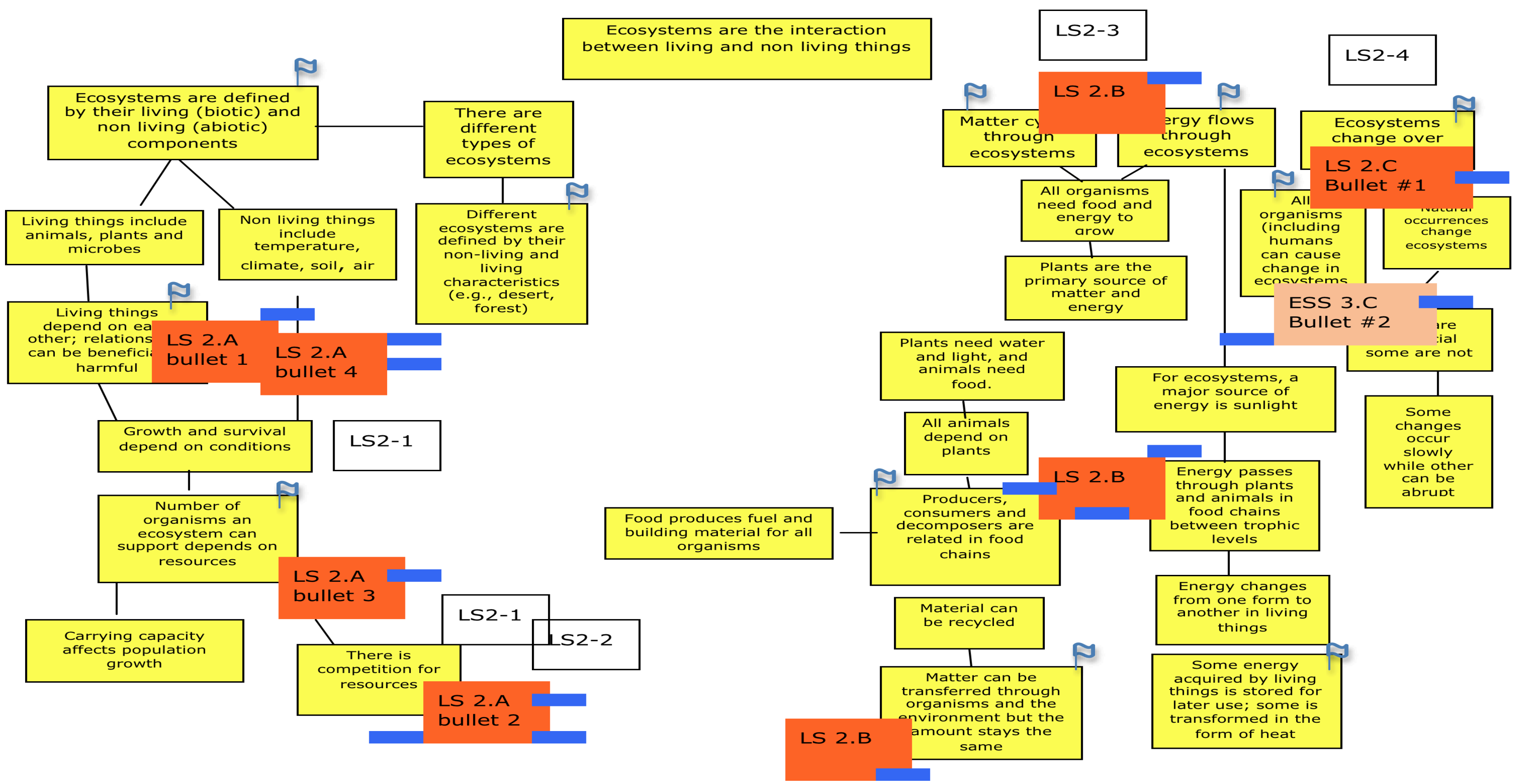
1. Start with the practice delineated in the PE.
2. Think about how students would answer the driving questions.
3. Determine the other practices needed to help support student learning.
4. Don't forget that the practices are highly connected—think of practices that naturally fit together.
5. Enter the practices on the PQP Chart.
6. Add "practice flags" to the DCIs on the Conceptual Flow.

Example: Practices

PE: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem

DCI	(Natural) Phenomena	Driving Question	Practice
LS2.A Organisms dependent on interaction of LT and NLT… Similar needs, competition.. Growth limited by resources..	• *zebra mussels taking over CA lakes (and Great Lakes)* • *kudzu growing all over the south* • *starlings* • *changing meadow or pasture to star thistle*	• Why do zebra mussels proliferate and push out other species? • Why are there so many zebra mussels in the great lakes? • Where did they come from? • Why have they survived so well where others haven't? • What do zebra mussels eat? • What eats zebra mussels? • What pH levels are optimal for zebra mussels?	• Analyze & interpret data • Conduct research to find data about the zebra muscles (CCSS) • Plan and conduct investigation about different aspects of ecosystems • Argue from evidence • Construct and refine model to explain phenomenon

Example Practices Added to CF



Taking it Home

- How might you use these tools?
- What structures do you have in place that would enable you to use these tools?
- What support do you need? From whom?

Planning for New Science Standards Workshop II Day 2

Arkansas Department of Education
and
K-12 Alliance/WestEd

Housekeeping

- Practice Professionalism
- Practice Technology Etiquette (phones, laptops, etc.)
- Practice Active listening (avoid sidebars, distractions)
- Honor Agenda (times and topics)
- Lunch on your own
- Please remember to take Post-Survey before leaving

Outcomes Revisited

- Recognize the relationship between
  - Disciplinary core ideas (DCIs)
  - Science and Engineering Practices (SEPs)
  - Crosscutting Concepts (CCCs)

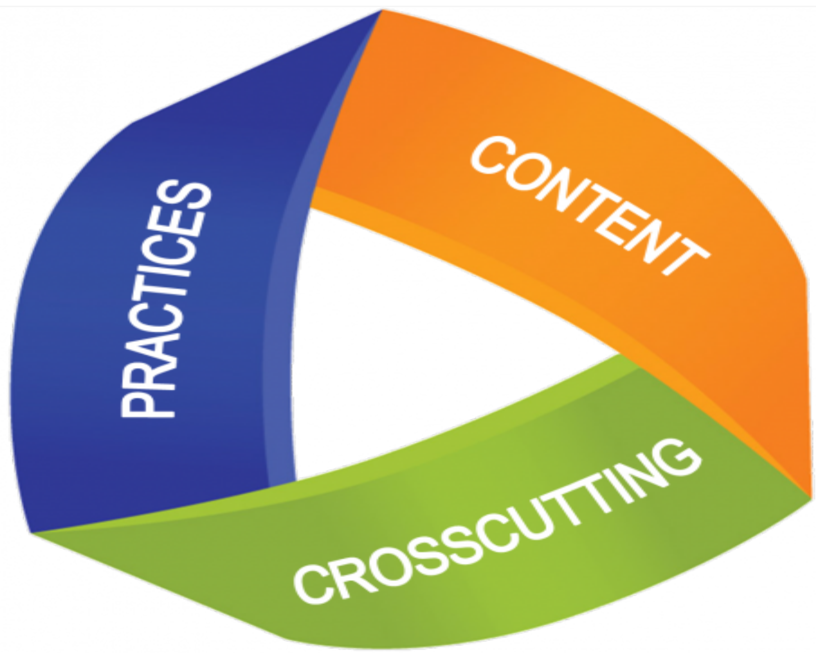
- Develop a Conceptual Flow (DCIs and PEs) to guide changes in instruction and assessment

- Complete a Phenomena, Question, Practice (PQP) Chart
  - determine best practices aligned to DCIs and PEs

Next Generation Science Standards: FOCUS ON Crosscutting Concepts

Core ideas in the discipline

Science and engineering



Concepts across disciplines

Using Crosscutting Concepts

Across Disciplines

Life	Earth	Physical
Photosynthesis	Earthquakes	Electricity
←	ENERGY	→

Within a Discipline

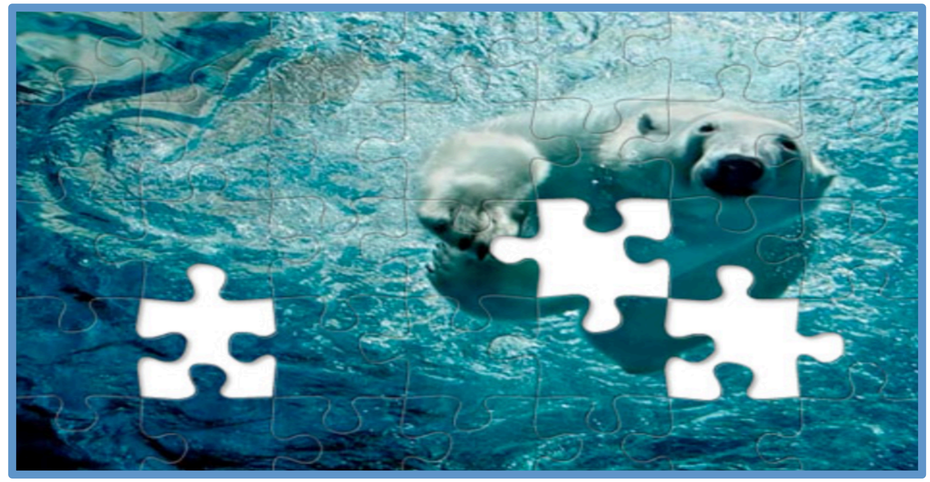
	Life Science	
Cells	Organ Systems	Ecosystems
←	SCALE	→

Crosscutting Concepts

* Patterns
* Cause and Effect
* Scale, Proportion, and Quantity
* Systems and System Models
* Energy and Matter: Flows, Cycles, and Conservation
* Structure and Function
* Stability and Change

Crosscutting Concepts (CCC) Activity

- Read assigned crosscutting concept
- Create product
- Each group shares product



Seeing Connections….

- As a table group review your PQP Chart for the specific DCI you selected.
- Which possible crosscutting concepts might align with the DCI and practices?
- Select CCC and enter it in the PQP Chart.

Crosscutting Concepts Column

DCI	(Natural) Phenomena	Driving Question(s)	Practice(s)	Cross Cutting Concepts

Other Units

Phenomena Questions Practices Developed by the Sacramento Area Science Project

Putting it Together: Example

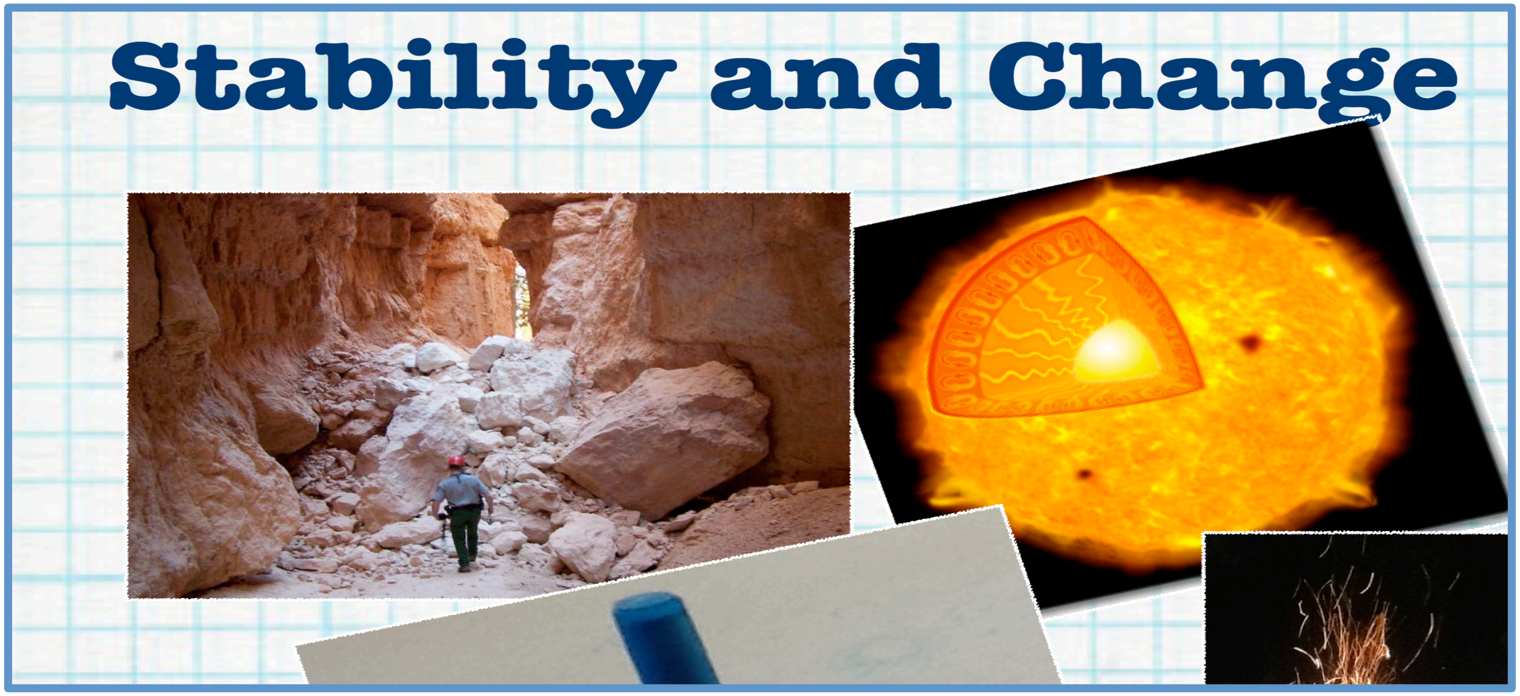
<table>
<tr><th>DCI</th><th>(Natural) Phenomena</th><th>Driving Questions</th><th>Practices</th><th>Crosscutting Concepts</th></tr>
<tr><td>LS2.A
#2</td><td></td><td></td><td></td><td rowspan="4">Cause and effect

Patterns

Matter and Energy

Stability and Change</td></tr>
<tr><td>LS2.A
#4</td><td></td><td></td><td></td></tr>
<tr><td>LS2.B</td><td></td><td></td><td></td></tr>
<tr><td>LS2.C
#1</td><td></td><td></td><td></td></tr>
</table>

How might the Crosscutting Concept selected be made explicit to students?



Exploring Science and Engineering Practices

Goals

- Clarify the science and engineering practices in the NGSS
- Link practices and engineering to Disciplinary Core Ideas (DCIs)

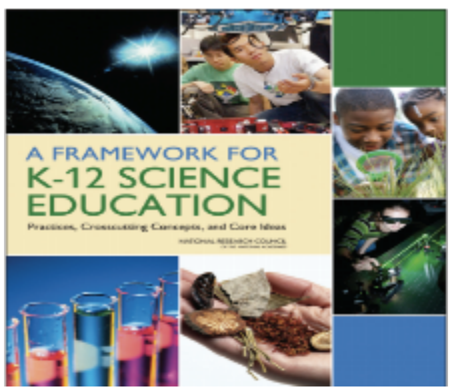
Science and Engineering

What is the difference between the work of scientists and the work of engineers?

Reading

How Engineering and Science Differ

NRC Framework pgs. 46-48



1/2010 - 7/2011

Highlight any important differences that you would like to include on your chart.

Add them to your chart.

The Big Idea

- If the goal is to answer a question, then students are doing science.
- If the goal is to define and solve a problem, then students are doing engineering.

NGSS Appendix F

1. Asking Questions and Defining Problems

Science	Engineering
<u>Purpose/focus</u> A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural world and designed world(s) works and which can be empirically tested.	**<u>Purpose/focus</u>** Engineering questions clarify problems to determine criteria for successful solutions and identify constrains to solve problems about the designed world.
<u>Specific Examples:</u> •What do I want to research? •What is the phenomena I want to understand? •What about that phenomena causes me to wonder? •What are the variables? •What do I want to control?	<u>Specific Examples:</u> •What is the problem? •What is the best technology to solve this problem? •What are the constraints? •What is the criteria?

Researching the Practices

Science and Engineering Practice

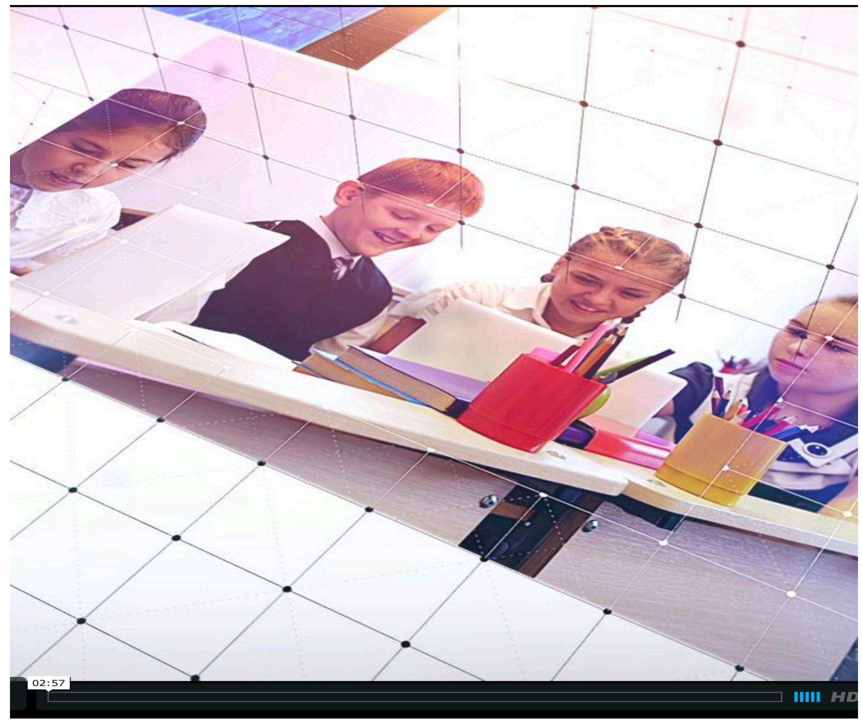
Science **Purpose/focus**	**Engineering** **Purpose/focus**
Specific Examples:	Specific Examples:

Exploring Science and Engineering Practices

Sometimes the differences are obvious… and sometimes they are not

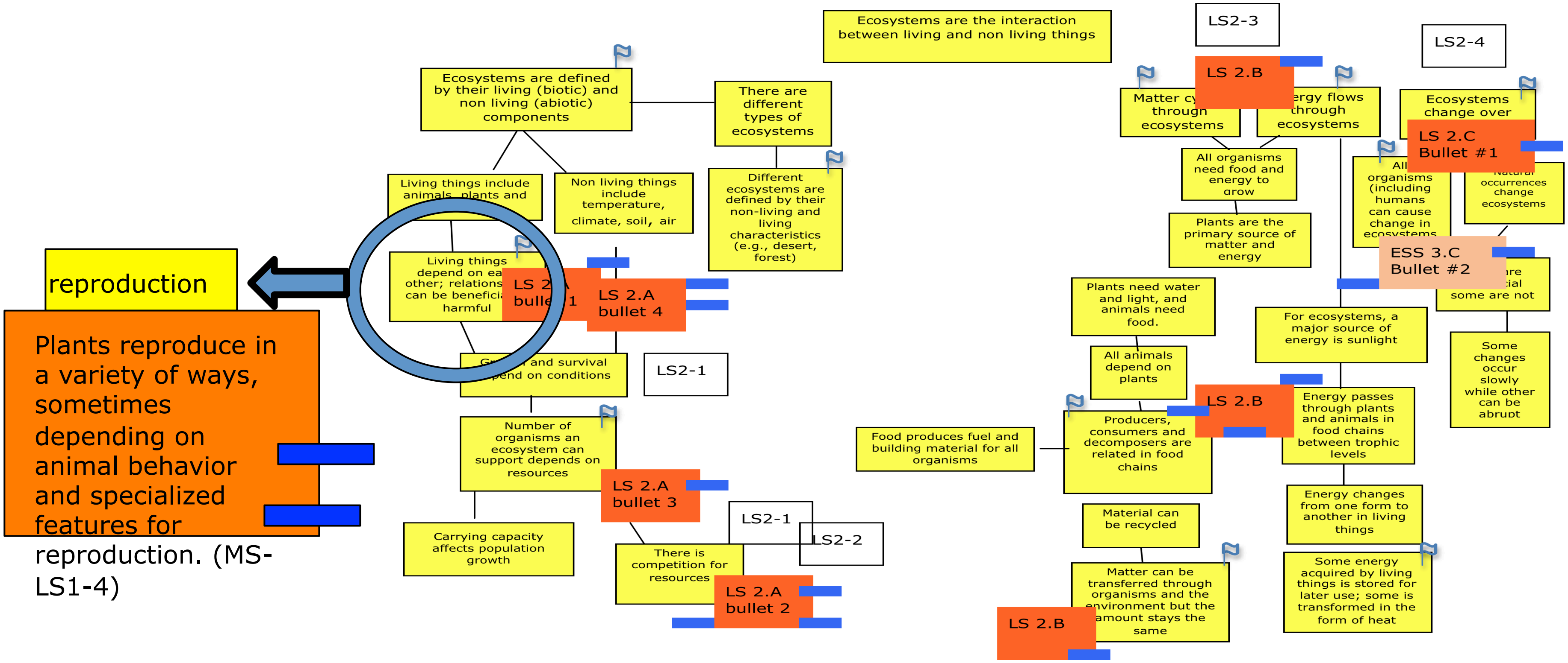
Science and Engineering Practices

Students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined.



NGSS Appendix F

Linking SEPs and DCIs



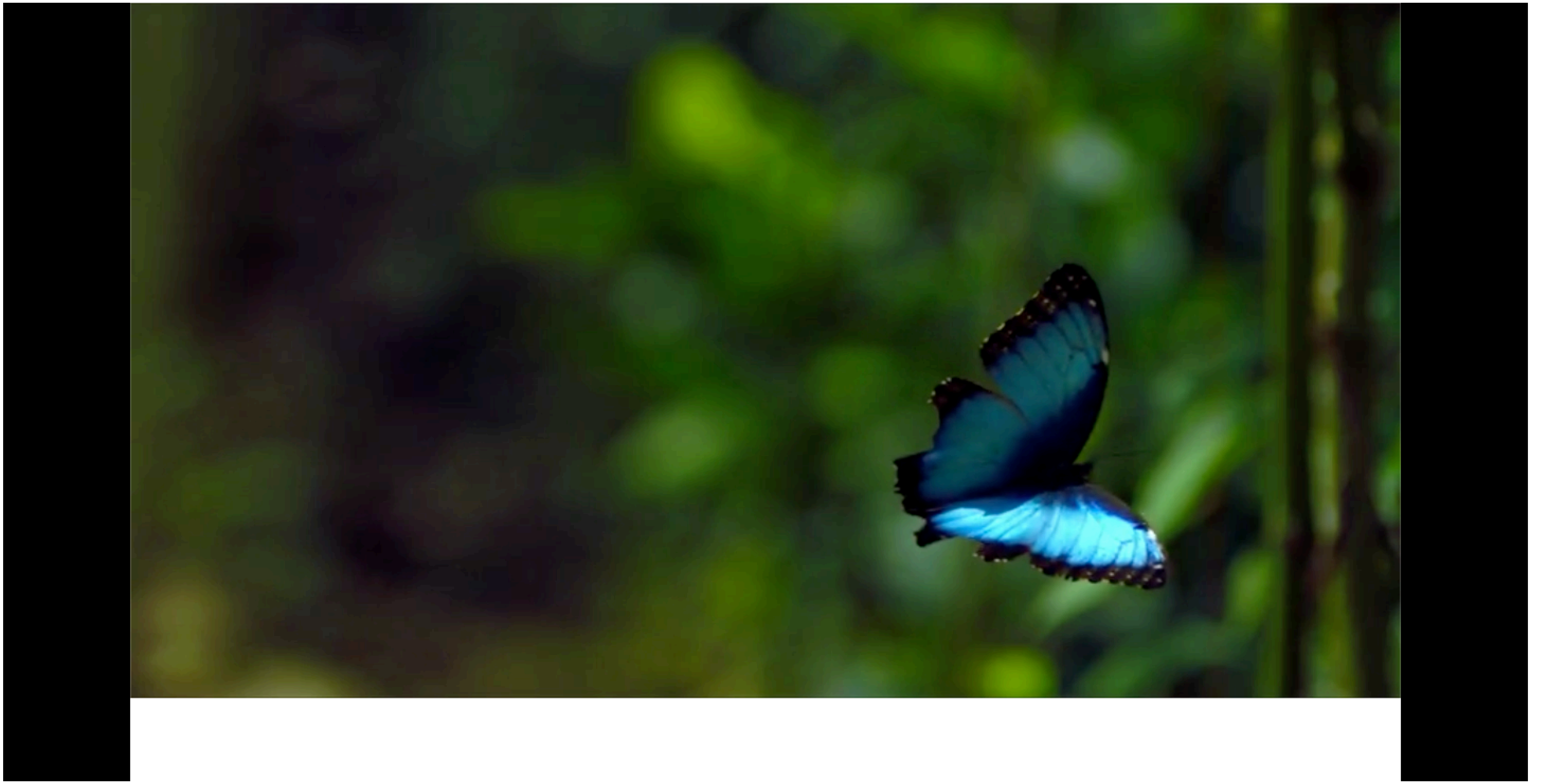
Flower Dissection

- There will be a variety of flowers at your table.
- Observe the flowers closely
- Discuss your observations in your group.

DCI AND PE from CF

PE: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plans respectively.

DCI	(Natural) Phenomena	Driving Question	Practice
LS1.B Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction	•Insects pollinating flowers •More flowering plants in some gardens than others •Cockleburs on my pants when I walk through the field	*How do insects pollinate flowers? *Do humans pollinate flowers? How? *Can any insect pollinate any flower? Why are some gardens in full bloom when others aren't Who besides humans tracks cockleburs	•Conduct Research about ways in which things are pollinated •Plan investigation on adaptation •Design a solution for humans to pollinate flowers •Develop an explanation about animal behaviors and plant structures.



Generate Questions

- Jot down some observations from the video.
- What questions do you have about what you observed in the video?
- Partners discuss questions.

Local Agriculture Context

- The school is in an agricultural area.
- Students have noticed that bee boxes are brought in to the area periodically and removed at other times only on "Organically Grown" watermelon fields.
- Students have also heard their parents talk about ways to pollinate plants if bees or other pollinators are not present in the local agricultural field.
-

Grocery Store

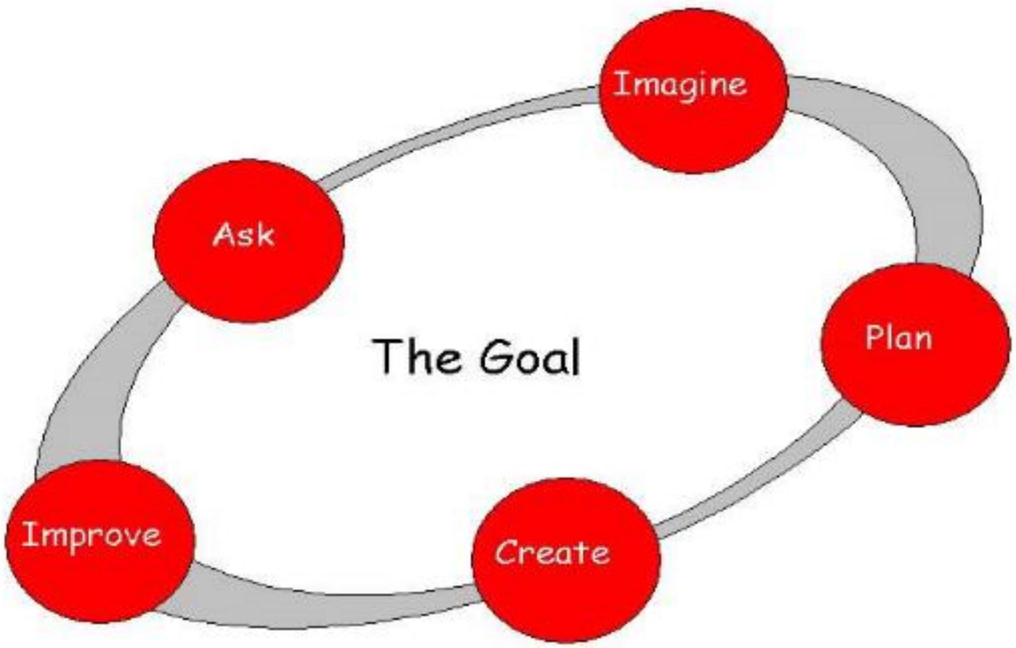
With Bees

Without Bees

Problem:
An Agricultural Company Wants to Hand Pollinate Plants

- You are part of an engineering team that must develop a pollinator for plants.
- The first task is to identify materials that could pick up and deliver pollen.
- Collect data to determine the best materials.

The Engineering Design Process



- Ask
- Imagine
- Plan
- Create
- Improve

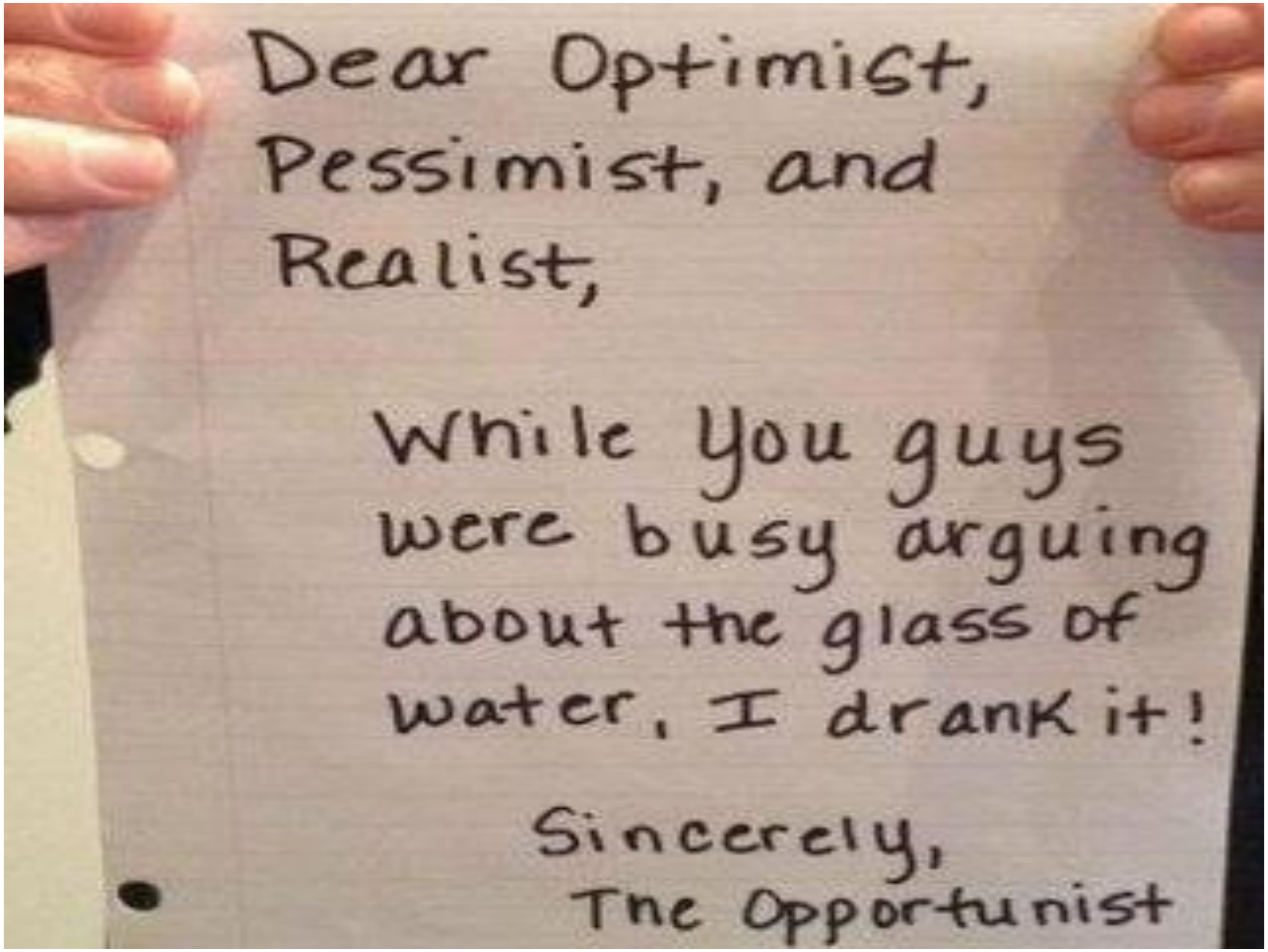
K-12 Alliance/WestEd 3/14

*Museum of Science EiE

Problem:
An Agricultural Company Wants to Hand Pollinate Different Plants

- The second task is to use a model of a flower (Bucket orchid, Dutchmen's pipe, Poppy/sunflower, and Jack in the Pulpit)
- Design a hand pollinator for the specific flower.
- Collect data to determine the best materials.

The intent is to show the importance of Engineering to understanding and reinforcing the Disciplinary Core Ideas.


Dear Optimist,
Pessimist, and
Realist,
While you guys
were busy arguing
about the glass of
water, I drank it!
Sincerely,
The Opportunist

Housekeeping

- Link to Post-Survey:
- https://www.surveymonkey.com/s/Two-DayNGSS_PostSurvey

- You will be asked to re-enter the **same** identifier in order to match your pre and post surveys.
- Your identifier is comprised of 6 digits:
  - initials of your first and last name
  - and your two-digit birth month
  - and two-digit birth date.
- Example: Tabitha Smith took the survey. Tabitha's birthday is July 23. Tabitha Smith's identifier is: TS0723

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