The NRC *Framework* and the *NGSS*: An Opportunity for Teacher Growth and Leadership

Arthur Eisenkraft
University of Massachusetts Boston
Favorites

• Your favorite food?

• Your favorite movie?

• Your favorite lesson?
Claim

• You all have excellent lessons
  – One per year
  – One per month
  – One per week
  – One daily
Today’s Goal

To have more lessons like your best lessons

... and to make your best lessons better.
How was this movie rated?

<table>
<thead>
<tr>
<th>Commercial success</th>
<th>Critical Failure</th>
<th>Critical Success</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>B</strong></td>
<td><strong>A</strong></td>
</tr>
<tr>
<td>Commercial Failure</td>
<td><strong>C</strong></td>
<td><strong>D</strong></td>
</tr>
</tbody>
</table>

Home Alone
How was this movie rated?

<table>
<thead>
<tr>
<th>Commercial success</th>
<th>Critical Failure</th>
<th>Critical Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Commercial Failure</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

It’s A Wonderful Life
How was this movie rated?

<table>
<thead>
<tr>
<th></th>
<th>Critical Failure</th>
<th>Critical Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial success</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Commercial Failure</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

School of Rock
Movies

- Critical Success and Commercial Success
  - Lord of the Rings
  - Finding Nemo
  - School of Rock
Movies

• Critical success and commercial failure
  – Bend it like Beckham
  – Lost in Translation
  – Citizen Kane
  – It’s a Wonderful Life
Movies

• Critical failure and commercial success
  – Alien (1979)
  – Friday the 13th (1980)
  – Police Academy (1984)
  – Home Alone (1990)
Movies

• Critical failure and commercial failure
  – Final Fantasy (2001)
  – The Lone Ranger (2013)
  – Heaven’s Gate (1980)
<table>
<thead>
<tr>
<th>Commercial success</th>
<th>Critical Failure</th>
<th>Critical Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alien (1979)</td>
<td>Friday the 13th (1980)</td>
<td>Lord of the Rings</td>
</tr>
<tr>
<td></td>
<td>Home Alone (1990)</td>
<td>School of Rock</td>
</tr>
<tr>
<td>Commercial Failure</td>
<td>Final Fantasy (2001)</td>
<td>Bend it like Beckham</td>
</tr>
<tr>
<td></td>
<td>The Lone Ranger (2013)</td>
<td>Lost in Translation</td>
</tr>
<tr>
<td></td>
<td>Heaven’s Gate (1980)</td>
<td>Citizen Kane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It’s a Wonderful Life</td>
</tr>
</tbody>
</table>
Criteria for a good movie

- Story
- Character/Acting
- Directing
- Overall Effectiveness of the Film
- Cinematography
- Costume Design
- Originality
- Soundtrack
Formula for a good movie

• No
• Not for commercial success
• Not for critical success
Sequels

• The Next Karate Kid   Failure
• The Godfather: Part II  Success
• The Godfather: Part III  Failure
• Men In Black 2   Failure
• Lethal Weapon 2  Success
• Toy Story 2  Success
• Oceans Twelve  Failure
Criteria vs Formula

- The criteria guide us (tangible)
- Criteria are necessary but not sufficient.
- Formula don’t exist (intangible)
  - je ne sais quoi
Do Now

• How would you teach shadows?

• Are there criteria for a good lesson?

• Is there a formula for a good lesson?
A game I like to play

• You give me a “formula” for a good lesson.

• I create a lesson

We all agree it’s a horrible lesson.

Conclusion: The “formula” is flawed.
Criteria: Understanding by Design*

1. Enduring understandings

2. Evidence of understanding

3. Create lesson

*Wiggins and McTighe
Understanding by Design

- Enduring understandings (Frameworks can help)
  - Big Ideas
    - Light travels in straight lines
    - Shadows are formed when light is interrupted by an opaque object
    - A ray model of light can explain shadows

- Evidence of understanding

- Create lesson
Understanding by Design

• Enduring understandings

• Evidence of understanding
  – Students can create shadows of different sizes
  – Students can predict changes in shadow lengths and check experimentally
  – Students can predict changes in shadow lengths and check using a ray model and/or mathematically

• Create lesson
Finding/Creating a lesson

• Use resources – text, internet, colleagues

• Do I understand the lesson?
• Is it appropriate for my students?
• Do I have the “stuff” required?
• Does it meet time demands?
ABC: Activity before Concept

• Activity
  – Candle lab with post-its for shadow objects
ABC: Activity before Concept

• Activity
  – How can I make the shadow larger?
ABC: Activity before Concept

• Concept 1:
  – Light travels in straight lines.
ABC: Activity before Concept

• Concept 2:
  – Create ray diagram model for light and shadows
ABC: Activity before Concept

• Activity 2:
  – Students draw two ray diagrams. Vary either the size of the paper, the distance from the light source or the distance from the screen.
ABC: Activity before Concept

• Activity 2:
  – Does this model produce the same results as the experiment?

MATH: Can we use the model to deduce the size mathematically?
ABC: Activity before Concept

• Concept 3:
  – Math: Use of similar triangles
Shadow Lesson Quality

• It meets certain criteria
• It did not follow a formula
Shadow Lesson Quality

• It meets certain criteria
• It did not follow a formula

• Your best lesson(s)
  – Meet certain criteria
  – Did not follow a formula
Criteria for good lessons within a good curriculum

• Understanding by Design
• 7E
  –ABC = Activity Before Concept
• 4 Essential Questions
Criteria for good lessons within a good curriculum

• Understanding by Design
• 7E
  – ABC = Activity Before Concept
• 4 Essential Questions
• Framework and NGSS
Criteria vs Formula

• The criteria guide us (tangible)
• Criteria are necessary but not sufficient.
• Formula don’t exist (intangible)
  • je ne sais quoi
Today’s Goal

To have more lessons like your best lessons

... and to make your best lessons better.
<table>
<thead>
<tr>
<th>Commercial success</th>
<th>Critical Failure</th>
<th>Critical Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alien (1979)</td>
<td></td>
<td>Lord of the Rings</td>
</tr>
<tr>
<td>Home Alone (1990)</td>
<td></td>
<td>School of Rock</td>
</tr>
<tr>
<td>Gigli</td>
<td>Movie 43</td>
<td>Bend it like Beckham</td>
</tr>
<tr>
<td>Movie 43</td>
<td></td>
<td>Lost in Translation</td>
</tr>
<tr>
<td>Citizen Kane</td>
<td></td>
<td>Lost in Translation</td>
</tr>
<tr>
<td>It’s a Wonderful Life</td>
<td></td>
<td>It’s a Wonderful Life</td>
</tr>
</tbody>
</table>
Good lessons and Framework (NGSS)

• That good lesson may meet the demands of the Framework (NGSS)

<table>
<thead>
<tr>
<th></th>
<th>Doesn’t meet NGSS</th>
<th>Does meet NGSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good lesson</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Poor lesson</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>
Good lessons and Framework (NGSS)

• That good lesson may meet the demands of the Framework (NGSS)

<table>
<thead>
<tr>
<th></th>
<th>Doesn’t meet NGSS</th>
<th>Does meet NGSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good lesson</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Poor lesson</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

• That good lesson can be better if we use Framework (NGSS) as a tool.
A Framework for K-12 Science Education – National Academy of Sciences

The Three Dimensions of the Framework

1. Scientific and Engineering Practices
2. Crosscutting Concepts
3. Disciplinary Core Ideas
Scientific and Engineering Practices

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

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quality
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change
Disciplinary Core Ideas

Physical Sciences

PS 1: Matter and its interactions
PS 2: Motion and stability – Forces and interactions
PS 3: Energy
PS 4: Waves and their applications in technologies for information transfer
Disciplinary Core Ideas

Life Sciences

LS 1: From molecules to organisms: Structures and processes
LS 2: Ecosystems: Interactions, energy, and dynamics
LS 3: Heredity – Inheritance and variation of traits
LS 4: Biological evolution – Unity and diversity
Disciplinary Core Ideas

Earth and Space Sciences
  ESS 1: Earth’s place in the universe
  ESS 2: Earth’s systems
  ESS 3: Earth and human activity

Engineering, Technology, and the Applications of Science
  ETS 1: Engineering design
  ETS 2: Links among engineering, technology, science and society
Criteria for good lessons within a good curriculum

• Understanding by Design

• 7E
  – Engage, elicit, explore, explain, elaborate, extend AND evaluate throughout
  – ABC = Activity Before Concept

• 4 Essential Questions

• Framework and NGSS
7E: Engage and Elicit

• Where did my shadow go?  (engage)

• What do I need for a shadow?  (elicit)
7E: Elicit

• Can a mouse’s shadow be as big as an elephant’s shadow?
7E: Explore

- Candle lab with post-its for shadow objects
- Safety concerns
- Students work for 8 minutes
7E: Explain

• How can I make the shadow larger?
• Claim: To make the shadow larger, I can
  ______________
7E: Explain (& Evaluate)

• How can I make the shadow larger?

• Claim: To make the shadow larger, I can
  – *Move the screen further away.*
  – *Use a larger object.*
  – *Move the light source further away.*
  – *Move the object away from the light source.*

• How can we explain this?
7E: Explain

• Light travels in straight lines.
• Does anybody have evidence for this?

• Two fist demonstration
Light travels in straight lines

- Photo of sun rays going through clouds
- Laser through chalk dust
7E: Explain

• Create ray diagram model for light and shadows
7E: Explain

- Create ray diagram model for light and shadows
7E: Explore

- Students draw two ray diagrams. Vary either the size of the paper, the distance from the light source or the distance from the screen.

- Claim and evidence request
- Claim: To make the shadow larger, I can
  - Move the screen further away.
  - Use a larger object.
  - Move the light source further away.
  - Move the object away from the light source.
7E: Explore

• Activity 2:
  – Students draw two ray diagrams. Vary either the size of the paper, the distance from the light source or the distance from the screen.
7E: Explain

• Does this model produce the same results as the experiment?

MATH: Can we use the model to deduce the size mathematically?
7E: Explain

- Math: Use of similar triangles
7E: Explain

• Math: Use of ratios
7E: Explain

- Math: Add complexity: (ball, rod at an angle, screen at an angle)
7E: Explain

- Math: Add complexity: (ball, rod at an angle, screen at an angle)
7E: Explain

• Math: Add complexity: (ball, rod at an angle, screen at an angle)
7E: Elaborate

- Where does the fuzziness come from?
7E: Elaborate

Shadow Region
7E: Elaborate

• Where does the fuzziness come from?
• Extension of the model
7E: Elaborate

• Where does the fuzziness come from?
• Extension of the model
7E: Elaborate

• Where does the fuzziness come from?

• Extension of the model
7E: Elaborate

• Where does the fuzziness come from?
7E: Elaborate

Three applications

• Theater – monster must be a 8 feet high, but we don’t know if the actor is 5 feet or 6 feet. What do we do?
7E: Elaborate

• Design a clock (assume that the Sun travels from East to West at 45 degrees latitude) using a vertical stick. Shadows outside during the day.

• What happens if the sundial clock uses the Washington Monument? Can you outrun the shadow?
7E: Elaborate

• Windmill shadows and potential danger with shadows due to strobe effects. What are the issues involved?
  – We have to maximize electricity generation
  – We have to keep the rotation of the blade(s) above or below a certain value.
7E: Elaborate

- Colored lights and colored shadows – theater complications.
- Do you really understand shadows and shadow formation?
7E: Extend

- Shadows and the eclipse (Earth casts shadow OR Moon casts shadow)
Science Content

- Light travels in straight lines
- Shadows formation experimentally
- Ray model of light
- Shadow formation using ray model
- Experimental evidence consistent with model
- Point source vs extended source
  - Umbra
  - Penumbra
- Modification of model
Math Content

- Ratios and proportional relationship
- Geometry – similar triangles
- Expressions and equations
- High school forecast or differentiated instruction
  - Trigonometric functions
  - Right triangles
  - Circles
  - Angles
- Model with mathematics
- Attend to precision
Engineering/Technology Content

- Theater – design shadow for a monster
- Theater – colored shadows
  - Don’t shadows have to be black?
Engineering/Technology Content

- Clock – sundial
  - Design
  - Systems
  - Analysis
  - Models
The Three Dimensions of the Framework

1. Scientific and Engineering Practices
2. Crosscutting Concepts
3. Disciplinary Core Ideas
Scientific and Engineering Practices

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

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

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

• Claim and evidence request
• Claim: To make the shadow larger, I can
  – *Move the screen further away.*
  – *Use a larger object.*
  – *Move the light source further away.*
  – *Move the object away from the light source.*
Crosscutting Concepts

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quality
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change
Patterns
Scale, proportion, and quality
Disciplinary Core Ideas

Earth and Space Sciences
ESS 1: Earth’s place in the universe
ESS 2: Earth’s systems
ESS 3: Earth and human activity

Engineering, Technology, and the Applications of Science
ETS 1: Engineering design
ETS 2: Links among engineering, technology, science and society
## 5-ESS1 Earth’s Place in the Universe

### 5-ESS1-1. Support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth.  
**Assessment Boundary:** Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).  

### 5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.  
**Clarification Statement:** Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.  
**Assessment Boundary:** Assessment does not include causes of seasons.

---

### Science and Engineering Practices

**Analyzing and Interpreting Data**
- Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.
  - Represent data in graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)

**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).
  - Support an argument with evidence, data, or a model. (5-ESS1-1)

---

### Disciplinary Core Ideas

#### ESS1.A: The Universe and its Stars
- The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)

#### ESS1.B: Earth and the Solar System
- The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)

---

### Crosscutting Concepts

**Patterns**
- Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

**Scale, Proportion, and Quantity**
- Natural objects exist from the very small to the immensely large. (5-ESS1-1)

---

**Connections to other DCIs in this grade-level:** will be available on or before April 26, 2013.

**Articulation of DCIs across grade-levels:** will be available on or before April 26, 2013.

**Common Core State Standards Connections:** will be available on or before April 26, 2013.
5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Scientific and Engineering Practices
Crosscutting Concepts
Disciplinary Core Ideas
### 5-ESS1 Earth’s Place in the Universe

**5-ESS1** Earth’s Place in the Universe

Students who demonstrate understanding can:

**5-ESS1-1.** Support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

**5-ESS1-2.** Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

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

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analyzing and Interpreting Data</strong></td>
<td><strong>ESS1.A: The Universe and its Stars</strong></td>
<td><strong>Patterns</strong></td>
</tr>
<tr>
<td>Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.</td>
<td>• The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)</td>
<td>• Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)</td>
</tr>
<tr>
<td>• Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)</td>
<td><strong>ESS1.B: Earth and the Solar System</strong></td>
<td><strong>Scale, Proportion, and Quantity</strong></td>
</tr>
<tr>
<td><strong>Engaging in Argument from Evidence</strong></td>
<td>• The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)</td>
<td>• Natural objects exist from the very small to the immensely large. (5-ESS1-1)</td>
</tr>
<tr>
<td>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).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Support an argument with evidence, data, or a model. (5-ESS1-1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Connections to other DCIs in this grade-level: will be available on or before April 26, 2013.

Articulation of DCIs across grade-levels: will be available on or before April 26, 2013.

Common Core State Standards Connections: will be available on or before April 26, 2013.
5-ESS1 Earth’s Place in the Universe

5-ESS1 Earth’s Place in the Universe
Students who demonstrate understanding can:

5-ESS1-1. Support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

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

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyzing and Interpreting Data</td>
<td>ESS1.A: The Universe and its Stars</td>
<td></td>
</tr>
<tr>
<td>Engaging in Argument from Evidence</td>
<td>ESS1.B: Earth and the Solar System</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pattern Definitions</td>
<td></td>
</tr>
</tbody>
</table>

Patterns
- Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

Scale, Proportion, and Quantity
- Natural objects exist from the very small to the immensely large. (5-ESS1-1)

Connections to other DCIs in this grade-level: will be available on or before April 26, 2013.
Articulation of DCIs across grade-levels: will be available on or before April 26, 2013.
Common Core State Standards Connections: will be available on or before April 26, 2013.
## 5-ESS1 Earth’s Place in the Universe

**5-ESS1.1. Support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth.** [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

**5-ESS1.2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.** [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

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
- **Analyzing and Interpreting Data**
  - Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.
    - Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)

- **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).
    - Support an argument with evidence, data, or a model. (5-ESS1-1)

### Disciplinary Core Ideas

#### ESS1.A: The Universe and its Stars
- The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)

#### ESS1.B: Earth and the Solar System
- The orbit of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)

### Crosscutting Concepts

- **Patterns**
  - Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena. (S-ESS1-2)

- **Scale, Proportion, and Quantity**
  - Natural objects exist from the very small to the immensely large. (S-ESS1-1)

Connections to other DCIs in this grade-level: will be available on or before April 26, 2013.

Articulation of DCIs across grade-levels: will be available on or before April 26, 2013.

Common Core State Standards Connections: will be available on or before April 26, 2013.
MS-ESS1-1: Earth’s Place in the Universe

• MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

Scientific and Engineering Practices

Crosscutting Concepts

Disciplinary Core Ideas
Today’s Goal

More lessons like your best lessons

... and your best lessons better.
Criteria for good lessons within a good curriculum

• Understanding by Design

• 7E
  – Engage, elicit, explore, explain, elaborate, extend AND evaluate throughout
  – ABC = Activity Before Concept

• 4 Essential Questions
  – What does it mean? How do we know? Why do we believe? Why should I care?

• Framework and NGSS
What could go wrong?
Great book ➔ Terrible movie
Great book → Terrible movie

Bonfire of the Vanities

13% on Rotten Tomatoes
Great book ➔ Terrible movie

10% on Rotten Tomatoes
The literal NGSS

The letter of the law (NGSS)

vs.

the spirit of the law (Framework)
The literal NGSS

• HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

• What happens to Newton’s 1\textsuperscript{st} and 3\textsuperscript{rd} Law?
  – No performance expectation
The literal NGSS

HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
• MS-PS2-1. Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.*
The literal NGSS

- HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

- Don’t eliminate Newton’s 1st and 3rd Law from the curriculum!
What could go wrong?
The literal NGSS

The letter of the law (NGSS)

vs.

the spirit of the law (Framework)
The literal NGSS

- **MS-LS4-2.** Apply scientific ideas to **construct an explanation** for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
- **Constructing Explanations as a Science Practice**

- **MS-LS4-3.** **Analyze displays of pictorial data** to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
- **Analyze and Interpreting Data as a Science Practice**
<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Scientific and Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Life Sciences</strong></td>
<td>1. Asking questions</td>
<td>1. Patterns</td>
</tr>
<tr>
<td>LS 4: Biological</td>
<td>2. Developing models</td>
<td>2. Cause and effect</td>
</tr>
<tr>
<td>evolution – Unity and</td>
<td>3. Planning investigations</td>
<td>3. Scale, proportion</td>
</tr>
<tr>
<td></td>
<td>5. Using mathematics</td>
<td>5. Energy and matter:</td>
</tr>
<tr>
<td></td>
<td>6. Constructing explanations</td>
<td>6. Structure and</td>
</tr>
<tr>
<td></td>
<td>7. Argument from evidence</td>
<td>function</td>
</tr>
<tr>
<td></td>
<td>8. Communicating information</td>
<td>7. Stability and change</td>
</tr>
<tr>
<td>Disciplinary Core Ideas</td>
<td>Scientific and Engineering Practices</td>
<td>Crosscutting Concepts</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Life Sciences</strong></td>
<td>1. Asking questions</td>
<td>1. Patterns</td>
</tr>
<tr>
<td></td>
<td>2. Developing models</td>
<td>2. Cause and effect</td>
</tr>
<tr>
<td></td>
<td>3. Planning investigations</td>
<td>3. Scale, proportion</td>
</tr>
<tr>
<td><strong>LS 4: Biological</strong></td>
<td>4. Analyzing data</td>
<td>4. Systems</td>
</tr>
<tr>
<td>evolution – Unity and</td>
<td>5. Using mathematics</td>
<td>5. Energy and matter:</td>
</tr>
<tr>
<td>diversity**</td>
<td>6. Constructing explanations</td>
<td>6. Structure and</td>
</tr>
<tr>
<td></td>
<td>7. Argument from evidence</td>
<td>function</td>
</tr>
<tr>
<td></td>
<td>8. Communicating information</td>
<td>7. Stability and change</td>
</tr>
</tbody>
</table>
The literal NGSS

Can we replace one practice for another:

- Constructing Explanations with
  - Analyze and Interpreting Data

- Apply scientific ideas to **construct an explanation** for the anatomical **Analyze displays of pictorial data to compare patterns** of similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Scientific and Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Sciences</td>
<td>1. Asking questions</td>
<td>1. Patterns</td>
</tr>
<tr>
<td></td>
<td>2. Developing models</td>
<td>2. Cause and effect</td>
</tr>
<tr>
<td></td>
<td>3. Planning investigations</td>
<td>3. Scale, proportion</td>
</tr>
<tr>
<td></td>
<td>5. Using mathematics</td>
<td>5. Energy and matter:</td>
</tr>
<tr>
<td></td>
<td>7. Argument from evidence</td>
<td>7. Stability and change</td>
</tr>
<tr>
<td></td>
<td>8. Communicating information</td>
<td></td>
</tr>
<tr>
<td>LS 4: Biological</td>
<td>1. Asking questions</td>
<td></td>
</tr>
<tr>
<td>evolution – Unity and</td>
<td>2. Developing models</td>
<td></td>
</tr>
<tr>
<td>diversity</td>
<td>3. Planning investigations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Analyzing data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Using mathematics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Constructing explanations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Argument from evidence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Communicating information</td>
<td></td>
</tr>
<tr>
<td>Disciplinary Core Ideas</td>
<td>Scientific and Engineering Practices</td>
<td>Crosscutting Concepts</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td><strong>Life Sciences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LS 4: Biological</td>
<td>1. Asking questions</td>
<td>1. Patterns</td>
</tr>
<tr>
<td>evolution – Unity and</td>
<td>2. Developing models</td>
<td>2. Cause and effect</td>
</tr>
<tr>
<td>diversity</td>
<td>3. Planning investigations</td>
<td>3. Scale, proportion</td>
</tr>
<tr>
<td></td>
<td>5. Using mathematics</td>
<td>5. Energy and matter:</td>
</tr>
<tr>
<td></td>
<td>6. Constructing explanations</td>
<td>6. Structure and</td>
</tr>
<tr>
<td></td>
<td>7. Argument from evidence</td>
<td>function</td>
</tr>
<tr>
<td></td>
<td>8. Communicating information</td>
<td>7. Stability and change</td>
</tr>
<tr>
<td>Disciplinary Core Ideas</td>
<td>Scientific and Engineering Practices</td>
<td>Crosscutting Concepts</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td><strong>Life Sciences</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| LS 4: Biological evolution – Unity and diversity | 1. Asking questions  
2. Developing models  
3. Planning investigations  
4. Analyzing data  
5. Using mathematics  
6. Constructing explanations  
7. Argument from evidence  
8. Communicating information | 1. Patterns  
2. Cause and effect  
3. Scale, proportion  
4. Systems  
5. Energy and matter:  
6. Structure and function  
7. Stability and change |
<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Scientific and Engineering Practices</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LS 4: Biological evolution – Unity and diversity</strong></td>
<td>1. Asking questions</td>
<td>1. Patterns</td>
</tr>
<tr>
<td></td>
<td>2. Developing models</td>
<td>2. Cause and effect</td>
</tr>
<tr>
<td></td>
<td>3. Planning investigations</td>
<td>3. Scale, proportion</td>
</tr>
<tr>
<td></td>
<td>5. Using mathematics</td>
<td>5. Energy and matter:</td>
</tr>
<tr>
<td></td>
<td>7. Argument from evidence</td>
<td>7. Stability and change</td>
</tr>
<tr>
<td></td>
<td>8. Communicating information</td>
<td></td>
</tr>
<tr>
<td>Disciplinary Core Ideas</td>
<td>Scientific and Engineering Practices</td>
<td>Crosscutting Concepts</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Life Sciences</td>
<td>1. Asking questions</td>
<td>1. Patterns</td>
</tr>
<tr>
<td>LS 4: Biological evolution – Unity and diversity</td>
<td>2. Developing models</td>
<td>2. Cause and effect</td>
</tr>
<tr>
<td></td>
<td>3. Planning investigations</td>
<td>3. Scale, proportion</td>
</tr>
<tr>
<td></td>
<td>5. Using mathematics</td>
<td>5. Energy and matter:</td>
</tr>
<tr>
<td></td>
<td>7. Argument from evidence</td>
<td>7. Stability and change</td>
</tr>
<tr>
<td></td>
<td>8. Communicating information</td>
<td></td>
</tr>
<tr>
<td>Disciplinary Core Ideas</td>
<td>Scientific and Engineering Practices</td>
<td>Crosscutting Concepts</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Life Sciences</td>
<td>1. Asking questions</td>
<td>1. Patterns</td>
</tr>
<tr>
<td>LS 4: Biological evolution – Unity and diversity</td>
<td>2. Developing models</td>
<td>2. Cause and effect</td>
</tr>
<tr>
<td></td>
<td>3. Planning investigations</td>
<td>3. Scale, proportion</td>
</tr>
<tr>
<td></td>
<td>5. Using mathematics</td>
<td>5. Energy and matter:</td>
</tr>
<tr>
<td></td>
<td>7. Argument from evidence</td>
<td>7. Stability and change</td>
</tr>
<tr>
<td></td>
<td>8. Communicating information</td>
<td></td>
</tr>
</tbody>
</table>
The literal NGSS

Beware the NGSS police who say you CAN’T replace one practice for another

Let’s use all practices and all crosscutting concepts
Today’s Goal

More lessons like your best lessons

... and your best lessons better.
<table>
<thead>
<tr>
<th>Critical Failure</th>
<th>Critical Success</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commercial success</strong></td>
<td><strong>Commercial Failure</strong></td>
</tr>
</tbody>
</table>
| Alien (1979)  
Friday the 13th (1980)  
Police Academy (1984)  
Home Alone (1990) | Lord of the Rings  
Finding Nemo  
School of Rock |
| Final Fantasy (2001)  
The Lone Ranger (2013)  
Heaven’s Gate (1980) | Bend it like Beckham  
Lost in Translation  
Citizen Kane  
It’s a Wonderful Life |
Criteria for good lessons within a good curriculum

• Understanding by Design

• 7E
  – Engage, elicit, explore, explain, elaborate, extend AND evaluate throughout
  – ABC = Activity Before Concept

• 4 Essential Questions
  – What does it mean? How do we know? Why do we believe? Why should I care?

• Framework and NGSS
Moving toward Quadrant A

<table>
<thead>
<tr>
<th></th>
<th>Doesn’t meet NGSS</th>
<th>Does meet NGSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good lesson</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Poor lesson</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

Good lessons that also meet Framework/NGSS
Next Steps

• How many lessons can you adapt this year?

• How many lessons can you adapt next year?
The Vision of the Framework/NGSS
You are the experts

• You teach every day.

• You have more experience with teaching than any college professor or researcher.
Knowledge Acquisition

• The Plumber informs the Physicist
  – Hot water pipes freeze quicker than cold water
Knowledge Acquisition

• The Plumber informs the Physicist
  – Hot water pipes freeze quicker than cold water

• The Teacher informs the Researcher
  – Boiling water
You are the experts

• You are the ones that can find out what works
• You can test it in the classroom because you are in the classroom.
• You can stimulate the research community with your findings
You are the experts

• You are the ones that can find out what works
• You can test it in the classroom because you are in the classroom.
• You can stimulate the research community with your findings
• You are the leaders of the educational community.
Teachers as Leaders

We change people’s lives
Teachers as Leaders

We communicate the beauty in the world
Teachers as Leaders

We help students reach their potential.
Margaret Mead:

Never doubt that a small group of thoughtful, committed citizens can change the world.

Indeed, it is the only thing that ever has.
We are changing the world and making it a better place.
Thank You

Arthur Eisenkraft
www.COSMIC.umb.edu