Developing and Teaching with Coherent Storylines to Support Three-Dimensional Science Learning

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“Science and engineering practices”
• Not just science process skills
• A coherent system of building and using knowledge, guided by common norms, tools, and discourse

For students’ work to truly reflect a social practice, students should participate in the developing and managing plans for investigation.

If students are analyzing data or constructing a model because that’s what the worksheet says to do, they are not engaging in a practice.
Do plants need light to grow?

Practice: Designing investigations

Disciplinary core idea: Plant growth

Crosscutting concepts: cause/effect, structure/function

But... What are you working on?
Why are you working on this?
Coherence from the students’ perspective

Students are partners with teachers in managing the trajectory of their knowledge building.

• Investigations motivated by student questions from phenomena.
• Each step is an attempt to address a question or gap in the current explanations and models.
• Engaging in practices helps the class make progress on questions they are trying to figure out or problems they are trying to solve.
How Can We Support Students as Partners in Knowledge-Building?

“We figure out the science ideas.”

“Storyline”

“We figure out where we are going each step.”

“We put the pieces of the science ideas together over time.”
How Can We Develop a Storyline in Which Students are Partners in Managing Investigations?

Five questions to guide our work:

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?
Example 1: What is happening to our corn?

*Second grade: plant growth, structure/function*

*Design Team:*
Lori Farkash, 2nd Grade Teacher, Moses Y. Beach School, CT
Nancy Michael, 2nd Grade Teacher, Pembroke Elementary School, CT
Ruth Purdie Dyer, 2nd Grade Teacher, WCAIS Magnet School, CT
1. How do we kick off investigations in a unit?

Oh, no! Mrs. Farkash spilled water all over the Harvest Corn!
What will happen?
1. How do we kick off investigations in a unit?

Notice and wonder

S: Is this fake?
T: Good question
S: I think it is.
S: Hers is all brown.
1. How do we kick off investigations in a unit?

Students draw on prior experiences to predict and wonder

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Oh, no! Mrs. Farkash spilled water all over the Harvest Corn!
What will happen?

A: I think it will get ruined. Maybe rot?
B: I think it might grow because it has water.
C: Get like a bigger piece of corn... fatter.
D: It will get darker because it's going to die.
E: It will stain because it's a decoration.
F: It will get slippery because it's wet.
G: I think it will turn black because water makes stains.
H: I think it will rot and get stinky.
I: I think the corn will float and it won't be able to drink all the water up so it will start changing the colors and get darker.
J: I think the part we hold (husk part) will turn green and the water will change color and the corn will turn yellow. The corn will get smaller - medium size.
K: I think it will rot. It will drown.

I Wonder...?

- If the water will get in the corn
- I wonder if it is made of seaweed?
- I wonder why they fall off so quick?
- I wonder if we put the pieces in the water will they grow?
- I wonder if it is real?
- I wonder if corn will turn yellow?
- Will water make the corn smaller?
- If we put the pieces in the water for a day will there be more pieces everywhere? Will it grow because they need soil?
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1. How do we kick off investigations in a unit?

How can we investigate these questions?

We could observe it every day (did the colors change?)
Draw sci-agram [science diagram] to show what’s happening?
Use models to show every stage so we can teach people what happened.
1. How do we kick off investigations in a unit?

- What do we notice?
- How can we explain this?
- Where else have we seen something like this?
- Do our explanations agree?
- What do we need to figure out?
1. How do we kick off investigations in a unit?

Anchoring Phenomenon Routine

<table>
<thead>
<tr>
<th>Explore Anchoring Phenomenon</th>
<th>Attempt to Make Sense</th>
<th>Identify Related Phenomena</th>
<th>Develop Questions &amp; Next Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do we notice?</td>
<td>How can we explain this?</td>
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<tr>
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<td></td>
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</tr>
</tbody>
</table>
Example 2 – How can We Hear Different Sounds From Across the Room?

Middle School: sound waves

Sound Unit Design Team

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- Lisa Brody, 6th-7th Grade Science Teacher, Park View School, Morton Grove, IL
- Malika Jones, 7th-8th Grade Science Teacher, Beach Park Middle School, Beach Park, IL
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- Keetra Tipton, 6th-8th Grade Science Teacher, Park View School, Morton Grove, IL
- Robert J. Wolffe, Professor of Education, Bradley University, Peoria, IL

tinyurl.com/soundMS
Student observe an unusual phenomenon
Patterns Students Noticed

1. There were different notes – some where higher & some were lower.
2. Volume depended on the distance we were from the sound source.
3. Some people heard screechy sounds, some heard music (someone singing & instruments [violin?])
4. Straws were moving left & right
5. Position of needle changed the sound.
6. Spinning the disc produces the sound; but needle is touching the disc when it makes a sound.
7. Faster spinning = faster sound.
8. Slower spinning sounded clearer.
9. There were lines on the disc (different line = different sounds)
Students model the phenomenon
Students generate questions

Students generate other sound-related phenomena, and generate questions they have.
Student questions

How do sounds fade away?

Why are some noises higher pitched than others?

How do we hear underwater?

Is sound a state of matter?

Why do we feel vibrations when we play instruments?

How does a sound go through walls?
Student questions

Why can’t some age groups not hear higher sounds with their ear, but some do, like dog whistle?

Does vibration cause sound?

Why do some objects make only 1 sound?

Can we hear amplified sound, even if it is blocked?

Does something need to touch another to make a sound?

Is sound made of particles?
Ideas for investigations

Students brainstorm ways to investigate these questions.

- Use different objects and observe their sounds; try different volumes.
- Study the structure & function of ear parts.
- Slow motion videos.
- Use our voices as sound sources.
- Zoom in even closer.
- Get in touch with inventors & makers of speakers, megaphones so we can figure out how those work.
- Place people in different areas & set up different tests (distance, volume, different sounds).
- Bring in different instruments.

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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 I help students *put together pieces* of the disciplinary core ideas and crosscutting concepts?
Where does the corn classroom go next?

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?
Let’s take it apart!

S: [It’s] real corn because real corn has that kind of hair.

S: It’s real! / It’s white.

T: You said if it’s real it would have something to hold it together.
S: And it does! It has a stem that goes inside it.

S: I wonder how they change these types of colors?

T: What parts do we see?
T: Are kernels seeds?
S: We should plant them and see if they grow.
Motivating investigations from our questions

Let’s take it apart!

Let’s leave some in water and observe it every day!
...after 10 days...
2. How do we work with students to motivate the next steps in the investigation?

Lesson

Looking Back
- Where did we leave off?

Looking Forward
- What are we trying to figure out?
- How can we work on this today?

Looking Back
- What have we agreed on?
- Where are we not sure?

Looking Forward
- Where should we go next?
Navigation is co-construction – teachers and students working together. Both investigations, observing corn over time to see if it grows and dissecting dry corn were in the planned storyline. But teachers worked with students to co-develop these ideas, rather than simply springing them on students as “today’s lesson.”
3. How do we help students use practices to figure out pieces of the science ideas?

- Where did we leave off? What are we trying to figure out? How should we work on this today?
- Investigating phenom with sci and eng practices
- Figuring out pieces of DCIs or CCCs
- What have we agreed on? Where are we not sure? Where should we go next?
Coherence from the students’ perspective

1. How do we kick off investigations in a unit?

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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 I help students put together pieces of the disciplinary core ideas and crosscutting concepts?
4. How do push students to go deeper and revise the science ideas we have built so far?

Productive arguments lead to new questions

![Image of corn and children]

Some think the sprouts are coming from the kernels...some think the sprouts are coming from the cob & some aren't sure! This is so exciting 😎
4. How do push students to go deeper and revise the science ideas we have built so far?

It’s coming from the cob because it comes from underneath the kernels.

I disagree with you because when I looked closely at this I saw a sprout coming out of a kernel.

I agree with both of you because I see some are coming from the kernels AND the cob.
4. How do push students to go deeper and revise the science ideas we have built so far?

Productive arguments lead to new questions, which lead to new investigations.
4. How do push students to go deeper and revise the science ideas we have built so far?

Experiment Set Up: “Cob into container, kernel into a different container”

Results!

🔍Look! The cob didn't sprout but the kernels did! Are the kernels seeds? 🤔 & now we're wondering, what's inside the kernel to make it sprout? 😳
4. How do push students to go deeper and revise the science ideas we have built so far?

We have a partial model

But what about...?

Routine 4: Problematizing Routine

Is it X or Y?

We should definitely test this!
New things we notice and gaps in our explanations lead to new questions

Now we have a reason to dissect a seed!

🎉 Look! The cob didn't sprout but the kernels did! Are the kernels seeds? 🤔 & now we're wondering, what's inside the kernel to make it sprout? 😐
New things we notice and gaps in our explanations lead to new questions

Now we have a reason to test the effects of light!

Noticing patterns - this plant appears to be growing toward the sunlight so does our plant need sunlight? We're going to set up an investigation to find out!
New things we notice and gaps in our explanations lead to new questions.

Go to this url to view the video clip: tinyurl.com/Storyline04

Password: NSTAwebinar (1 min 25 sec)

What did students figure out?
What did students figure out?

I think it’s going to die because... the one in the dark because... it’s at least how much a corn could grow, because that’s really tall and because I already see some of the pieces are getting brown.

I agree with you Tessa because it looks greener and it doesn’t have that much brown. I’m noticing that this one had so much brown and it’s not green anymore. And I know that a lot of plants are green. When they get yellow like grass, when they’re brown they die.
5. How do we help students put together what they figured out across lessons?

Look! The cob didn't sprout but the kernels did! Are the kernels seeds? 😐 & now we're wondering, what's inside the kernel to make it sprout? 😊

Noticing patterns - this plant appears to be growing toward the 🌞 so does our 🌻 need 🌞? We're going to set up an investigation to find out!

Routine 5: Putting Pieces Together Routine
Storylines: Coherence from the students’ perspective

Why Is Our Corn Changing?

Lesson Routine

<table>
<thead>
<tr>
<th>L1</th>
<th>Anchoring phenomena</th>
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<tbody>
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</table>

Questions

<table>
<thead>
<tr>
<th>L2</th>
<th>Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What is this thing made of?</td>
</tr>
</tbody>
</table>

Phenomena / Problems

<table>
<thead>
<tr>
<th>L3</th>
<th>Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What happened to the wet harvest corn?</td>
</tr>
</tbody>
</table>

What we figured out

- A decoration (harvest corn) that our teacher brought to class was accidentally left outside and got wet. We wondered if it was ruined, whether it was real corn (like the corn we eat), and if anything would happen to it. We had some ideas for some investigations we wanted to pursue.

- This decoration (harvest corn) had some structures that are similar to the corn we eat (kernels and a cob), and some differences (color and hardness).

- Little things came out of the corn. The kernels became plumper and softer.
**Full Corn Unit storyline**

### Lesson Routine

1. **Questions**
   - What did we figure out?
   - How do the plants change?
   - What happened to the wheat corn?
   - What made the wheat corn grow?
   - What are the different parts growing in different directions?
   - How did the wheat corn change?
   - What did we figure out by putting some seeds in different places?

2. **Phenomena / Problems**
   - We grow yellow corn in the wheat field and put seeds in it.
   - We check the wheat corn.
   - We plant different types of plants and put them in different places.
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3. **What we figured out**
   - We grow yellow corn in the wheat field and put seeds in it.
   - We check the wheat corn.
   - We plant different types of plants and put them in different places.
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Example 2 - Arguments in building the model lead to questions and investigations

**Phenomena**

**Questions**

- How can we hear so many different voices and sounds when we spin the record?
- What does the record look like up close?
- How does the needle interact with the grooves on the record?
- Do other things that make sound also move back & forth?
- If they are moving, what allows these instruments to move the way they do?
- Does every object vibrate when it makes a sound?

**What we figure out**

- We need a sound source and a detector (ear & brain) to hear a sound. Sound travels from the sound source to our ear.
- There are wavy grooves on the record. The structure of the grooves causes the needle to be pushed in different directions as the record spins.
- After an instrument is struck or plucked and it springs back, it repeatedly change shape back and forth for a while (vibrates).
Disagreement emerges

Amelia: Yes, because um, you might be- not be able to hear a sound but when an object vibrates you can um, it does like make a sound.

Julio: Um I think that not everything vibrates when it makes a sound. ...because mostly things that make sounds are solids and some solids can be really sturdy and not move at all.

Oscar: I would think that there's like- when you hit it it doesn't change a lot but it still has a little vibration

Aaron: It's like kind of, it's like, um if you had a chain saw in the floor it's gonna crack, but if just people stomp on it I don't think it will [vibrate]. Like it could have a little cracks maybe.
How can motion help us investigate differences in sounds?

- Vibrating object
- Computer records how the distance between the stick and detector changes over time
- Motion detector (Initial distance from stick to detector = 0.5 m)
What patterns did students find in the graphs of the vibrations for louder vs. softer sounds?

**What students notice**

“It goes up then down, and repeats.”

“Over time high points decrease (in height) and low points increase (in height).” (...We learn that scientists refer to this distance as amplitude.)

“You can compare how far apart they are this way too.....” (...We learn that scientists refer to how far apart they are in time as frequency.)

“It looks like a lot of waves.”
## Five routines to support coherence

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 I help students *put together pieces* of the disciplinary core ideas and crosscutting concepts?**
Tools for using these routines to analyze, teach with, or develop storylines:
http://www.nextgenstorylines.org/tools/

Open-source storylines:
http://www.nextgenstorylines.org

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