Learning Progressions

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What is a learning progression?

- Taking a stance on what should develop
- Formulating detailed conjectures about typical pathways of learning
- Instantiating the design
- Conducting research both to test and to revise the design
What are the problems LPs address?

- Little agreement on the focus of science education
- Almost no longitudinal research to see how our “bets” pay off in the long term
- Undifferentiated lists of topics and skills
- Modular nature of educational experience -- little intentional building
Students who are proficient in science:

- Know, use, and interpret scientific explanations of the natural world;
- Generate and evaluate scientific evidence and explanations;
- Understand the nature and development of scientific knowledge;
- Participate productively in scientific practices and discourse
More on the four strands

- The four strands co-constitute each other
- Should be inseparable in education
- Need for students to learn science in the context of doing science
Learning Progressions
Principles

- Building ideas across time
- Unpacking ideas from a learning perspective
- Focus on linchpin ideas
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ECOLOGY 5: Trophic relationships between organisms can be diagrammed as a food chain, a linking of predators and prey.

THINK/REASONING 4: Build and evaluate scientific explanations based on evidence.

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**Scientific Explanation:**

**Scientific question:** Are spiders predators, prey, or both?

**Claim:** Spiders are both predators and prey.

**Evidence:**
1. Spiders are the prey of wasps.
2. Spiders are the predators of insects.

**Reasoning:**
Spiders are both predator and prey because a predator eats other animals and a prey is eaten by another animal.

**Concluding Sentence:**
Therefore, spiders are both predators and prey.

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**Hints:**
- Is the animal a predator, a prey or both a predator and prey?
- What animal is a spider prey for? For what animal is the spider a predator?
- What is the definition of a predator and a prey?
- Repeat your claim.
ECOLOGY 10:
Because many animals rely on each other, a change in the number of one species can affect many different members of the web.

THINK/REASONING 4:
Build and evaluate scientific explanations based on evidence.
Building Ideas Across Time

Major Features

- Intentional, systematic building
- Revisiting of ideas
- Demands assessment over multiple units and years and sensitive to early, intermediate, and more advanced conceptions
What are the payoffs if we do this?

- A cumulative history of the “lives of learners”
- Deep thinking and reasoning about science
- Empirical results illustrating places of growth “spurts” and “plateaus”
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Unpacking learning goals

Standards are not a learning model

Unpacking learning goals:
- Fidelity to the scientific ideas
- Consideration of learning and pedagogical concerns
- Where is the hidden complexity? How does this build on prior understandings? What does it mean to use this scientific idea?
Unpacking a scientific practice: Scientific Modeling

Engaging in the practice
- Construct model; use to explain or predict phenomena; evaluate the model; revise model.

Metamodeling knowledge: motivates and makes the practice meaningful
- Purpose of models (predict, explain); models as representations; criteria for evaluating and revising models (accuracy, generality, parsimony)
Scaffolding practice (Modeling water transport in plants, 4th grade)

Entrée to modeling: “a picture to help show someone how…”

Students incorporate findings from empirical investigations into revised models
Developing More Sophisticated Models (6th Grade)

Original Model: Smell as “waves of odor”

Revised Model: Smell as particles moving through space
Steps toward a progression of more sophisticated practice

**4th grade**
- Construct models to illustrate and explain
- Models generalized from instances, but still pictorial
- Evaluate models for accuracy and understandability

**6th grade**
- Construct models to explain abstract phenomena
- Models more schematic, focused on mechanism
- Evaluate models for fit with data, generality; realize need to revise model if cannot generate prediction
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Concepts That Act As Linchpins

- **Pivotal in learning and development**: the concepts lie at the hub of a broad network of concepts and beliefs in a domain.
- **Challenging**: students’ representations of concepts are often very different from those of current-day scientists and require careful nurturing.
- **Generative**: the concepts can help foster broadly useful expertise in measurement, mathematical representations, epistemology, and scientific methods.
Weight Is Pivotal For Learning About Matter

- For students, weight is the gateway to mass and, by extension, one of the foundations upon which their understanding of matter will be constructed.

- Weight has important quantitative and mathematical relations with other concepts: density, volume, gravity (acceleration), buoyancy, etc.

- Weight is an additive scalar quantity subject to basic arithmetical operations.
Weight Is Challenging

- Young students over-rely on sensory data. For young children weight is “felt weight”. Tiny things have no weight (and hence can have no mass). This will make it hard to accept the molecular theory of matter, according to which very tiny particles have weight (and mass).
- Young students have long learned (and been taught) to think of number as counting number. In order to grasp relations of proportionality involving weight, they need to understand that numbers and measures can themselves be ratios. They need to learn about rational numbers and measures.
- Mystery of infinitesimals & limits. Pieces of matter have correspondingly small weights and correspondingly small measures.
Learning about weight can help students understand the concept of *density*. [Without instruction, many students fail to differentiate weight from density.]

Weight provides a host of opportunities about *measuring*, *modeling*, and *using symbolic representations* (number-lines, mathematical notation, graphs, etc.)

Weight offers students examples where *sensory data and measurement data conflict*, introducing them to issues such as sensitivity, reliability, etc.
Learning progressions take a long-term view of learning that requires placing bets on the concepts and representations worthy of “major investments” in early stages of instruction.

These “bets” are based on careful analyses of:
1. science content and, even more significantly,
2. students’ evolving knowledge and representations of scientific phenomena.

Linchpin concepts should offer payoffs going well beyond the content: typically, they will usher in advances in students’ grasp of measurement, modeling, epistemology, and mathematical representation.

All learning progressions are works in progress that require mid-course adjustments based on research (basic as well as applied).
Synthesis
Virtues of Models

• About Something ("Content")
• For Some Purpose ("Inquiry")
• Accountable to Someone ("Community")
Developing Modeling

- Time Scale (History)
  - Microgenesis
  - Ontogenesis
  - Sociogenesis
- Disciplinary Practices/Learning Performances
  - Modeling/ Entrée for Children
  - Central Conceptual Structures/ “Unpacking”
- Linchpin Concepts
Modeling Growth (1-6)

Linchpin: Measure, Difference
- Physical Resemblance {Literal Similarity}
- Stretch to Representation of Change in an Attribute

Resources: Draw, Order
Linchpin: Ratio

Round 2
Fast Plant Growth

Day 7
April 22

Day 11
April 26

Day 13
April 28

Height of Round Two Fast Plants
(6 pellets fertilizer)

Days of Growing

Days of Growing

Peters Fast Plant Growth Chart
Linchpin: Distribution, Feedback Loop
Teacher Professional Development
Discussion