Scientific Analogical Modeling Capabilities of Third-Grade Students

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Analogical Modeling: a Crucial Part of Learning Science

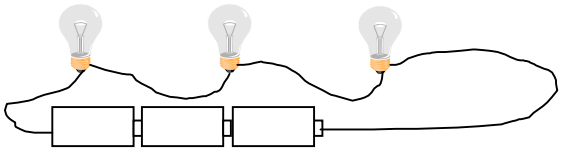
Analogical modeling –
using and refining functional analogies to tangible, everyday phenomena to understand the mechanisms of a system.

Allows the application of everyday knowledge and experience to new concepts.

Previous "Modeling" at AAPT

"Modeling" like Scherr et al. (AAPT 125).

College students modeling electric circuits with analogies to water, traffic, etc.



like ?

or

?

Students had a lot of difficulty - resistant to idea and didn't consider it physics.

Different than:

"Modeling" (Hestenes et al. mathematical modeling) or "Mental Models" (Zollman, others, conceptual models.)

Analogical Modeling in Elementary Grades

- Harlow and Otero (AAPT 127) - third-graders' conceptual models of electricity similar to college students'.

- Very few studies describing young children's explicit use of *analogical* modeling.

- **Absent** from elementary education in the *National Science Education Standards*.

Research Questions

- Are young children not yet capable of this kind of sophisticated inquiry activity?
- What *will* they do if asked to develop analogical models?
- What kind of expertise and difficulties do they show?
- What kinds of things help facilitate good modeling process? (Curriculum, environment, …)
- What can this tell us about the capabilities and difficulties that older students have?

Characteristics of Good Modeling Process

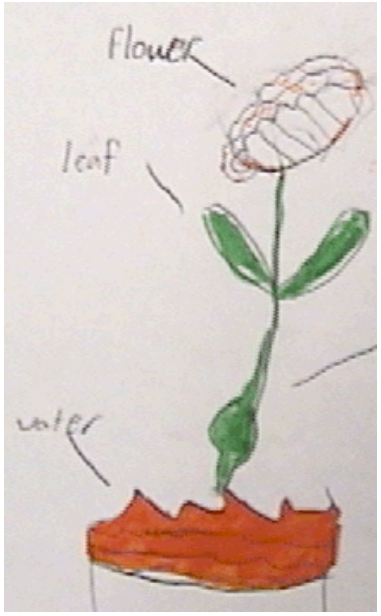
Good modeling process includes:

1. **Creativity** inventing and refining models.
2. **Using common sense**, everyday knowledge.
3. **Seeking consistency** - trying to account for *all* observations with a single model
4. **Being critical of models**, challenging yourself and others to follow *implications* of ideas.
5. Continuously **refining models.**

Modeling

Example in 3rd-grade:

- How does a carnation sitting in colored water change the color of its petals?



- Is it like a sponge, a straw, or something else, and *how*?

1.Creativity

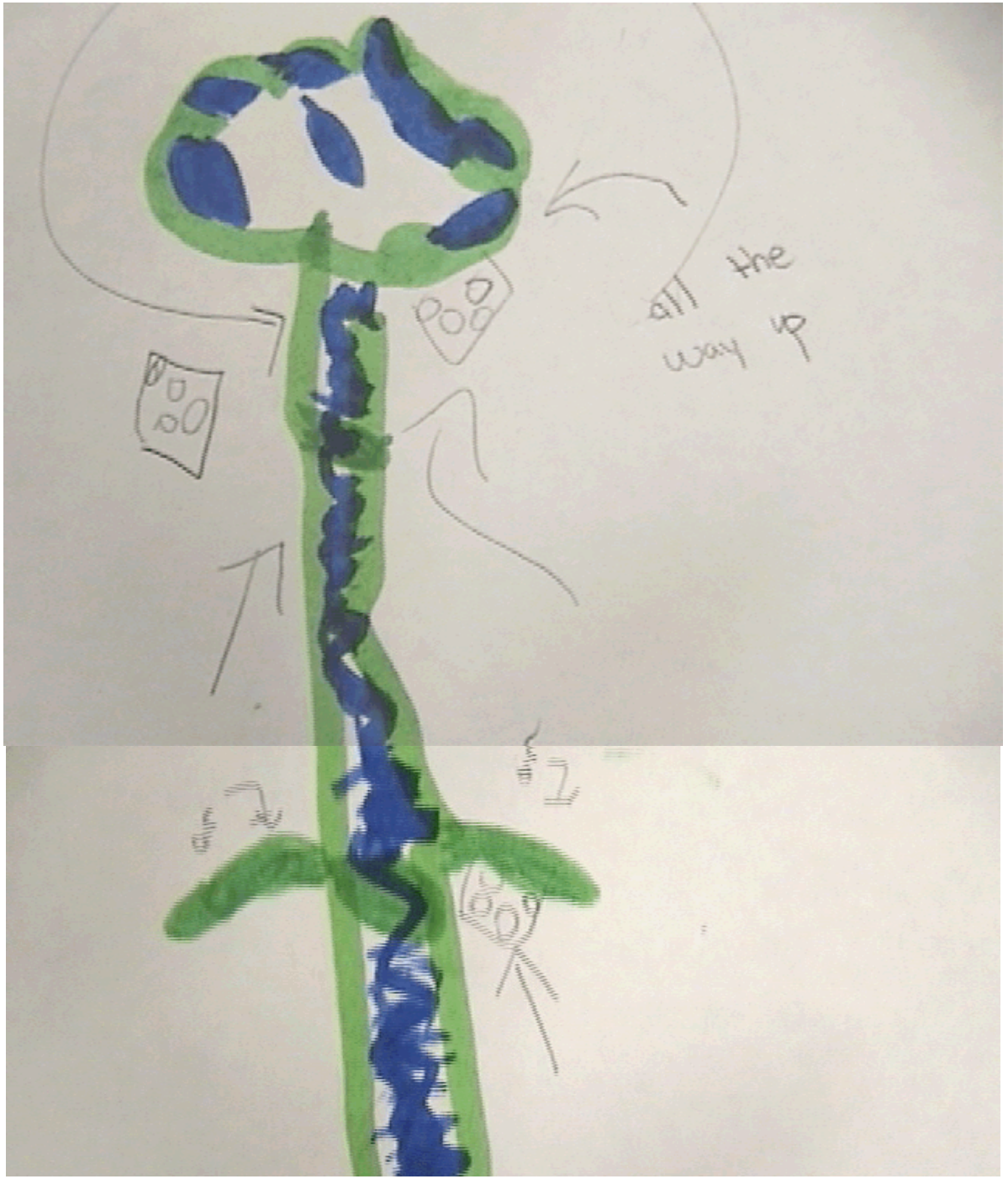
Part sponge, part paper towel,

A straw,

Many sponges,

A tree,

An elephant.



2. Using everyday knowledge.

Most of the children seem clear that this was important.

They are adamant that
no imaginary or magic objects are allowed.

2. Using everyday knowledge.

Connor: On *The Simpsons*, there's this bounty paper towel…

Julian: We're not talking about the…

Connor: I know it's, it's an analogy, and when you… take it up, you just

Julian: I remember that one, but we're not supposed to be talking about The Simpson's thank you very much

...

Connor: No, no! Special paper towels from *the Simpsons*!

Julian: No, not special. That is not a special flower.

Connor: That is not a special paper towel either. It looks like a flower.

Kathryn: Excuse me. Connor, excuse me. But I don't think- This is not like *The Simpsons*. We are real people.

3. Consistency

The children are careful to account for *all* observations.

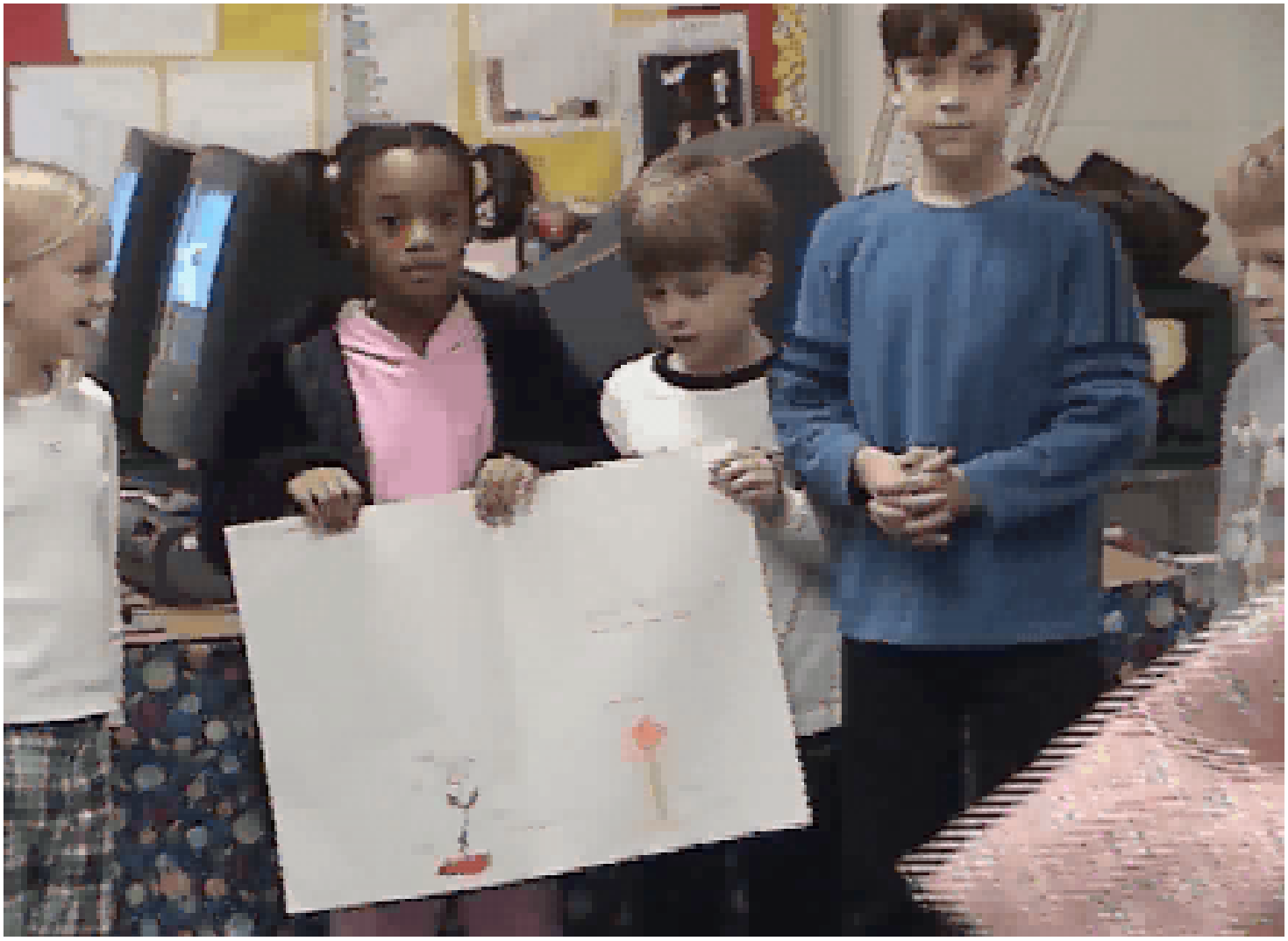
- **Distribution of color:** The petals change color, but the stem doesn't.
- **Timing:** The process takes a long time - several days.
- **Continuity**: The process seems to be continuous.

Consistency

Accounting for:

Petals changing color,

but not stem.



The stem stays the same color like the sponge because the sponge can't really get stained.

The top, which is white - usually the color of the water would take over the top. That's the same thing with the paper towel.

Consistency

Accounting for:

timing of staining (must be slow);

and continuity of process.

Now a straw doesn't absorb. I actually think that a straw doesn't absorb water at all. Unless there's an air hole at the top of that flower that has air sucking up.

4. Critiquing Each Other.

The children press each other strongly for consistency and mechanism.

Critiquing

Do you have a mechanism, and how does it work?

Kathryn: I have a question. Are you using like a straw or a sponge, or is it just a flower? Like to suck up?

?: It's kind of like a sponge. We were thinking like a sponge.

Kathryn: Oh.

5. Refining

The children use each other's ideas and insights to refine their models in response to critiques.

Ex. Series of squeezing/splattering sponges solves single sponge continuity problem.

Conclusions

Children already possess many of the skills necessary for analogical modeling and can exhibit considerable expertise and sophistication in their *first attempts!*

Implications for Elementary Education

➡ Much of elementary science education should involve the **encouragement, nurturing, and refinement** of children's *pre-existing* capabilities.

➡ **Being able to recognize these capabilities** is crucial.

Implications for Secondary and Higher Education

➡ High school and college students *also possess* these capabilities.

➡ Difficult to encourage *if skills unused for many years* and *if they have learned a narrow approach to science learning.*

➡ Curriculum focus - reactivation, encouragement, refinement.

Thank you.