# Developing a Learning Progression for Scientific Modeling: Making Scientific Modeling Accessible and Meaningful for Learners

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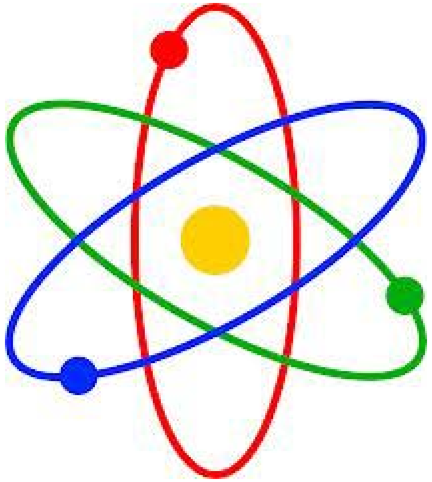
Future: Work with a group of people with same beliefs: technology should make things easier not harder

- What is the paper about ?

- How is it relevant to Computational Thinking

This paper is about



Scientific modeling
Learning progression

# Annotation paragraph

The paper is good starting point for understanding modeling and its implications. The findings of the paper defines 4 levels of use of models as generative tools for explaining and predicting and another 4 levels which shows the differences between changes in models as understandings improve.

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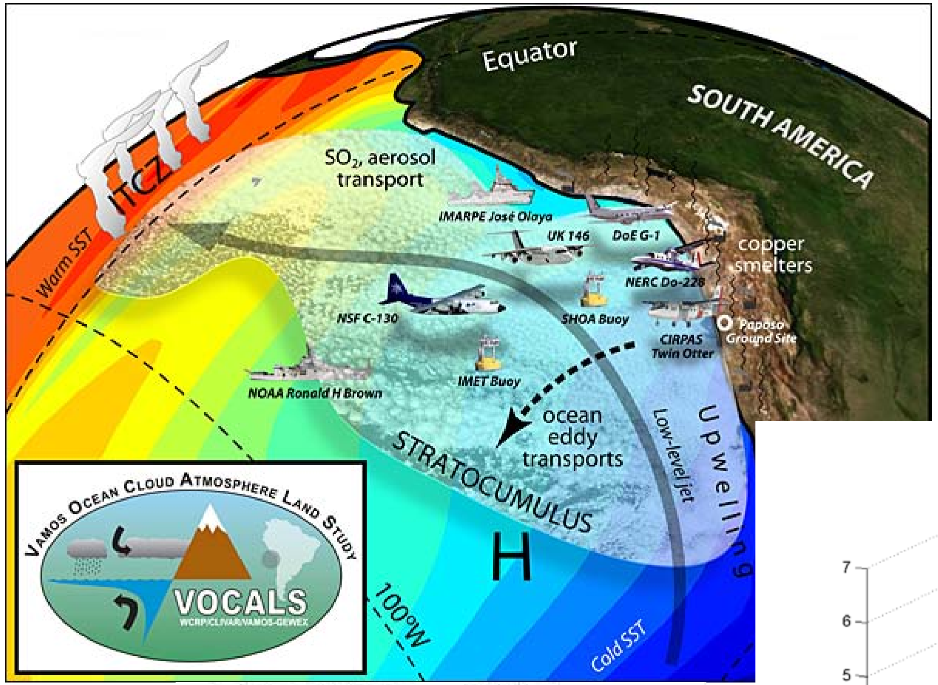
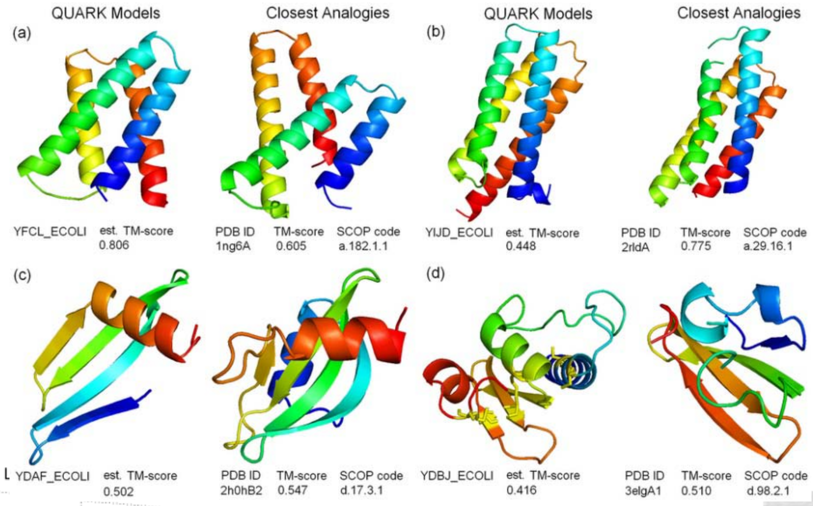
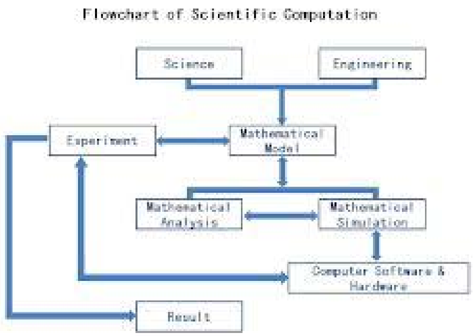
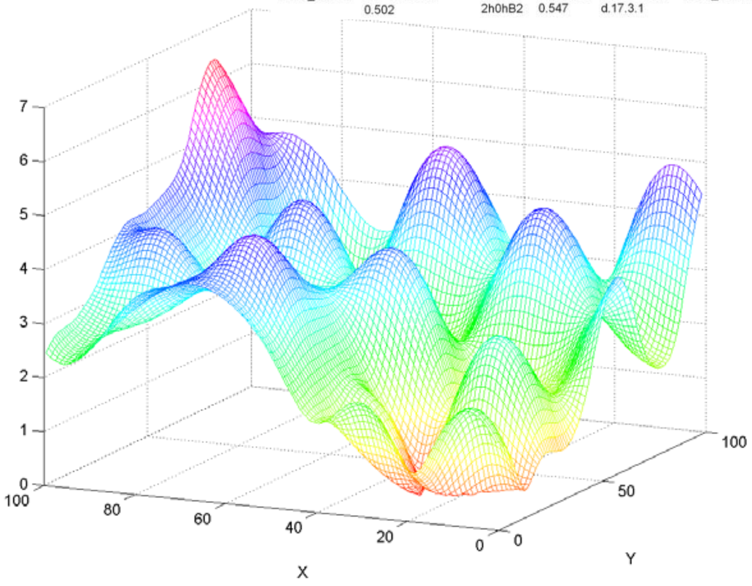
# Scientific Modeling is…..

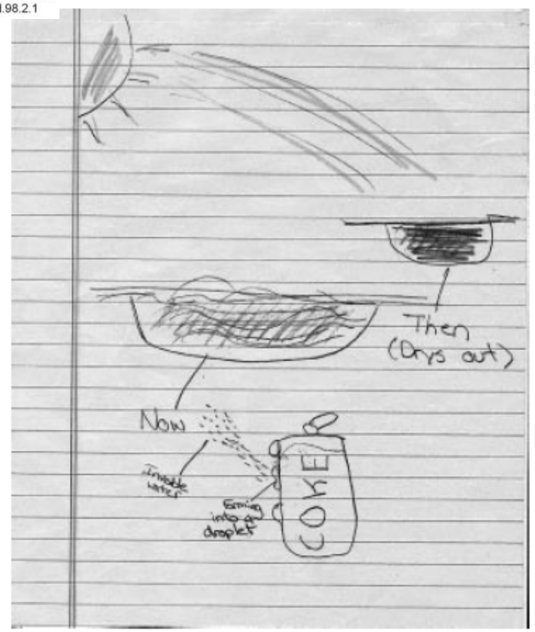


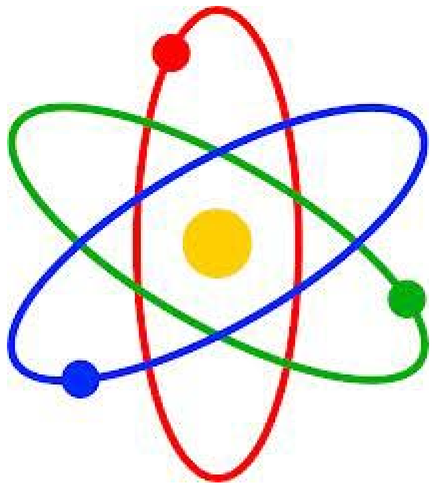




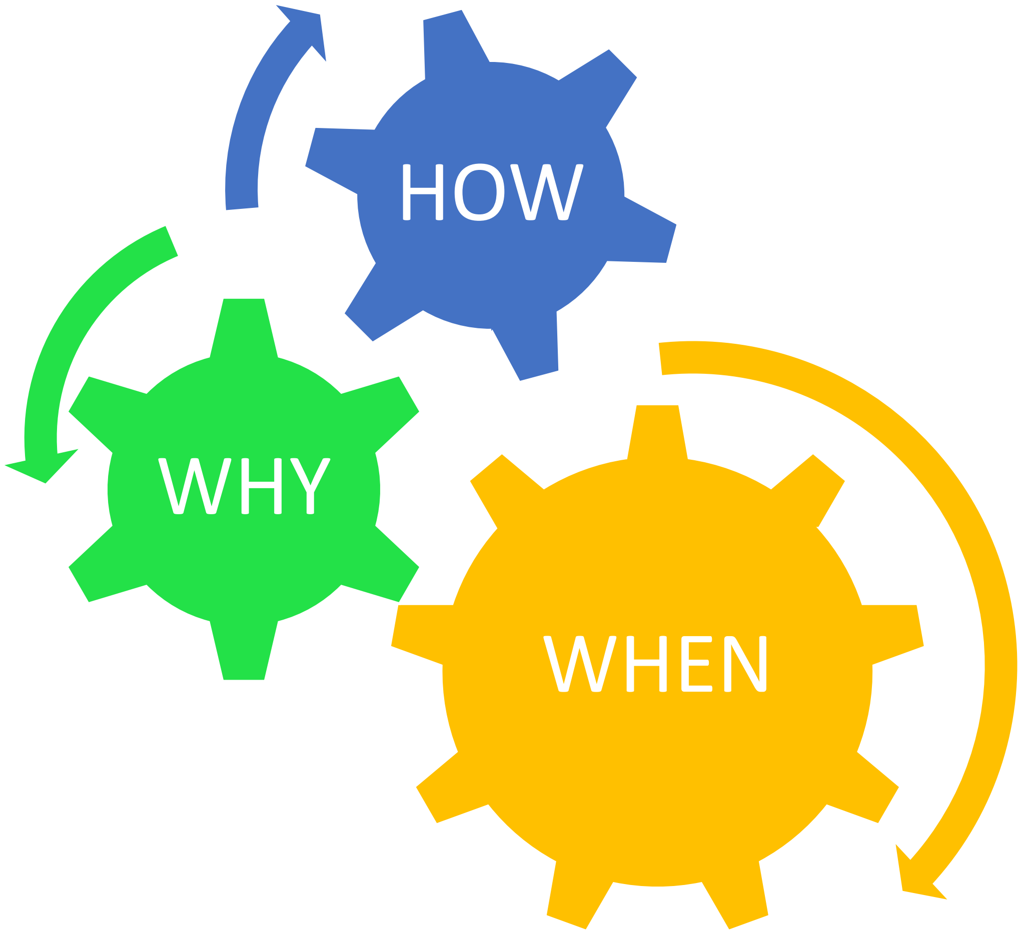
# What is scientific modeling ?

1. Abstracts
2. Simplifies a system
3. Focuses on key features
4. Explain
5. Predict



*scientific phenomena*

# Learning progression




# This paper investigates the following questions

1. What aspects of modeling practice can be made meaningful and productive for science learners?

2. What successes and challenges emerge when students engage in modeling practices?

# The framework used

Integration of

- metamodeling knowledge and elements of the practice
- sensemaking and communicative aspects of the practice

# What is metamodeling knowledge ?

1. how models are used
2. why they are used
3. what their strengths and
4. limitations

For this study “the practice of modeling” means

1. Students *construct* models consistent with prior evidence and theories to illustrate, explain, or predict phenomena.
2. Students *use* models to illustrate, explain, and predict phenomena.
3. Students *compare* and evaluate the ability of different models to accurately represent and account for patterns in phenomena, and to predict new phenomena.
4. Students *revise* models to increase their explanatory and predictive power, taking into account additional evidence or aspects of a phenomenon.

Table 1
*Candidate components of metamodeling knowledge for a learning progression for modeling*

| |
|---|
| Nature of models |
| Models can represent non-visible and non-accessible processes and features |
| Different models can have different advantages |
| Models are representations that have limitations in what they represent about phenomena |
| Models can be changed to reflect growing understanding of the phenomena |
| There are multiple types of models: diagrams, material models, simulations, etc. |
| Purpose of models |
| Models are sense-making tools for constructing knowledge |
| Models are communication tools for conveying understanding or knowledge |
| Models can be used to develop new understandings, by predicting new aspects of phenomena |
| Models are used to illustrate, explain, and predict phenomena |
| Criteria for evaluating and revising models |
| Models need to be based on evidence about the phenomena |
| Models need to include only what is relevant to their purpose |

# Sensemaking and communicative aspects of the practice

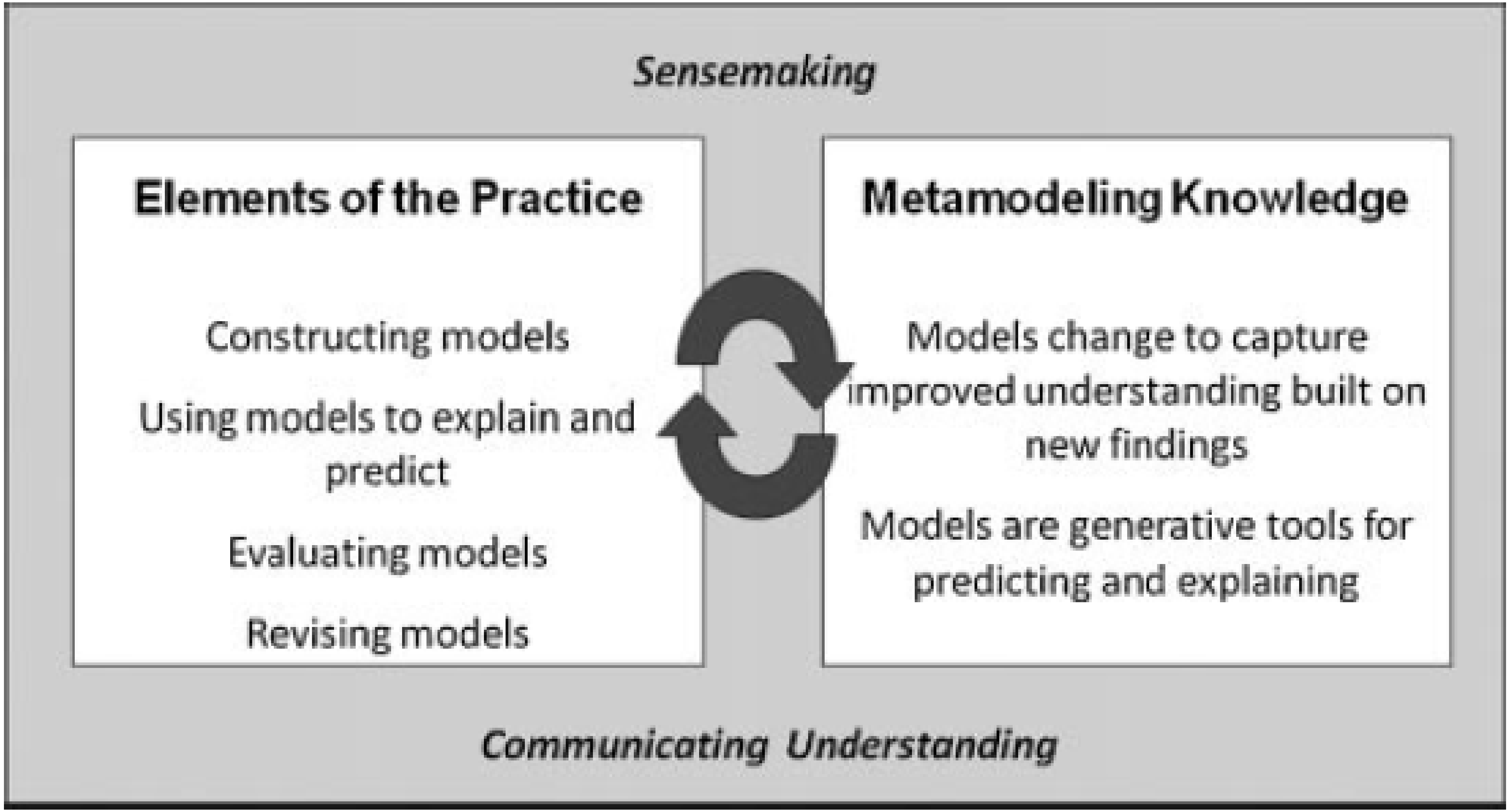
## Sensemaking

- for themselves
- to try to understand a phenomenon
- articulating their understanding as an expressed model to help
- clarify their thinking and
- develop group consensus

## Communicative

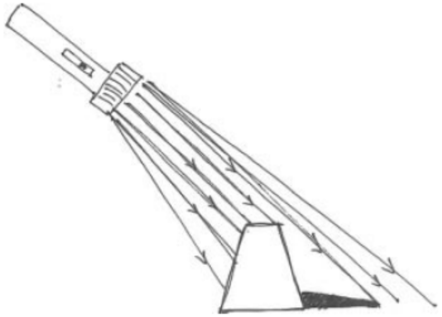
- the learners are at the point where they are readyto share their ideas with others,
- articulating their model to see if others agree
- try to persuade others or help

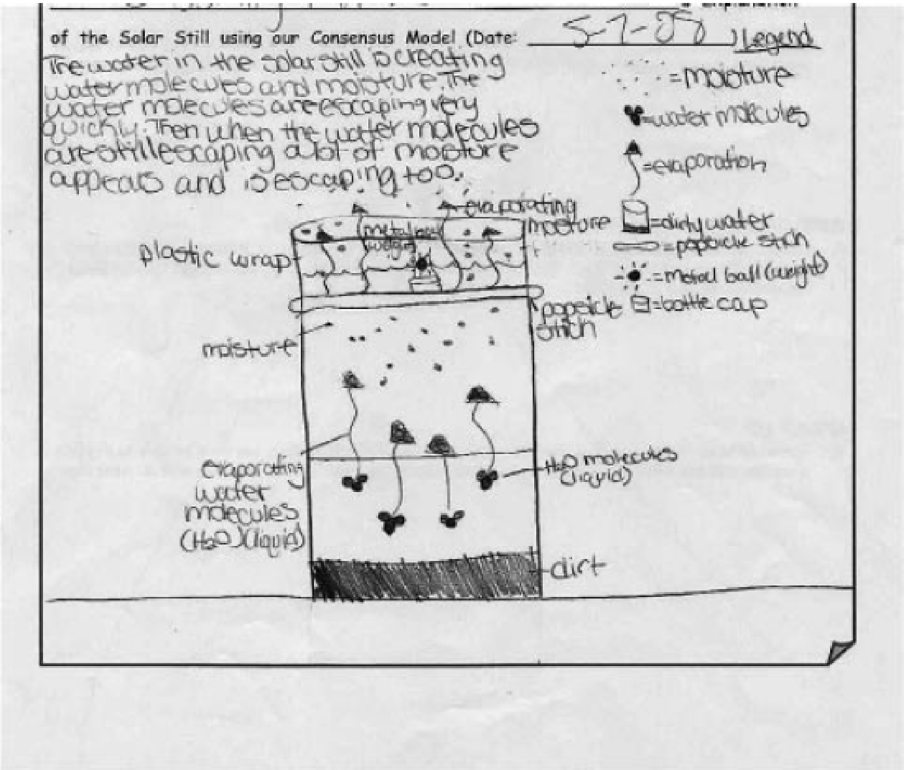
them understand the phenomena.


Sensemaking
Elements of the Practice
Constructing models
Using models to explain and predict
Evaluating models
Revising models
Metamodeling Knowledge
Models change to capture improved understanding built on new findings
Models are generative tools for predicting and explaining
Communicating Understanding

# How ?

- 5th and 6th grades students
- Modeling evaporation and condensation phenomena, Can I believe my eyes? How can I smell things from a distance?
- Focus group interviews by the researchers





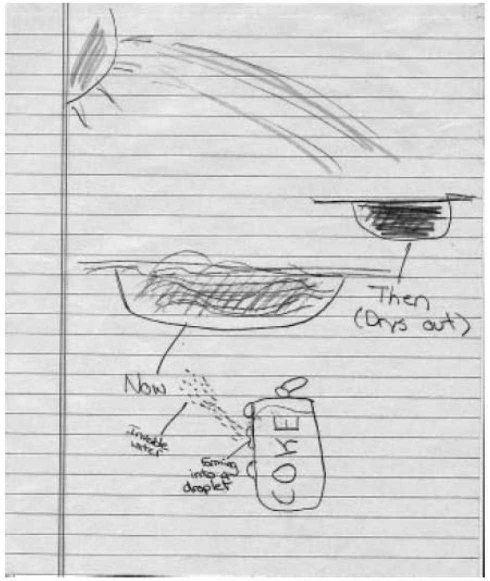




*Figure 3.* A 5th grade student's pre-interview evaporation and condensation model.

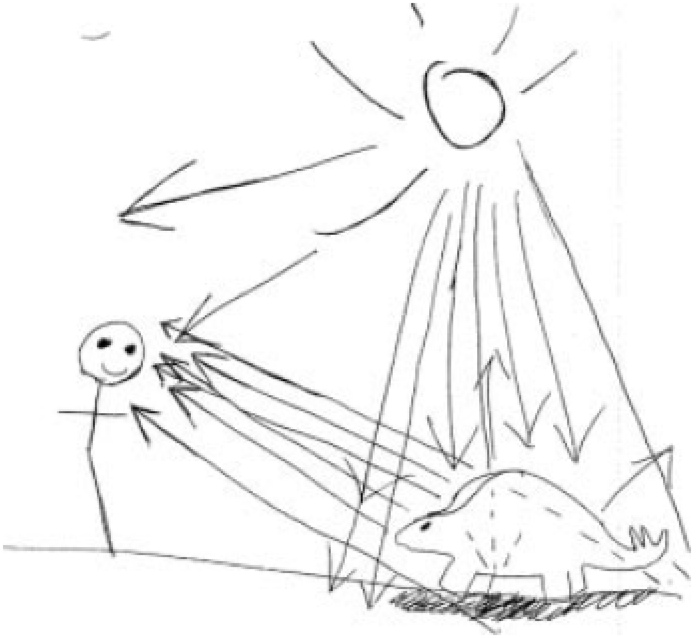


Table 2
*Instructional modeling sequence for elementary curriculum materials*

| Sequence | Description |
|---|---|
| Anchoring phenomena | Introduce driving questions and phenomena for a particular concept. Use a phenomenon that may necessitate using a model to figure it out. |
| Construct a model | Create an initial model expressing an idea or hypothesis. Discuss purpose and nature of models. |
| Empirically test the model | Investigate the phenomena predicted and explained by the model. |
| Evaluate the model | Return to the model and compare with empirical findings. Discuss qualities for evaluation and revision. |
| Test the model against other ideas | Test the model against other theories, laws. |
| Revise the model | Change the model to fit new evidence. Compare competing models, and construct a consensus model. |
| Use the model to predict or explain | Apply model to predict and explain other phenomena. |

# What are the differences ?

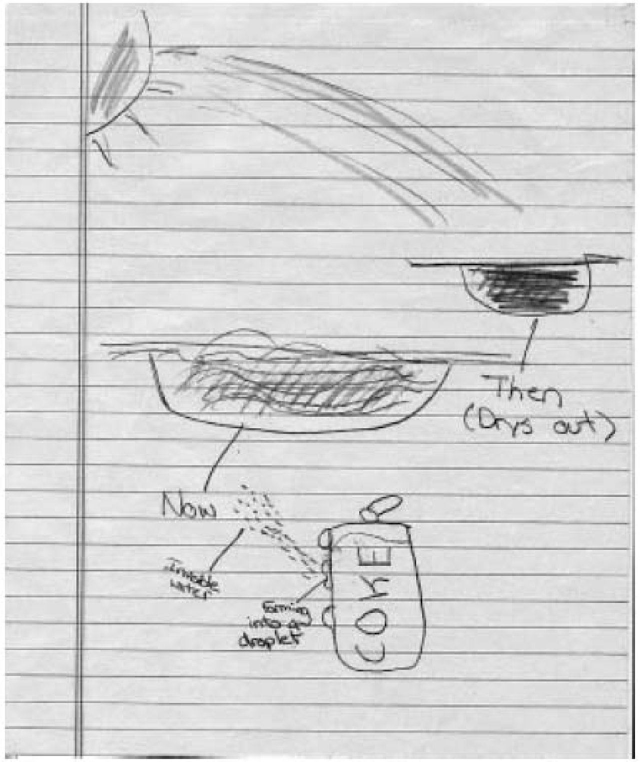



*Figure 3.* A 5th grade student's pre-interview evaporation and condensation model.

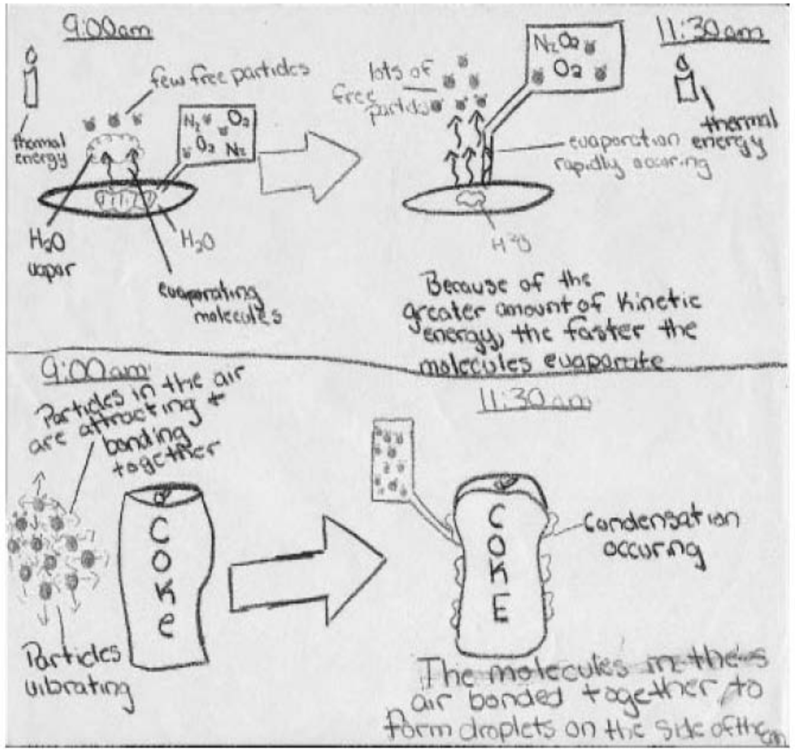



*Figure 5.* A 5th grade student's post-interview evaporation and condensation model compared to the pre-model in Figure 3.

# Results

- Models as Generative Tools for Explaining and Predicting
- Models Change as Understandings Improve

Table 3

*A learning progression for understanding models as generative tools for predicting and explaining*

| Level | Performances |
|---|---|
| 4 | Students *construct and use models spontaneously* in a range of domains to help their own thinking. |
| | Students *consider how the world could behave according to various models*. Students construct and use models to generate new questions about the behavior or existence of phenomena. |
| 3 | *Students construct and use multiple models to explain and predict more aspects of a group of related phenomena.* |
| | Students view models as tools that can support their thinking about existing and new phenomena. Students consider alternatives in constructing models based on analyses of the *different advantages and weakness* for explaining and predicting these alternative models possess. |
| 2 | *Students construct and use a model to illustrate and explain how a phenomenon occurs*, consistent with the evidence about the phenomenon. |
| | Students view models as a *means of communicating their understanding of a phenomenon* rather than a tool to support their own thinking. |
| 1 | *Students construct and use models that show literal illustrations of a single phenomenon.* |
| | Students do not view a model as tool to generate new knowledge, but do see models as *a means of showing others what the phenomenon looks like.* |

Table 4

*A learning progression for understanding models as changeable entities*

| Level | Performances |
|---|---|
| 4 | *Students consider changes in models to enhance the explanatory power prior to obtaining evidence* supporting these changes. Model changes are considered to develop questions that can then be tested against evidence from the phenomena. |
| | Students evaluate competing models to *consider combining aspects of models* that can enhance the explanatory and predictive power. |
| 3 | *Students revise models in order to better fit evidence that has been obtained and to improve the articulation of a mechanism in the model*. Thus, models are revised to improve their explanatory power. |
| | Students compare models to *see how different components or relationships fit evidence more completely and provide a more mechanistic explanation of the phenomena*. |
| 2 | *Students revise models based on information from authority (teacher, textbook, peer) rather than evidence gathered from the phenomenon or new explanatory mechanisms.* |
| | *Students make modifications to improve detail, clarity or add new information*, without considering how the explanatory power of the model or its fit with empirical evidence is improved. |
| 1 | *Students do not expect models to change with new understandings*. They talk about models in absolute terms of right or wrong answers. |
| | Students compare their models to assess, if they are *good or bad replicas of the phenomenon.* |

# Where do you see Computational Thinking ?

Or

# Elements of Computational thinking ?

- The definition of scientific modeling
- The learning progression
- The way it has been assessed
- Can computational thinking help students to model better ?

Thank you