Investigating the relationship between scientific modeling and content knowledge development

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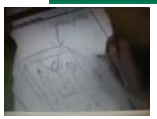
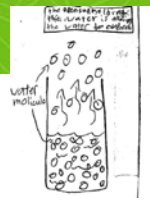
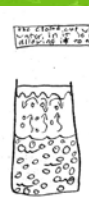
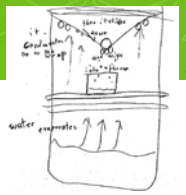








Project Overview

Research Questions

We are investigating the relationship between scientific modeling practice the underlying content knowledge. Our research question is:

• How do students' modeling practices and content knowledge progress when learning science through a model based unit?

Methods

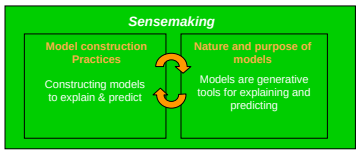
Participants:
- Three teachers in three Michigan public schools piloted our unit: one urban and two suburban schools.
- 95 fifth grade students from those teachers' classes.

Curriculum material:
- A 6-week unit centered around model teaching and learning of evaporation and condensation.

Data source:
- Students' pre/post written assessments.
- Students' notebooks.
- Thirteen Post clinical interviews at the end of the unit.

Data analysis:
- An initial coding rubric based on the identified patterns within students' responses.
- Coding a small randomly selected sample of students' responses using the initial rubric in an iterative process to revise the rubric.
- Using the revised coding rubrics to code all responses.
- Analyzing students' written responses both quantitatively and qualitatively.

Learning progression of Scientific Modeling



•A **scientific model** is an abstract, simplified, representation of a system of phenomena that makes its central features explicit and visible, and can be used to generate explanations and predictions.

• **Scientific modeling** includes the elements of the modeling practice (constructing, using, evaluating and revising scientific models) and the meta-modeling knowledge that guides and motivates the practice.

• **Reflection of nature and purpose of models** include people's understanding of the nature, utility, and evaluation of models, their understanding of the process of modeling, and how this understanding is used in their reasoning with models.

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Results

Content knowledge about evaporation and condensation

Students made significant improvement on the pre/post content-oriented questions.

Written assessment Question 1: After you take a cold Coke can from a refrigerator, you notice that the outside of the can is wet. Your father says that it is wet because the can was sweating, and the Coke inside the can came through the can. What do you think about his explanation? Explain your thinking. (familiar context)

Categories	Pretest (%)	Posttest (%)	Example responses in each category
Correct	17	37	"I think its incorrect, what really happened was condensation, the warm water water vapor outside clung to the cold can."
Partial correct	51	49	"I know that the coke doesn't come out, I know that when its cold the water forms around the can. Then when its hot the water unfreezes."
Incorrect	31	13	"yes because he left it there and it was hot and went through the can"

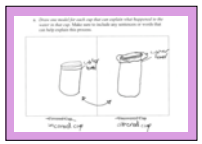
Written assessment Question 2: Explain what may happen to a color marker that was left uncovered for a week using one of the model you drew about open or closed cup. (new context)

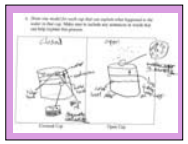
Categories	Pretest (%)	Posttest (%)	Example responses in each category
Correct	12	31	"Because it's just like a uncovered marker it starts to dry up and it evaporates."
Partial correct	40	41	"When you leave a colored marker with it's top off for a week the marker dries up because the moisture leaks out and dissolves."
Incorrect	39	18	"the ink is gone".

Model constructing practices

Students' model construction practices generally improved from level 1 to level 2

Written assessment Question 3: Draw a model for a covered and an uncovered cup to explain what happened to the water in the cup.





In the first model of the cup the student just shows the cup and water level. In the second model, there are more unobservable characteristics like the dots in the air and microscopic molecules.

Level	Level description for generative construct map	Representations included in the model	Pretest (%)	Posttest (%)
2	*Students construct a model to illustrate and explain how a phenomenon occurs*, consistent with the evidence about the phenomenon.	Arrows showing direction of evaporation or condensation	26	36
		Mentions or shows change over time	12	26
		Mentions or shows change of scale (e.g. magnifying glass)	2	12
		Describes mechanism or process of water (e.g. water spreading out)	27	41
		Dots or particles as water vapor in air	21	42
		Describes conditions under which evaporation or condensation occurs	0	3
1	*Students construct models that show literal illustrations of a single phenomenon.*	Only include observable characteristics (did not include any unobservable characteristics above) and do not explain how the phenomenon occurs	16	8

Reflection on the purpose and nature of models

We did not find significant gains in students' reflection of nature and purpose of modeling. At the end of the unit, the majority of students remained at level 1 or 2.

Written assessment Question 4: Why do you think the two drawings are called models? (Nature of models)

Level	Level description for students' responses	Pretest (%)	Posttest (%)
2	Students view models as *means of communicating their understanding of a phenomenon* rather than a tool to support their own thinking.	15	17
1	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*.	71	74

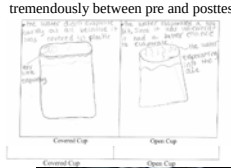
Note: a small percentage of students gave unintelligible responses so the total percentages add up to less than 100%.

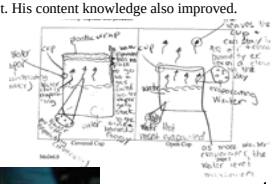
Interview Question: What's the purpose of models?

Level	Level description for generative construct map	*Interview responses at each level*
3	Students view models as tools that can support their thinking about existing and new phenomena.	*"We used models to understand objects, what it does, how it helps and it also helped us out, like if we showed our models to someone else, we could give them more ideas and when they showed it to us it gave us more ideas so we could improve our models. We just used them in all different ways. Helping others, just understand it more, kind of looking at it, all of if just helped."*
2	Students view models as *means of communicating their understanding of a phenomenon* rather than a tool to support their own thinking.	*"Probably just how it makes things more clear and easier to understand. That's the main reason, I think".*
1	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.*	*"Something somebody makes of a different size of something – a different……'cause it's like making something, but in a different size. For example, this car is a toy car that you play with and a real car is something that you don't play with"*

Relationship between three aspects

Example: Student KP has the most sophisticated understanding of nature and purpose of models among all interviewees. His evaporation model changed tremendously between pre and posttest. His content knowledge also improved.





❖Quantitative analysis:
- ➢Significant correlations between students' gains on model construction items and gains of content knowledge items, and between gains for model construction practice items and gains for items on the reflection about nature and purpose of models
- ➢No significant correlation between their gains of reflection on nature and purpose of models items and gains on content knowledge items

❖Qualitative analysis:
- ➢Some students progressed in all three aspects
- ➢Some students gained content knowledge, modeling practices, but not in reflection on nature and purpose of models

Conclusions

- ❖ **Content knowledge** – students made considerable improvement in understanding of evaporation and condensation
- ❖ **Model construction practice –** some students shifted from level 1 to level 2
- ❖ **Reflection on purpose and nature of models –** students remained at level 1 or level 2. Students focused on models as communicative tools rather sense making tools to progress their own thinking.
- ❖ **Conclusion** – students' reflection on nature and purpose of models was not strongly related to their progress in content knowledge.
- ❖ **Our Explanation –** the curriculum materials and assessment may not have provided enough opportunities to reflect on purpose of nature of models.
- ❖ **Continuing work –** We are working in an iterative process to revise assessment and curriculum and test them a second time.