Instructional Scaffolds to Shift Students' Epistemic Evaluations toward the Scientific

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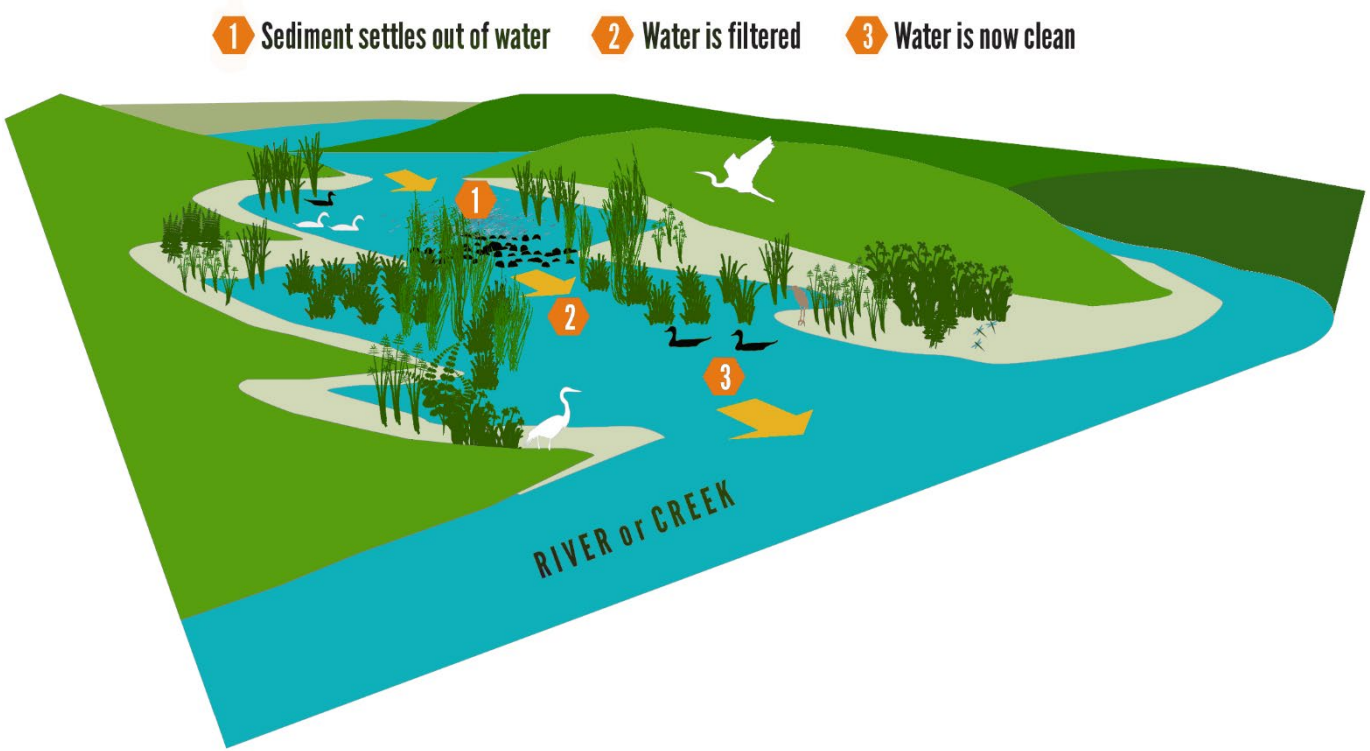

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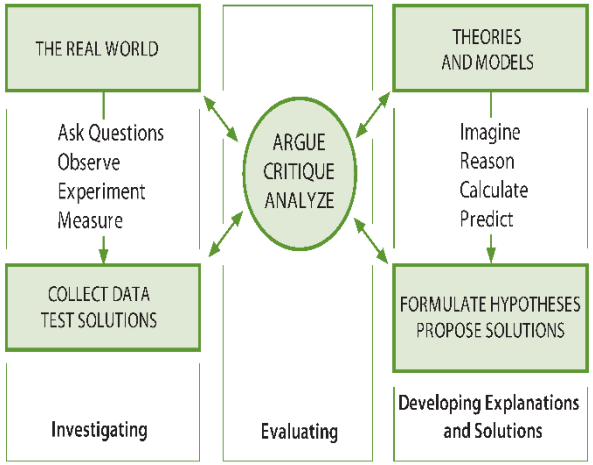
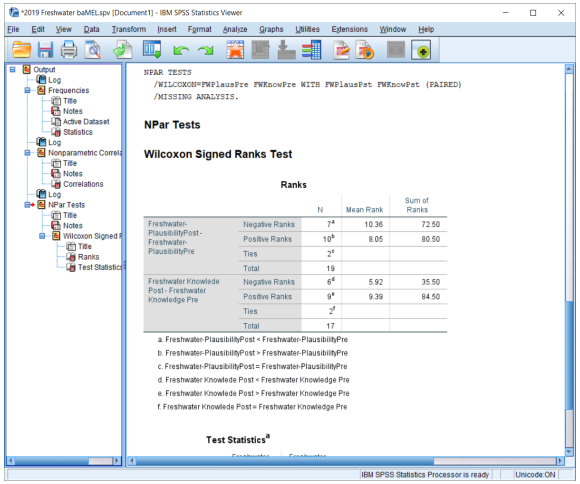
This presentation will overview our recent research about students' understanding of socio-scientific topics



Theoretical and empirical foundations



Our present studies

Implications and the road ahead

Pressing and complex local and global challenges requires increased scientific literacy…

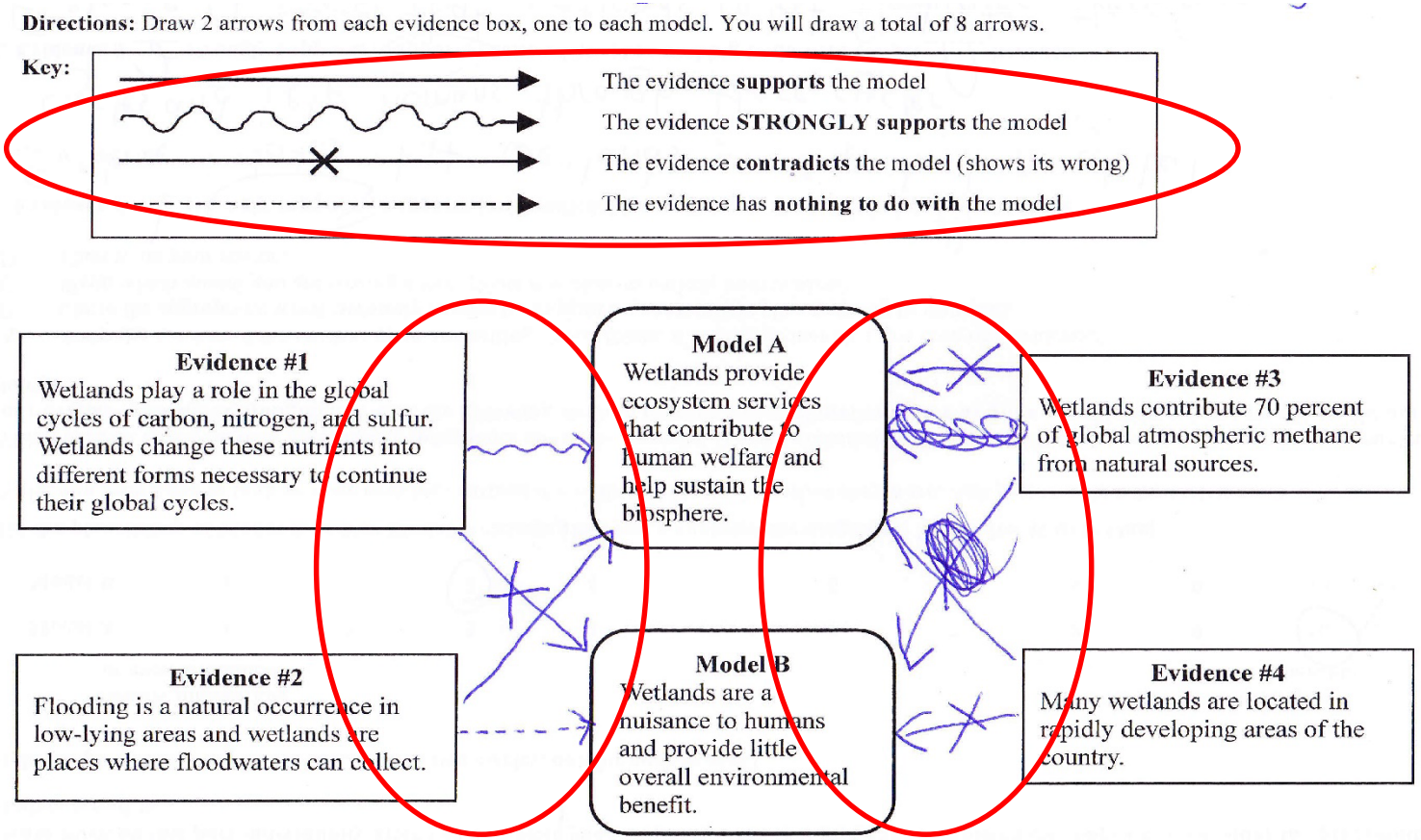
…and to deepen scientific literacy, students must understanding both (a) what scientists know and (b) how scientists come to know what they know

However, students may find scientific explanations to be implausible

Epistemic judgments (e.g., plausibility) may be formed through automatic cognitive evaluations with little purposeful thinking (Lombardi et al., 2016)

Classroom instructional scaffolds can help make students' evaluations explicit, thoughtful, & scientific

Chinn & colleagues (2012, 2014)

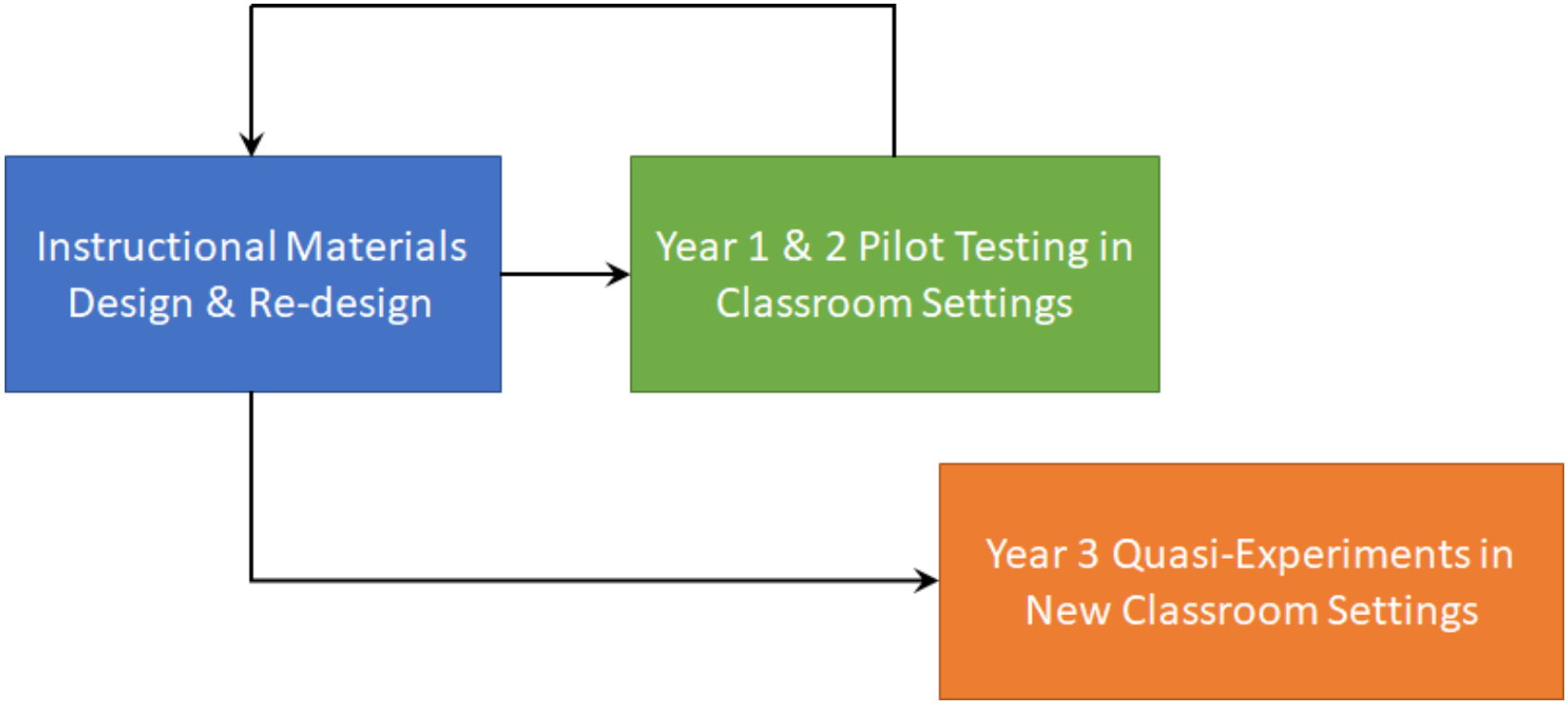


Example of student completed Model-Evidence Link (MEL) diagram

More critical evaluations may also promote students' reappraisal of their initial plausibility judgments & knowledge reconstruction (Lombardi et al., 2016)

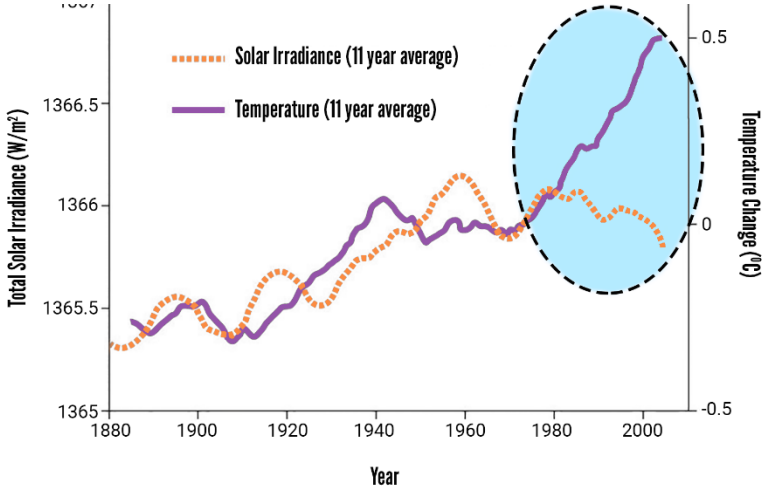
Our projects investigate students' evaluations, plausibility, & knowledge about socio-scientific topics

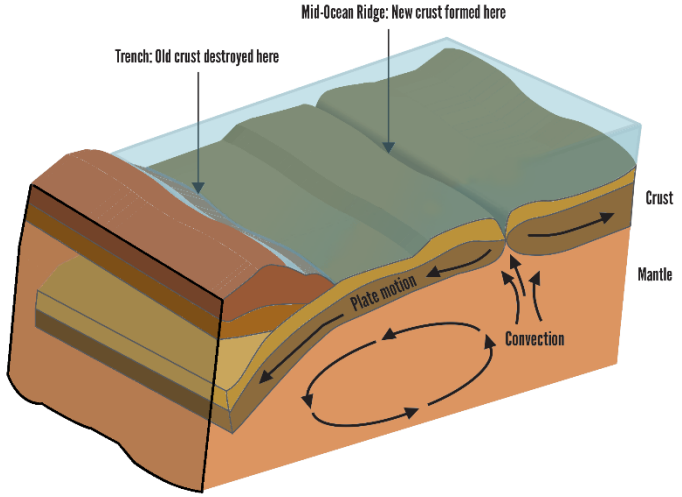
Schematic of our first research project (2013-2017)



Secondary students experienced repeated instruction about socio-scientific topics during a full school year

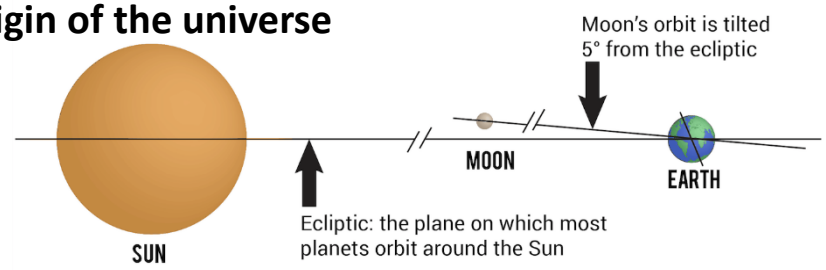
Causes of current climate change & connections to extreme weather events

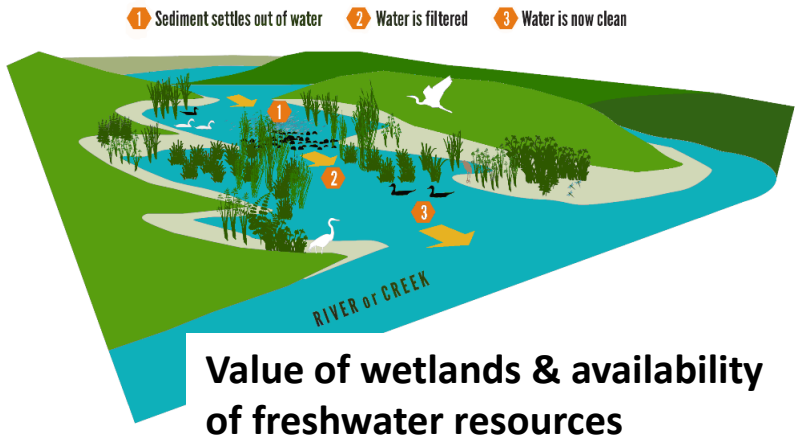




Hydraulic fracturing & earthquakes

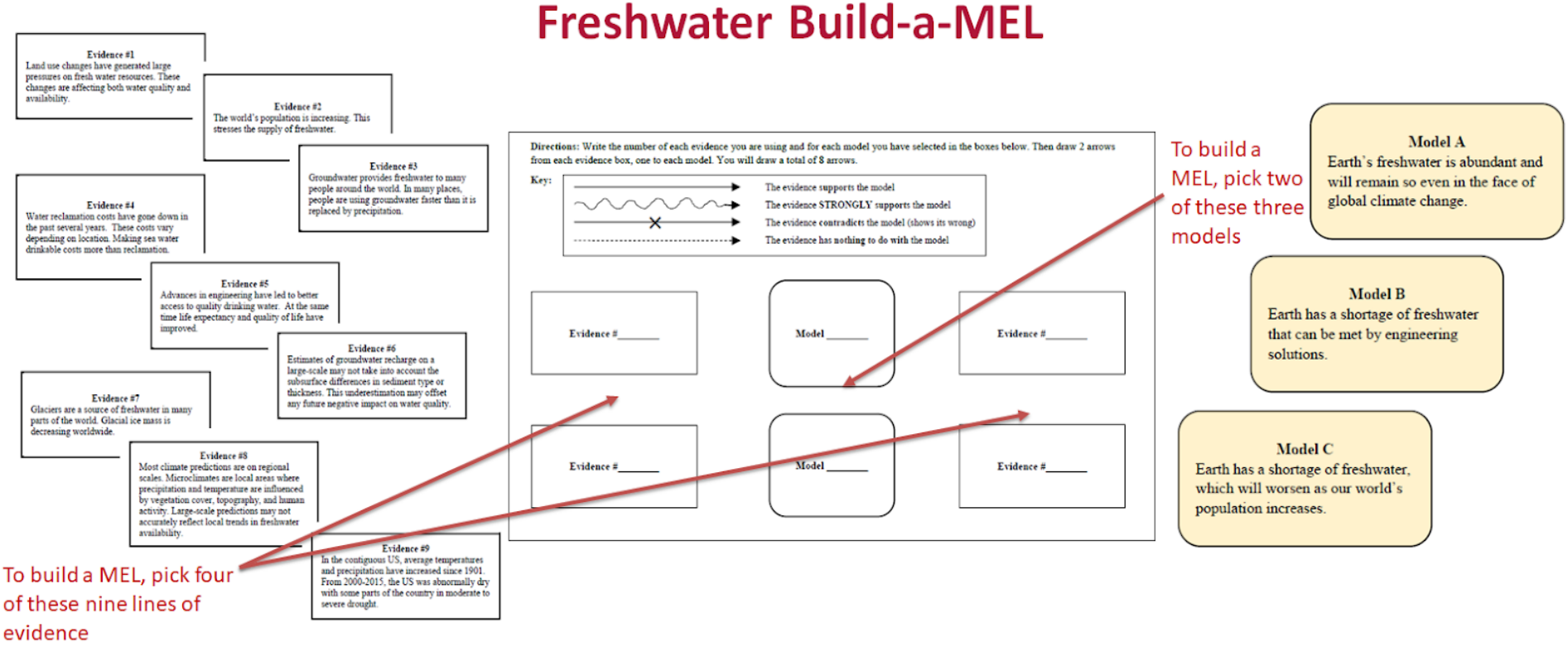
Formation of the Earth's Moon & origin of the universe





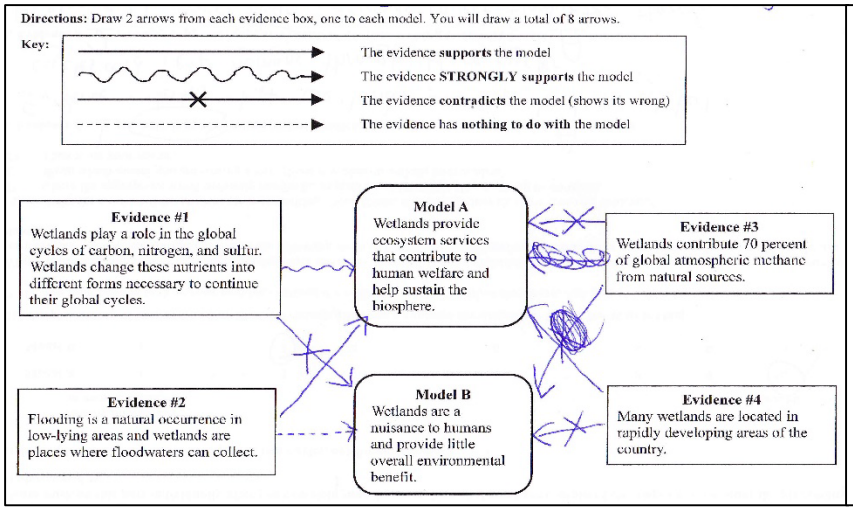
Value of wetlands & availability of freshwater resources

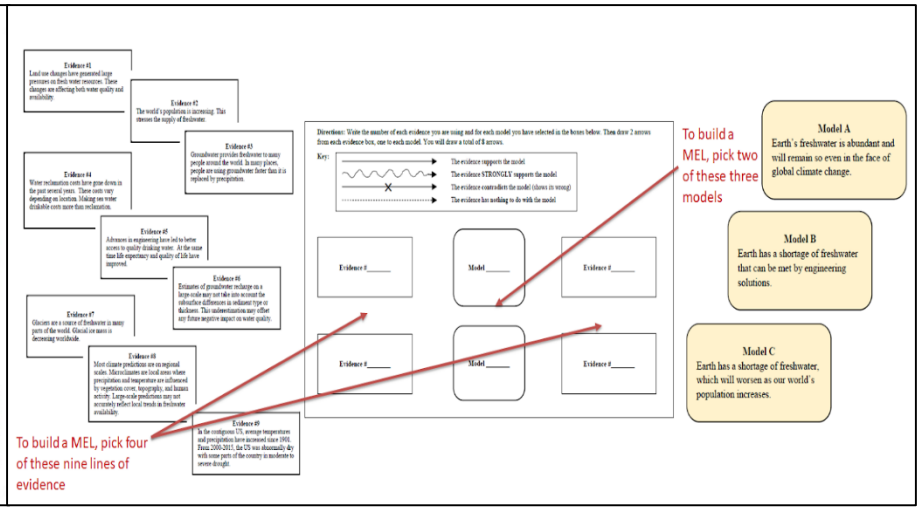
Our current project examines scaffolds with the potential to increase students' conceptual agency



Students who exercise conceptual agency are authors of their own contributions, accountable to the classroom learning community, and have the authority to think about and solve problems (Nussbaum & Asterhan, 2016; Pickering, 1995)

Study 1 compared students' learning between the two types of MEL activities





H: the build-a-MEL would result in greater levels of evaluation, scientific shifts in plausibility, & increased knowledge about water resources than the preconstructed-MEL

N **= 76 grade 6-12 students at two different schools, 1 in Georgia & 1 in New Jersey**

All students completed a written explanation task after completing their diagram or table

Provide a reason for three of the arrows you have drawn. **Write your reasons for the three most interesting or important arrows.**

A. Write the number of the evidence you are writing about.
B. Circle the appropriate word (**strongly supports | supports | contradicts | has nothing to do with**).
C. Write which model you are writing about.
D. Then write your reason.

1. Evidence # 1 **strongly supports | supports | contradicts | has nothing to do with Model** A **because:**
Evidence 1 says that human activities have lead to greater releases of greenhouse gases, which have been rising for the past 50 years. This strongly supports Model A because it is explaining that our climate change is being caused by human activities.

2. Evidence # 1 **strongly supports | supports | contradicts | has nothing to do with Model** B **because:**
Evidence 1 contradict Model B, because evidence one says that human activities have lead to greater releases of greenhouse gases, while model B says that increasing amounts of energy from the sun is what is causing climate change.

3. Evidence # 2 **strongly supports | supports | contradicts | has nothing to do with Model** B **because:**
Evidence 2 contridicts Model B because evidence 2 says that Earth has recieved less of the suns energy, and mode B says the opposite, that climate change has been caused by increasing amounts of energy from the sun.

Using a rubric developed by Lombardi et al. (2017), we score tasks for evaluation on a scale from 1 to 4, with 1 = erroneous, 2 = descriptive, 3 = relational, and 4 = critical

Students rated the plausibility (pre and post) of two or three alternative explanatory models for a phenomenon

Case 1: Probabilistic Reasoning

Circle the plausibility of each model. [Make two circles. One for each model.]

	Greatly implausible (or even impossible)									Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

Case 2: Plausibilistic Reasoning (common)

Circle the plausibility of each model. [Make two circles. One for each model.]

	Greatly implausible (or even impossible)									Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

Case 3: Plausibilistic Reasoning (uncommon)

Circle the plausibility of each model. [Make two circles. One for each model.]

	Greatly implausible (or even impossible)									Highly Plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

We calculate plausibility scores as the scientific explanation rating minus the alternative model(s) rating, with scores ranging from +9 (highly scientific) to -9 (non-scientific)

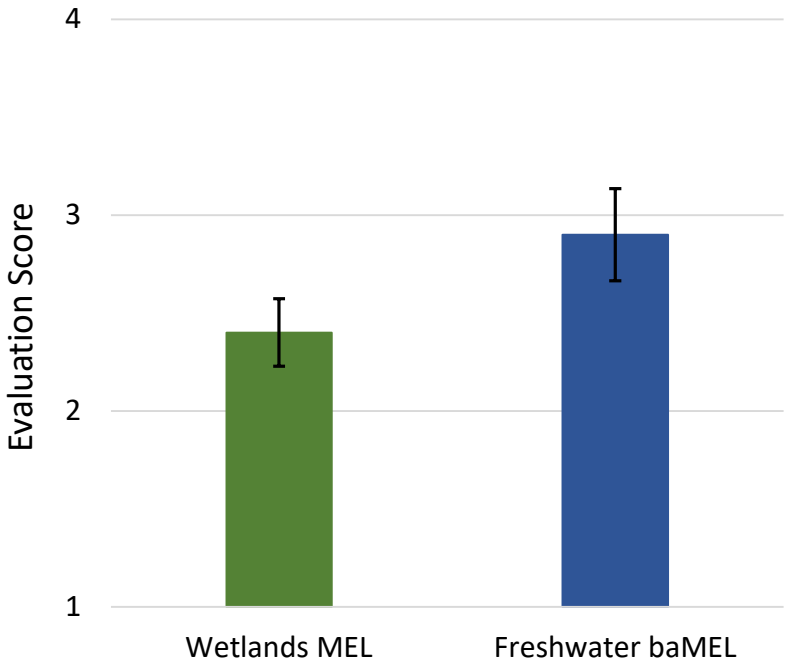
Short knowledge surveys probed students' understanding for each topic pre and post instruction

Below are statements about freshwater resources. Rate the degree to which you think that *hydrologists* agree with these statements.

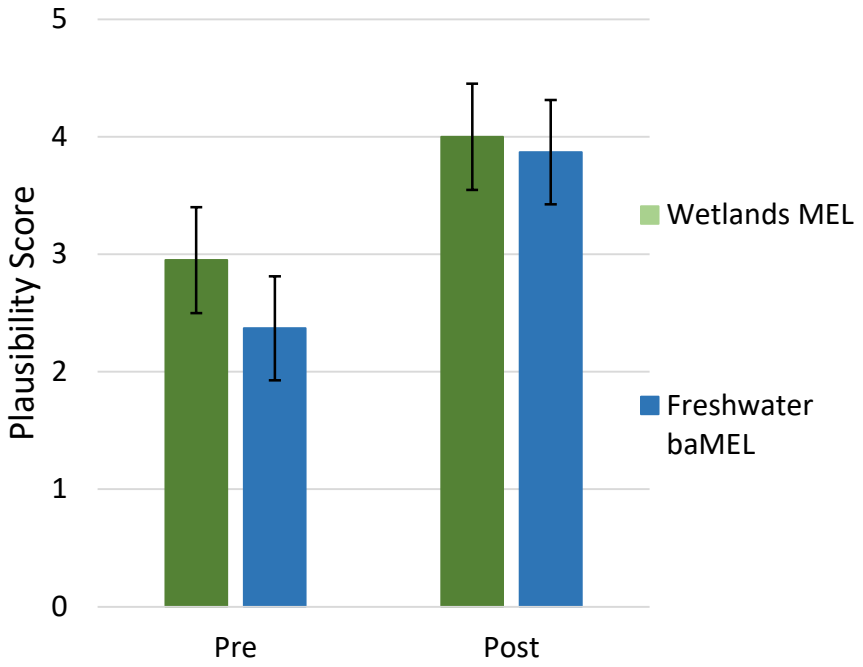
	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1. Water reclamation makes contaminated water safe for humans to use.	A	B	C	D	E
2. Engineers will solve current shortages of freshwater.	A	B	C	D	E
3. Freshwater is abundant and will remain so even in the face of global climate change.	A	B	C	D	E
4. Land use decisions affect Earth's surface, but have little impact on the water cycle.	A	B	C	D	E
5. Technology advances have made water safer for human use.	A	B	C	D	E
6. Groundwater recharge rates are similar from place to place because soils are generally uniform.	A	B	C	D	E
7. Global temperatures have increased. But, there has not been an overall decrease in global glacial ice.	A	B	C	D	E
8. Microclimates have various levels of precipitation. This affects how much water is available for human use.	A	B	C	D	E
9. Over the past 100 years, lower amounts of rainfall have occurred across the US. This means that greater amounts of land have been affected by drought in the last 20 years.	A	B	C	D	E
10. Current shortages of freshwater will get worse around the globe as world population increases.	A	B	C	D	E
11. Climate change and increasing populations will lead to more freshwater shortages.	A	B	C	D	E

Possible knowledge scores range from 5 = very low to 55 = very high

The build-a-MEL resulted in greater levels of evaluation and slightly more pronounced shifts in plausibility



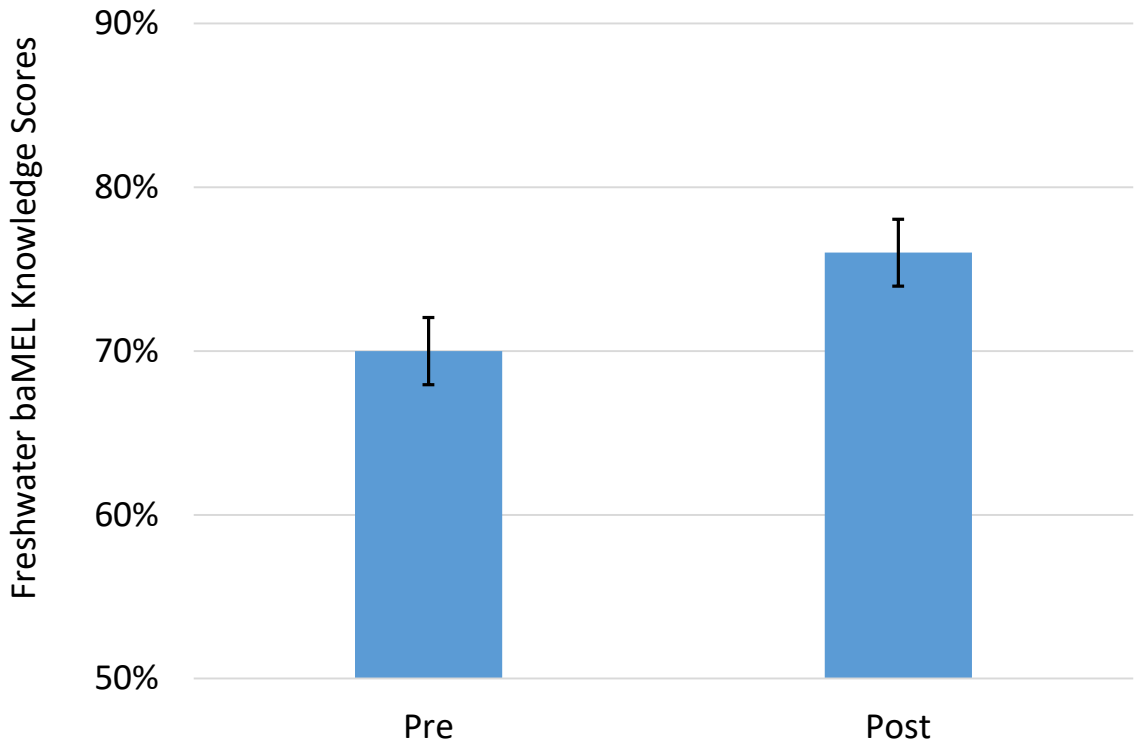
Wilcoxon Signed Ranked Test, $z = 1.17$



$z = 2.24$ (Freshwater build-a-MEL)
$z = 1.88$ (Wetlands pre-constructed MEL)

The build-a-MEL had ~1 category higher evaluation scores than the pre-constructed MEL. Plausibility shifts were ~+1.5 & +1 categories for the build-a-MEL & pre-constructed MEL, respectively

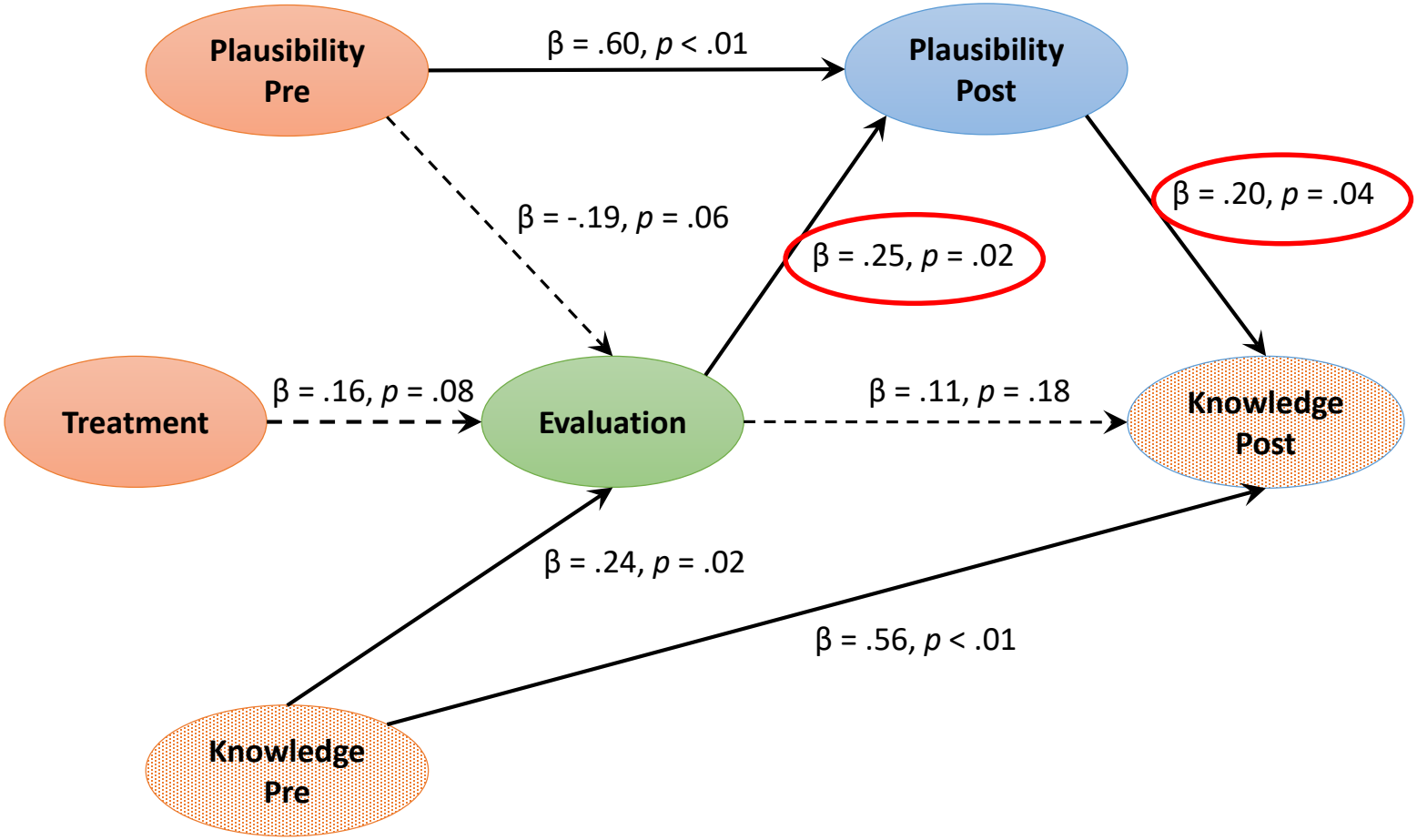
The build-a-MEL resulted in increased knowledge about freshwater resources



***t*(75) = 4.46, *p* < .001, *d* = 0.51, medium effect size**

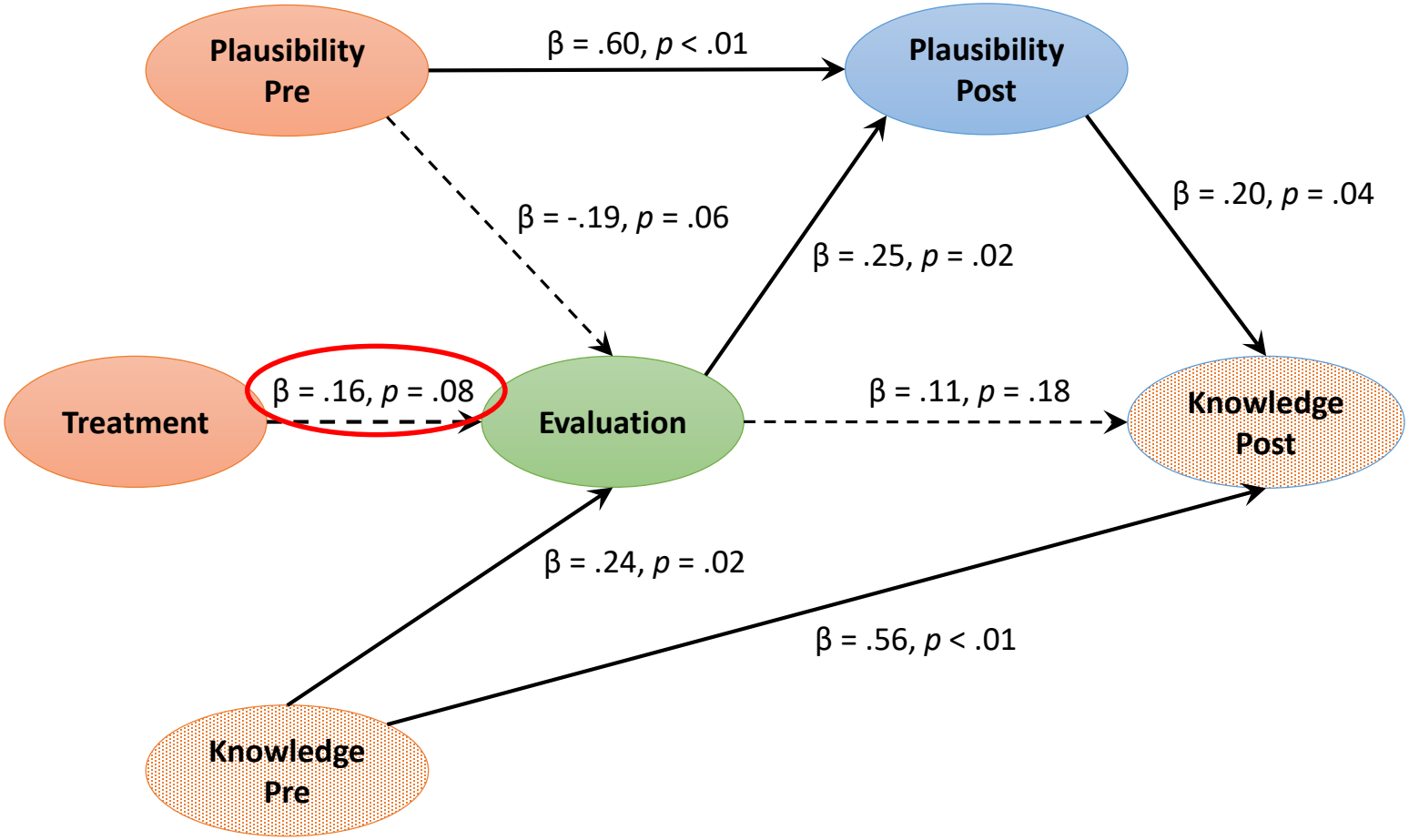
Pre knowledge was about 70% correct and post knowledge was about 76% correct (i.e., knowledge increased about 6% over 90 minutes of instruction time)

These pilot data suggest that greater levels of evaluation influence plausibility and knowledge



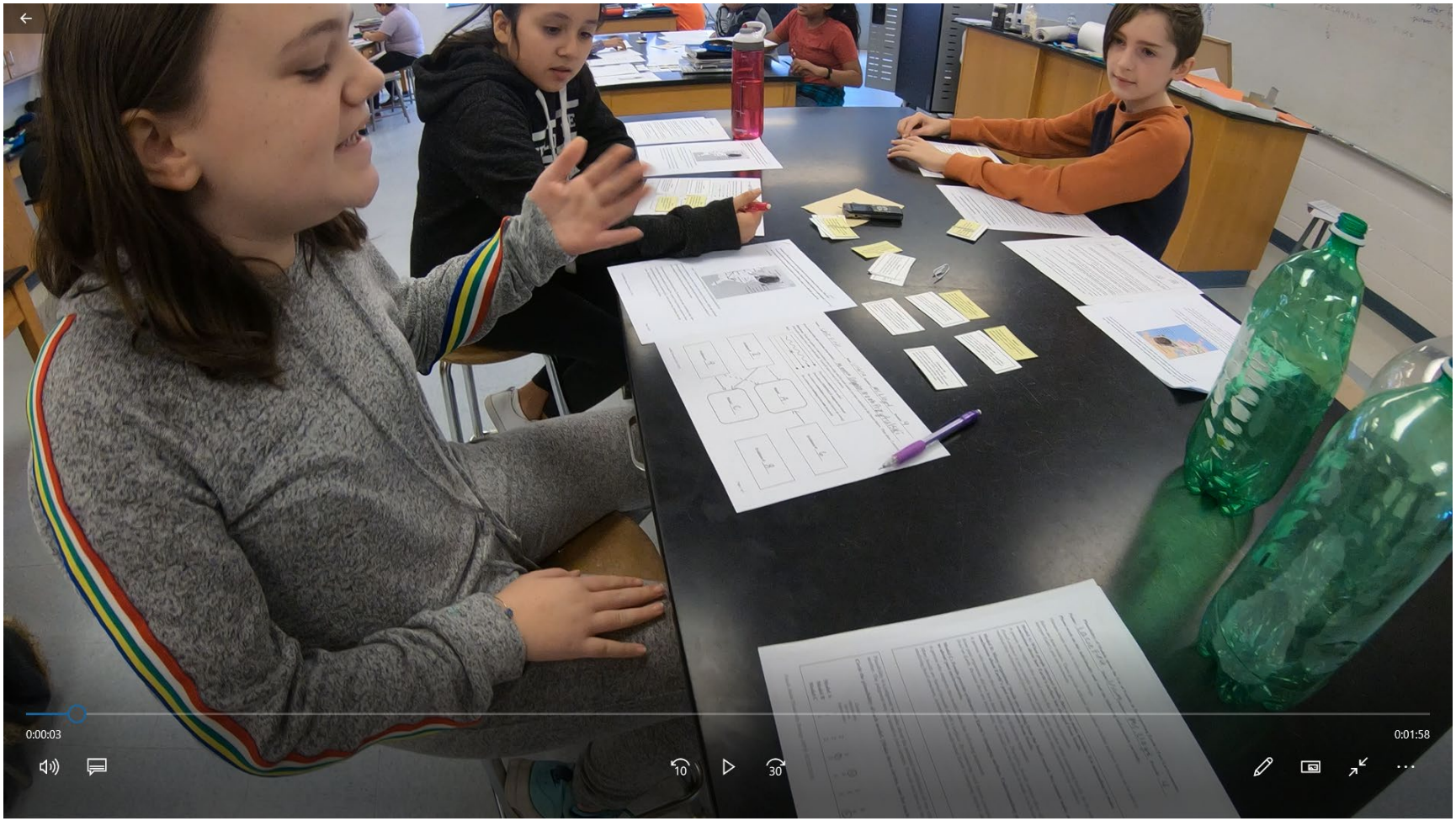
GoF = .562 (large explanatory power), ARS = .316

However, we are not seeing a meaningful advantage of the build-a-MEL over the pre-constructed MEL



GoF = .562 (large explanatory power), ARS = .316

Study 2 qualitatively analyzed video and audio data to examine students' conceptual agency during instruction



Evidence of conceptual agency included: (a) initiating claims, (b) delegating tasks, and (c) arguing from evidence

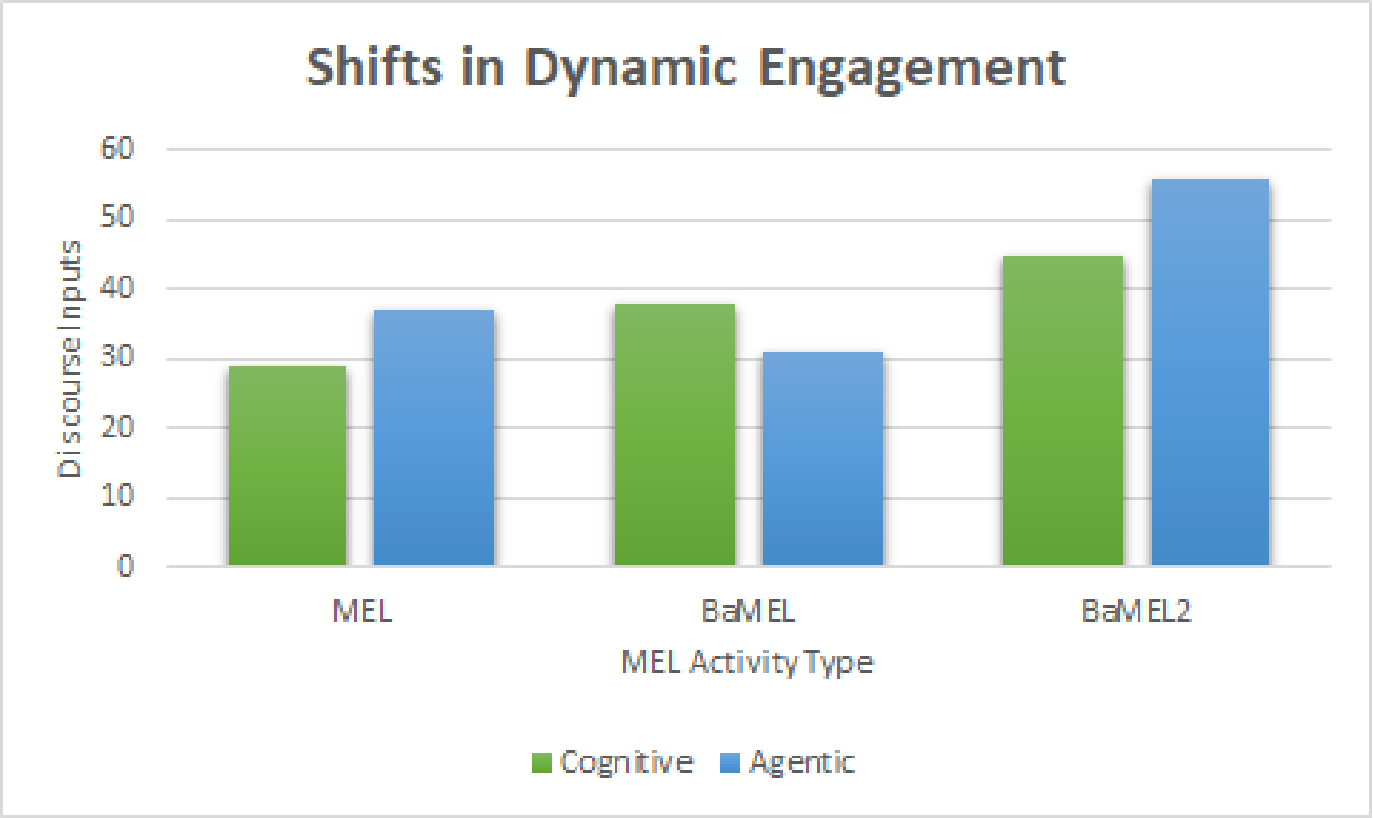
Ray (pseudonym): Ok, ok guys lets focus. So we have model A and model C right? So lets read model A and model C again. Model A. When people interpret fossils they often make mistakes. Its misleading to make conclusions about how Earth's surface has changed from fossils. Right?

Ray: Right that's a very important piece too of information too. So let's go onto to…uhhh 4. So…ahhhh…so who did 4. I know I didn't... [S4] you must have right?

S3: 19,000 years old. Here it says…. Ok So these coral reefs have been found like really down under water. But they need sunlight and sunlight can't go through the water.

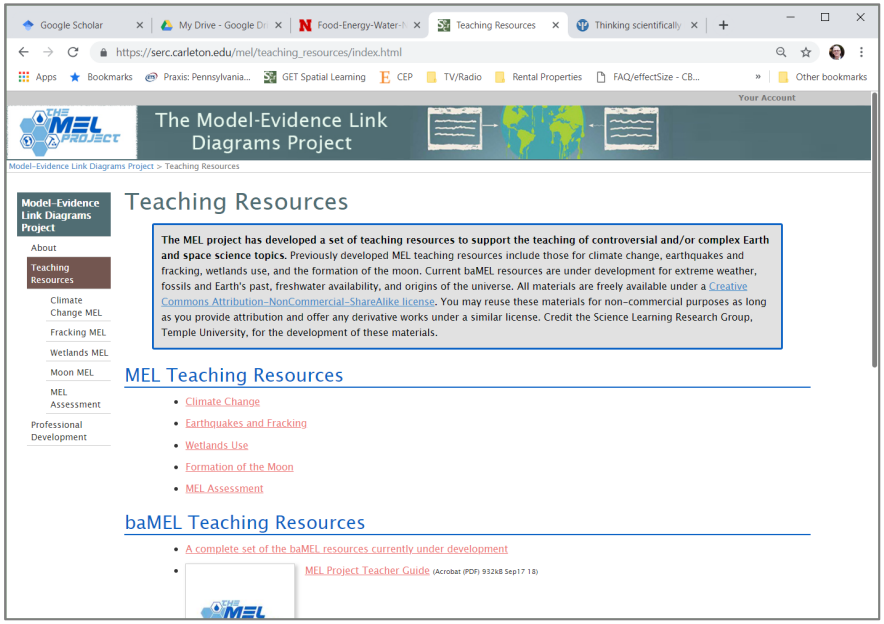
Ray: No. It can't go until a certain point.

A single-student case study revealed increased core conceptual agency during classroom interactions



Higher inputs of cognitive and agentic engagement potentially suggest increased of conceptual agency

Currently we have completed 2 years of data collection and preparing to collect more in the 3rd and 4th years



Our team is currently examining and analyzing incoming data

Please stay tuned and visit our websites early and often

http://serc.carleton.edu/mel/

http://sciencelearning.net

In summary…

…researchers and teachers need to help learners more critically evaluate & reappraise their epistemic judgments…

…and development of critical thinking practices are essential for all so that we can equitably address current and future local, regional, and global challenges