

INTRODUCTION & RESEARCH QUESTIONS

Classroom discourse is co-created by teachers and students. Teachers play prominent roles due to their positions of authority, but the drive to master scientific knowledge and practices must ultimately come from the students themselves. Rigorous and responsive teaching as well as learning for understanding are supported by disciplined curiosity.

Scientific and engineering practices are expressions of disciplined curiosity about the natural world. Scientific curiosity includes asking questions, a desire for knowledge, and the commitment that natural phenomena are explainable using scientific principles and models. Effective and authentic science education should therefore reflect scientific curiosity.

Formative assessment and responsiveness to students' ideas require another kind of disciplined curiosity: curiosity about student thinking. Previous analysis of clinical interviews of students conducted by Carbon TIME teachers suggested differences in their curiosity about student thinking. Student assessment data indicated differences in learning gains between classrooms. These patterns lead to the following questions:

1. How do Carbon TIME teachers represent scientific curiosity in the classroom and encourage and scaffold students' scientific curiosity?
2. How do teachers differ in their expression of curiosity about student thinking, and what are the effects on classroom discourse?
3. To what extent are teachers' curiosity practices in the clinical interviews reflective of their classroom teaching practices?

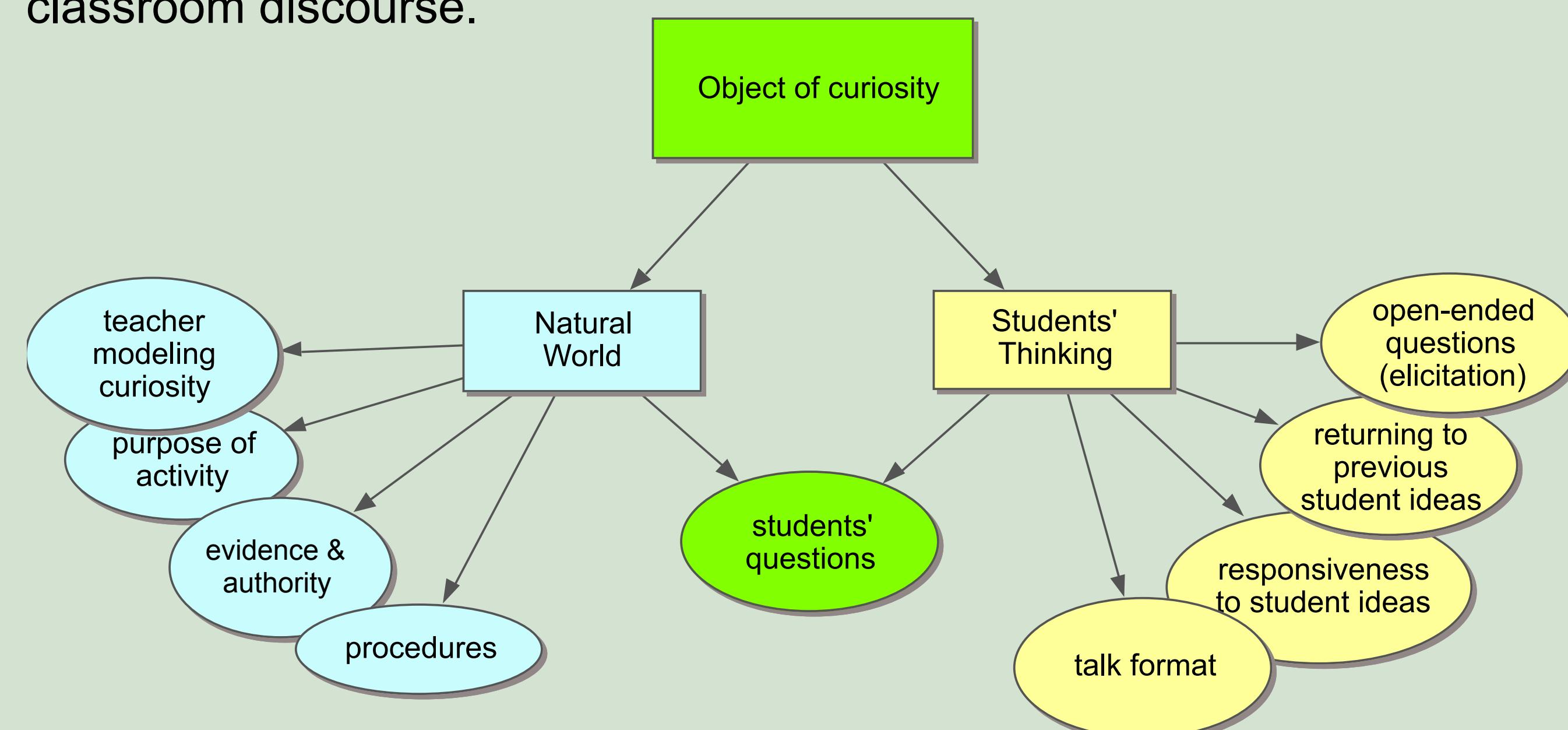
DATA SOURCES AND METHODS

Data sources: Videos of 13 teachers implementing Carbon TIME activities in their classrooms & transcripts of the clinical interviews they conducted with students.

Methods: A grounded theory approach to coding was used.

1. Initial open coding – described two objects of teachers' curiosity
2. Constant comparative analysis – attributes for each category
3. Intermediate coding – values (tentative discourse levels)

A framework was developed that draws on Zuss' association of curiosity with communities of practice and Inan's characterization of curiosity as a linguistic skill to conceptualize the curiosity practices represented in classroom discourse.



CURIOSITY PRACTICES FRAMEWORK

Three discourse levels are proposed, with one representing the lowest levels of rigor and responsiveness and three representing the highest.

| | Level 3 | Level 2 | Level 1 |
|--|---|---|---|
| Scientific curiosity: purpose of activity | Answering questions or determining hidden mechanisms | Confirmation of science facts and theories | School science (hands-on) |
| Scientific curiosity: evidence & authority | Directly linking physical evidence to predictions or claims | Collecting data, identifying patterns, or making guesses without explicit links to the question or claim | Teacher or curriculum materials as authority |
| Scientific curiosity: procedures | Involves students in developing or "problematizing" the procedures | Links procedure to practices and what scientists do or breaks procedures into conceptual chunks | Emphasizes following directions and correctly using materials |
| Scientific curiosity & student thinking: students' questions | Scaffolding curiosity: teacher's response encourages scientific sense-making (principles, hypotheses, etc.) | Validating curiosity: teacher's response indicates question is worthy or interesting but not followed up on | Teacher answers with facts only or dismisses the question |
| Student thinking: returning to previous student ideas | Emphasizing how ideas are changing over time or conflicting | Emphasizing answered and un- questions | Doesn't return to previous ideas or references previous ideas without any connections |
| Student thinking: responsiveness to student ideas | Probing students' ideas or asking other students to build on or evaluate (focus on students' stories) | Teacher carrying out their storyline with focus on students contributing correct answers/ examples | Teacher's storyline is enacted with little attention to students' ideas |
| Student thinking: talk Format | Teacher scaffolding sense-making through strategic talk moves | Pair or group talk without teacher scaffolding of sense-making | Predominantly teacher talk (may have some IRE or fill in the blank) |

Video examples for teachers' responses to students' questions

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|---------|--|
| Level 3 | Student: "If you use a heat lamp would that be the same as the sun?" Teacher 24 responds "Perfect question. Is it the light or the heat that might be the energy source. How could you test that?" Discuss experiment to test light vs. heat as energy source for plant growth. |
| Level 2 | During procedural instructions student asks if BTB will burn. Teacher 39 tells them no because it is water based, but later allows them to test this for themselves. Students report to teacher "you were right." No conceptual connections to organic/inorganic or sense-making is supported. |
| Level 1 | Student asks if giving a plant sugar water will help it grow. Teacher 11 explains it is too large to enter cells. Other students suggest spraying it on leaves or using powdered sugar. Teacher says "Thanks for playing" but the plant will just have to feed itself through photosynthesis and moves on. |

A COMPARISON OF PRACTICE

A classroom with high learning gains and a classroom with low learning gains were selected to systematically compare using this framework.

Enactment of the ethanol burning investigation:

Both teachers had students model the combustion of ethanol while they waited for results from the ethanol burning investigation.

- Teacher 12 – scaffolded students in applying observations from the investigation to determine the reactants and products of the
- Teacher 33 – the two activities were not conceptually connected

| | Teacher 12 | Teacher 33 |
|--|---|--|
| Scientific curiosity: purpose of activity | L3: Frames activity as a chance to "apply knowledge [from soda water fizzing investigation] to a more complex scenario... what happens when ethanol burns." | L1: No reference to why the investigation was being conducted. |
| Scientific curiosity: evidence & authority | L3: Scaffolds students' predictions by linking their initial ideas to the procedure (i.e. BTB won't change color if the ethanol is evaporating). | L1: No attention to scientific evidence. Teacher explains procedure and directs students to written directions. |
| Student thinking: responsiveness to student ideas | L3: Teacher supplies "just in time" information about the structure of ethanol to help scaffold a student's prediction. When the student suggested that free C, H, and O atoms would be produced the teacher asks for other students to comment on that idea then scaffolds their response by asking what they learned about bonding in soda water lab. | L1: Teacher asks only fill-in-the-blank questions that elicit a a choral response. When a student suggests that the flame will go out when the container is placed over it the teacher agrees and explains why without involving the students (and points out that the instructions already cover that). |
| Student thinking: talk format (whole class instructions) | L3: Teacher scaffolds sense-making in extended whole class discussion using talk moves. | L1: Predominantly teacher talk; student responses were single words or phrases. |

Patterns in the interviews (two post instruction interviews each):

- Teacher 12 went "off script" 60 times – probing often focused on distinguishing between matter & energy or "what do you mean by...?"
- Teacher 33 went "off script" 42 times – questions were almost exclusively closed-ended and elicited specific facts

NEXT STEPS & ACKNOWLEDGEMENTS

The analysis presented here is a qualitative description of the levels of teachers' curiosity practices. The next step is to utilize Studicode software to systematically code the classroom videos using this framework (which will likely lead to revisions) and to compare the results to the patterns observed in the interviews.

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