Routines of Interactions Around *Carbon TIME* Tools That Enhance Student Learning

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Research Questions

What does student engagement in the Practices look like?

How deeply or productively are students engaged?

Who benefits from Carbon TIME *and why?*

Conceptual Framework

- Curiosity, Agency, & Motivation
- Principled Reasoning
- Social Role in the Group

Methods

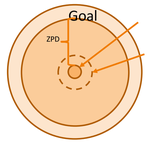
Qualitative analyses of focal students' interactions in four case study classrooms

Ms. Nolan	Ms. Callahan	Mr. Ross	Ms. Apol
• Grade 10 • Large City • 34% FRL • 55% White • 14% Asian • 12% Black • 11% Hispanic • **Annemarie N.**	• Grade 9 • Small City • Pull-out Program • 78% White • 18% Asian • 4% Black & Hispanic • **Danny C.**	• Grade 9 • Mid-sized City • 19% FRL • 48% White • 20% Asian • 18% Black • 8% Hispanic • **Eshal R.**	• Grade 7 • Rural Fringe • 35% FRL • 91% White • 1% Asian • 1% Black • 5% Hispanic • **Leah A.**

Data Sources

- Student-facing videos
- Post-unit student interviews
- Student work on process tools (i.e., Explanations Tools, Evidence-Based Arguments Tools, etc.)
- Pre & Post tests

Key for Pre/Post Test "bubbles"



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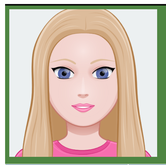
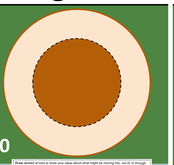
Carbon TIME

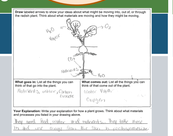


Leah A. | Typically Struggling Student; Ms. Apol's Class

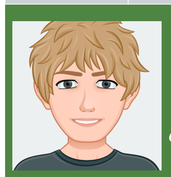
Sometimes we wouldn't like go over it like well enough. So like sometimes I like wouldn't know. But like I'm kind of shy. So I'm not like the one that raises their hand or anything…But my lab group helped me out and stuff.

Pre: 2.4
Post: 2.4
Change: 0





Attributes	Descriptor of Student	Key Evidence
Curiosity, Agency, Motivation	Leah tried to pay attention and follow through on activities.	Expressing Ideas Tool completely filled out
Principled Reasoning	Leah repeated the rules about matter and energy but didn't have a solid grasp of how they apply in the real world. She knew scientific vocabulary, but struggled to use the terms appropriately or understand what they represented.	Post Test response to *How does the grass get its energy?* "I know that plants take things in with their roots but only a very small amount but a plant uses sunlight to photosynthesize so I think that plants get most of their mass from photosynthesis/sunlight."
Social Role in the Group	Leah relied on others for answers rather than trusting her own understanding or reasoning. Her lack of confidence is evident in her behavior during discussions—she didn't speak unless prompted, and quickly agreed with other students who disagreed with her. Her peers frequently interrupted her in small group discussions.	During the interview, Leah was interrupted by Louis 13 times. She interrupted him 6 times.



Danny C. | Typically Successful Student; Ms. Callahan's Class

The food the girl ate was digested in her intestines, which break down the polymers in the food (carbs, lipids and proteins) into monomers (glucose, fatty acid, glycerol and amino acids). This uses water to 'cap off' the unstable ends of the monomers with a hydrogen atom or an O-H. These monomers are then used to build the polymers that her cells need to grow and divide.

Pre: 3.2
Post: 3.7
Change: 0.5

Attributes	Descriptor of Student	Key Evidence
Curiosity, Agency, Motivation	Danny was confident in his understanding of the science and curious to learn more. He engaged in sense-making aloud more than through writing. He relished opportunities to think through science problems, including the forced-choice questions on the tests. It is unclear if the class pushed him to his academic potential.	During an interview, when a classmate asked if oxygen is also taken in by the sunflower, the interviewer asked the group what they thought, and Danny responded first by saying, "I would think it would be like more like efficient to just use the O2 that it makes from the photosynthesis. But I don't really know…." (taps fingers on table)
Principled Reasoning	Danny consistently traced atoms and attended to scale in his explanations. He also leveraged conversations around the EBA tool to make sense of observations and claims.	Post Test response to *What happens to atoms in the fat of a person who loses weight?* "The fat is used for cellular respiration, where energy is released by the breaking of C-C and C-H bonds in the fats. The atoms are rearranged with oxygen from the air to create water vapor and carbon dioxide, which the man exhales."
Social Role in the Group	Danny recognized the value and benefit of working together as a class. Most of the time, his classmates went along with what Danny said. He also knew that he participates a lot, so he tried to give others opportunities to participate.	Interview: "Working on your own, on that like kind of a project, it can be kind of like problematic, like in that way that if you do have an outlier, like if you would never know it, because that's like your only data, so... But if you have like a bunch of people, all doing the same project, you can say: well okay, so this is what like the average like should look like. And this is what— mine like wasn't looking like that. So you have to see what it should be, so you don't get so confused."

Summary of Findings

Students in Ms. Apol's class rarely had meaningful opportunities to engage in three-dimensional reasoning. Ms. Apol limited students' opportunities for sense-making by "rescuing" them from the struggle. She scaffolded procedural display by having students fill in process tools following her instructions, so even the typically successful science students had few opportunities to engage in 3-D reasoning.

- Typically successful students—***Louis & Kay***—used science skills they previously acquired to make sense of the content, but did not hone those practices.
- Typically struggling students—***Leah & Isaiah***—did not receive scaffolding to further their scientific understanding and practice.

Mr. Ross "fit in" *Carbon TIME* into his typical classroom routines. His focus was on curriculum that is flashy and engaging but lacks a deep commitment to sense-making and 3-D learning. Mr. Ross was working on embedding discourse into his classroom environment.

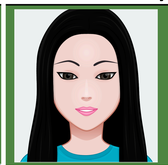
- Typically successful students—***Eshal, Rick, & Janine***—had the opportunity to engage personally in 3-D reasoning and reach a high level of proficiency.
- Typically struggling students—***Zanthe***—did not receive the scaffolding provided by following the *Carbon TIME* storyline in order to engage in 3-D reasoning.

Ms. Nolan prioritized following the Instructional Model and made that adherence to the storyline visible to her students. Ms. Nolan used the process tools for students to first bring their initial ideas forward and then to scaffold 3-D learning. Discourse routines allowed both strong and struggling students to work together to reason through their understanding of the material.

- Most students in Ms. Nolan's class, including the typically successful students—***Jules & Zubin***—as well as the typically unsuccessful students—***Annemarie & Dena***—were meaningfully engaged in 3-D reasoning and made significant progress.

Ms. Callahan teaches in a STEM magnet school where students with strong science backgrounds and interest in science apply for entrance. Ms. Callahan capitalized on students' commitment to science learning by moving them through the *Carbon TIME* curriculum and adding detail to the story.

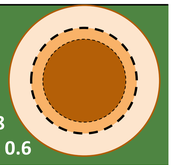
- Due to the nature of Ms. Callahan's school, all four focus students—***Danny, Holly, Susanna, & Jamie***—were typically successful science students. All of her focus students successfully engaged in 3-D reasoning and made progress.



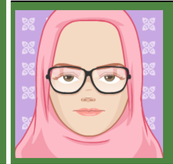
Annemarie N. | Typically Struggling Student; Ms. Nolan

I really liked the way that the materials were laid out. I found it easy to follow and it helped me know where we were in the unit. I'm kind of shy so I'm not like others who raise their hands a lot. I liked working in my lab group and felt prepared for the test.

Pre: 2.2
Post: 2.8
Change: 0.6



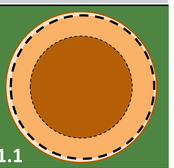
Attributes	Descriptor of Student	Key Evidence
Curiosity, Agency, Motivation	Annemarie saw value in school and strove to be a good student. She successfully used the tools with fidelity to help her make meaning of the concepts. Coming into the class she showed a broad understanding of vocabulary but lacked depth in that understanding	Using the tools as evidence: She took careful notes and was highly skilled at capturing key terms and phrases in science. She filled out her process tools thoroughly; her written explanations were consistently thorough.
Principled Reasoning	Annemarie clearly improved her understanding of the differences between transitions of matter and energy and was able to provide consistent evidence of this on both forced choice and open ended responses on her tests.	Her post-tests showed an improved depth of understanding in the rules of matter and energy moving from level 2 responses to level 4 (top level) on many of her questions.
Social Role in the Group	Annemarie followed instructions well and consistently tried her best. However, she did not easily engage in discourse with others in her group. She never volunteered to share her ideas in large class discussions and rarely shared in small group discussions without being prompted.	Annemarie was very quiet in her group, only speaking up when prompted. However, the ideas she shared indicated she was carefully following any discussion and had a grasp of the concepts. She commented that the repeated and predictable use of the tools between units allowed her to know exactly what was expected of her.



Eshal R.| Typically Successful Student; Mr. Ross's Class

(…) I felt like the learning, it was facilitated so that I could learn easier because of cooperation in group and in class. And a lot of activities , it was like more independent based so that we could learn more and kind of question what we think.

Pre: 2.7
Post: 3.8
Change: 1.1



Attributes	Descriptor of Student	Key Evidence
Curiosity, Agency, Motivation	Eshal's participation was limited by the teacher's IRE discourse, but she continued to raise her hand to answer his questions. Ms. Ross and Eshal's peers paid attention to Eshal's contributions. She paid close attention to the unit materials she was working on.	During a group discussion about ways to represent a glucose molecule Mr. Ross's asked, Which one (from three different representations) do you think gives more information? Eshal responded that she liked the three-dimensional ball & stick representation but also noted that in the linear representation the structure can be seen clearly, "and as we know, structure correlates to function, and that's very important."
Principled Reasoning	Eshal used the rules of matter and energy across her explanations on the tools and verbally. Her use and understanding of *Carbon TIME*'s discourse was notable across the data set.	Post-test response to How does a girl's digestive system (stomach and intestines) help her gain mass as she grows? "The digestive system breaks down large organic polymers (sugars, proteins, fats) into small monomers (simple sugars, amino acids, fatty acids) and then can transfer through the blood to the cells where it is stored (biosynthesis)."
Social Role in the Group	Eshal was recognized by peers as one of the smartest students in class. She led small group discussions, and constantly participated in class discussions by questioning and arguing about matter and	**Interviewer:** Who would you consider to be the three sort of smartest students in your class in this unit? **Rick (another focus student):** I think it would probably have to be Eshal, maybe Noah and…huh. I can't think of another one.

Limitations

- The 16 focus students are at best rough representatives of the four classes as a whole, and these teachers do not represent the full range of teachers and classrooms in the project.
- Categorizing students as typically successful or struggling and providing pretest and posttest scores—and even the brief profiles—vastly oversimplifies the variety of student resources, approaches, and experiences.

Conclusions

We traced focus students' engagement using three attributes: a) curiosity, agency, motivation; b) principled reasoning; c) social role in the group. We generated claims based both on students' own resources and the scaffolding provided by teachers and classroom discourse observed in the nature of students' engagement and in their learning.

- Most students needed significant scaffolding for 3-D learning through adherence to the *Carbon TIME* storyline and intentional use of process tools.
- In most classes, there were some students who were successful in *Carbon TIME* even with limited scaffolding in 3-D learning and reasoning (e.g. students in Ms. Callahan's class; Eshal in Mr. Ross's class).
- Some typically struggling students (e.g. Annemarie in Ms. Nolan's class) actively engaged in classroom discourse when 3-D learning was scaffolded. Other typically struggling students (e.g. Leah in Ms. Apol's class) had few opportunities to engage in sense-making in the absence of this scaffolding.