TEACHER GUIDE SEGMENT

This lesson was designed to be aligned to the three dimensions of the Next Generation Science Standards (NGSS), specifically through the engagement of students using science and engineering practices (SEPs) and applying the crosscutting concepts (CCCs) to understand the disciplinary core ideas (DCIs). Understanding reaction rate is a foundational chemistry concept and is used as the anchor phenomenon for this lesson. Reaction rate is outlined in NGSS Performance Expectation, HS-PS1-5 ("Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs"). Understanding reaction rate on both a microscopic and macroscopic level will help students better understand everyday activities, such as cooking and baking, as well as more complicated topics in chemistry, such as an oxidation-reduction reaction. Students will engage in an inquiry project that promotes autonomy, creativity, and collaboration. Students will learn a foundational chemistry topic and will apply it to the world outside of the classroom. They will also work on their arguments based on evidence and obtaining, evaluating, and communicating information. By turning this concept into a way to engage in the engineering & design cycle, students will have a richer and deeper understanding of reaction rate. Additionally, the lesson also offers a more reflective experience on the importance of developing, using and revising models and conducting investigations to collect data and test hypotheses. From the teacher perspective, this is a low-cost, student-centered lesson that moves students from the traditional "step-by-step", rote memorization type of engagement.

Prerequisites
Before undertaking this lesson, students should have some understanding of how to visualize molecules and atoms on the microscopic level. They should be comfortable with the scientific practice of developing and using models as well as writing CER (claim, evidence, and reasoning) paragraphs. For more information on how to write or instruct a CER, go to the "For Teachers" section.on the video page of this lesson on the MIT BLOSSOMS website

Materials:
All materials can be purchased through Amazon
1. Film Canisters
2. Alka Seltzer
3. Worksheet (printed, provided with this lesson)

Suggestions for guiding students through each of the lesson's classroom Activities:
Activity 1: If your students don't have a familiarity with modeling, be sure to have a model drawn already to show students how to represent Alka Seltzer and water on the molecular level. If needed, give students sentence starters to help them compare and contrast the data from the rockets.
Activity 2: If your students don't have familiarity with CER paragraphs, have sentence starters and a model paragraph to scaffold those parts of the lesson. Intentionally group your students so that they are able to have productive conversations about their models, and circulate during this time to help students and to construct a whole-class discussion to come to consensus on their modeling work.
Activity 3: Intentionally group your students so that they are able to have productive conversations about their models, and circulate during this time to help students design an optimal rocket that considers the factors that affect reaction rate. You can differentiate the lesson at this point by modifying how many factors each student focuses on in their final design.

Alignment to the Next Generation Science Standards:
You may have noticed that I prompted your students using the language of the crosscutting concepts embedded within the prompts. I also included several suggested prompts for you to use during your interaction with your students. The inclusion of these prompts is important and very intentional. Inclusion of crosscutting concepts

in the lesson ensures that the lesson is truly three-dimensional. For example, recall I asked the following questions at the beginning of the lesson:

- What *patterns* did you observe?
- How are the *structure* of the rockets similar and different?
- What factors do you think *caused* how the rockets performed?

These prompts were purposefully designed to structure student thinking towards specific aspects of the phenomenon (in this case, reaction rates). This dimension provides a scaffold upon which teachers and students can organize the cognitive structures for unifying the science disciplines.

In addition to the crosscutting concepts, students used several science and engineering practices during the lesson such as:

- Asking Questions and Defining Problems
- Developing and Using Models
- Analyzing and Interpreting Data
- Arguing from Evidence
- Designing a Solution

Incorporating the three dimensions of the NGSS in a purposeful and strategic manner transforms this lesson from a traditional "cookbook style" lesson to a student-centered investigative lesson. Students will come away with more ownership of the concept due to their experience of discovery and design.