Carbon TIME Professional Development Module 2

Professional Development Module 2 provides an in-depth look at *Systems and Scale*, which lays the foundation for all of the other *Carbon TIME* units. The table below illustrates how Module 2 contributes to each of the four *Carbon TIME* Professional Development Course of Study goals.

Professional Development Module 2 Goals

	***Carbon TIME* Professional Development Course of Study Goals**			
	Goal 1: Understanding Three-Dimensional Learning and *Carbon TIME* Curriculum	**Goal 2: Preparing to Teach *Carbon TIME* Units**	**Goal 3: Learning from Classroom Experiences and Student Work**	**Goal 4: Creating and Sustaining Supportive Professional Communities**
Module 2	**Models the teacher's role** in assessing and scaffolding students' three-dimensional engagement with phenomena.	**Models key *Systems and Scale* activities,** which lay the foundation for all *Carbon TIME* units.	**Identifies questions for teachers to ask themselves about indicators of students' success** in the *Systems and Scale* unit.	Provides an opportunity for teachers to work together as a supportive, professional community to **plan and enact *Systems and Scale***.

Module 2 Introduction and Overview

This module includes three sessions that provide modeling and coaching for the essential features of the *Systems and Scale* Unit, and is designed to both help teachers prepare to teach *Systems and Scale* (the first and foundational unit) as well as to engage deeply with tools designed to assess and scaffold students' three-dimensional performances that will be used across all units. Each session focuses on one of the three student roles (questioner, investigator, and explainer) in the Instructional Model. Each session includes four key features:

- An introduction that locates the lessons in the Instructional Model, supports teachers in following the unit storyline, and identifies target performances for students.
- A "deep dive" into one key activity: Teachers experience the full discourse routine and discuss how to enact its features in their own classrooms. This deep dive provides modeling and coaching on *Carbon TIME's* discourse routine.
- Exploring resources on the *Carbon TIME* website that support other activities in this part of the unit. These explorations provide modeling and coaching for *Carbon TIME's* Instructional Model and website organization.
- Essential advance preparation: ordering materials and deciding which optional activities to do.

Activities for Module 2 – Following the Unit Storyline

One of the goals for this module is supporting teachers in experiencing and understanding *Carbon TIME* unit design – the Instructional Model – as an intentionally sequenced set of experiences that supports students' engagement as questioners, investigators, and explainers as they work together to figure out the unit Driving Question. The following resources can help teachers follow the unit storyline as they engage in the sessions as learners.

- ***Carbon TIME* Instructional Model** – the *Systems and Scale* unit-specific Instructional Model – including key observations, patterns and models addressed in this unit – is available through the unit-level "IM and Storyline" tab
    - Additionally, each Lesson-level "Overview" tab (ex: for *Systems and Scale* Lesson 1) has an image of the Instructional Model as the Unit Map.

    - And, each Activity-level PowerPoint (ex: *Systems and Scale* Activity 1.2 Expressing Ideas and Questions about Ethanol Burning PPT) has an image of the Instructional Model on the 2nd slide.
    - For further support, the Carbon TIME Instructional Model Educator Resource is also available in the *Carbon TIME* Library for additional information about the intentional design of *Carbon TIME* units.
- ***Systems and Scale* Unit Storyline Chart** is also available through the "IM and Storyline" tab, as well as in the Unit-Specific Resources section of the *Carbon TIME* Library
    - Unit Storyline Charts are organized to easily view each Lesson (or related group of activities). This chart provides a summary of the question addressed in that section of the unit, what students do, and what students figure out.
- **Assessing the Learning Tracking Tool for *Systems and Scale*** – Available through the password-protected Assessment site, this teacher-facing "answer key" provides sample responses for activity-level summary questions: What did we do? What did we figure out? What are we asking now?
- **Target Student Performances** – available for each Activity in the first "Overview and Prep" tab (ex: for *Systems and Scale* Activity 1.2), as well as compiled for the entire unit through the Unit Goals tab and in the Unit-Specific Resources section of the *Carbon TIME* Library

Activities for Module 2, Session 1: Students as Questioners

Module 2, Session 1 provides an opportunity for teachers to engage as authentic learners through the initial part of the *Systems and Scale* unit. In this way, teachers have an opportunity to experience the unit as their students will – engaged in expressing ideas and asking questions – while also reflecting on their experiences and discussing with colleagues ways in which they can support (assess and scaffold) students' three-dimensional performances.

As you engage teachers (or your colleagues) in these activities, we suggest using the teacher-facing directions available in the Activity-level "Directions" tabs (ex: *Systems and Scale* Activity 1.2) to guide you as a facilitator of learners. The directions are also copied into the notes section of each Activity PowerPoint.

1. Introduce the Student Target Performance for Expressing Ideas and Questions.
    a. Activity 1.2 Student Target Performance: Students ask and record specific questions about changes in matter and energy in response to the unit driving question: What happens when ethanol burns?
    b. Why is this important? Students come to science class with their own ideas and questions about phenomena. Students need opportunities to express and publicly compare ideas and questions. Student engagement establishes them as epistemic agents who are *figuring out* the unit driving question.
2. Use *Systems and Scale* Activity 1.2: Expressing Ideas and Questions about Ethanol Burning to engage teachers as learners.
    a. Engage in the initial demonstration of burning ethanol and water, with sharing of related ideas.
        i. Activity 1.2 PowerPoint, slides 3 & 4
        ii. *Carbon TIME*: Burning Demonstration video is available on MSU's CREATE for STEM Institute YouTube *Carbon TIME* Playlist
    b. Engage in a complete Discourse Routine around the Expressing Ideas and Questions Tool.
        i. Activity 1.2 PowerPoint, slides 5-8
        ii. 1.2 Expressing Ideas and Questions Tool for Ethanol Burning
    c. Read the *Systems and Scale* Storyline Reading about the work of Elizabeth Fulhame.

        i. Use the Questions, Connection, Questions Reading Strategy and coordinating Educator Resource, available through the *Carbon TIME* Library's Cross-Unit Teaching Tools.

3. Notice and choose to use and discuss now; provide an overview of now; or return later to other components of Activity 1.2.
    a. Learning Tracking Tool for *Systems and Scale*
        i. Activity 1.2 PowerPoint, slide 11
        ii. This tool is is used repeatedly throughout the unit, for students (and the class as a whole) to discuss and record activity-level summary questions: What did we do? What did we figure out? What are we asking now?
    b. Student Exit Ticket(s)
        i. Activity 1.2 PowerPoint, slide 12
        ii. Exit tickets are provided at the end of many Activities and include 2 questions: a "Conclusion" question that reviews ideas from the Activity, as well as a "Predictions" question that prompts students to think about upcoming Activities.
        iii. These Exit Tickets are designed to be used optionally and flexibly.
    c. *Systems and Scale* Big Idea Probe: Fill 'Er Up
        i. *Carbon TIME* Big Idea Probes are formative assessment tools designed to be used multiple times across a unit to stimulate student-to-student discussion about specific scientific and informal ideas related to a real world question.
        ii. See the Using Big Idea Probes Educator Resource for more support.
    d. Developing and using a Driving Question Board
        i. Initial ideas and questions from Activity 1.2 may be used for a Driving Question Board. See the Using a Driving Question Board Educator Resource for more support and suggestions.
4. Notice and choose to use and discuss now; provide an overview of now; or return later to Activity 1.1 *Systems and Scale* Unit Pretest (the other Activity in Lesson 1).
5. Provide an overview of activities in Lesson 2 – Powers of Ten and Investigation Tools.
    a. Activities in this lesson provide foundational knowledge and practice for students. Typically, teachers do not need to engage as learners in these activities, so we recommend an overview of this Lesson and the Activities.
6. Notice and choose to use and discuss now; provide an overview of now; or return later to the Assessing documents available through the *Carbon TIME* Assessment site.
    a. Assessing worksheets include common student responses at various Learning Progression levels.
    b. See the Purposes of Assessment in *Carbon TIME* for additional information about the use of assessments for accountability, insight into students' ideas, and students' self-assessment.
7. Use the Teacher Target Performance Tool for *Systems and Scale* to engage teachers in a reflective discussion.
    a. Activity Chunk: Activity 1.2; Students as Questioners
    b. Target Performance for Activity 1.2: Students ask and record specific questions about changes in matter and energy in response to the unit driving question: What happens when ethanol burns?
    c. Assessing Tools and Strategies: Discuss and record teacher ideas for, What tools and strategies can you use for formative assessment, summative assessment, or student self-assessment?
    d. Scaffolding Tools and Strategies: Discuss and record teacher ideas for, What tools and strategies can you use to scaffold students' successful engagement in the target performance?

Activities for Module 2, Session 2: Students as Investigators

Module 2, session 2 provides an opportunity for teachers to engage as authentic learners through the second part (up the triangle) of the *Systems and Scale* unit. In this way, teachers have an opportunity to experience the unit as their students will – engaging in making predictions, planning and carrying out an investigation to answer the unit driving question (What Happens when Ethanol Burns?), collecting and analyzing data, and developing evidence-based arguments about conclusions from the investigation. This session continues to support teachers in meaningful dialogue with their colleagues as they reflect on experiences and discuss ways in which they can support (assess and scaffold) students' three-dimensional performances.

1. Introduce the Student Target Performance for Predictions & Planning.
    a. Activity 4.1 Student Target Performance: Students develop hypotheses about how matter moves and changes and how energy changes when ethanol burns and make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter; they record data about changes in mass and BTB when ethanol burns and reach consensus about patterns in their data.
    b. Why is this important? Making predictions allows students to test their initial ideas and questions. Students begin to use scientifically-sophisticated reasoning (tracing matter an energy through the Three Questions) in expressing their rationale for their predictions.
2. Use *Systems and Scale* Activity 4.1: Predictions about Ethanol Burning to engage teachers as learners.
    a. Read and discuss the 4.1: Good Explanations of Chemical Change Reading and the Three Questions Handout.
        i. Activity 4.1 PowerPoint, slide 4
    b. Watch the initial portion of the *Carbon TIME Systems and Scale* Video.
        i. Activity 4.1 PowerPoint, slide 5
    c. Complete and discuss the Predictions and Planning Tool.
        i. Activity 1.2 PowerPoint, slides 5-8
        ii. 4.1 Predictions and Planning Tool: Investigating Ethanol Burning
3. Use *Systems and Scale* Activity 4.2: Observing Ethanol Burning to engage teachers as learners.
    a. Set up and complete the investigation.
        i. Activity 4.2 PowerPoint, slides 3 & 4
    b. While you wait, share ideas and predictions about the Three Questions.
        i. Activity 4.2 PowerPoint, slides 5-7
    c. Collect data, compare to other class' data (using the final portion of the *Carbon TIME Systems and Scale* Video), and discuss and record patterns in data.
        i. Activity 4.2 PowerPoint, slides 8-13
4. Introduce the Student Target Performance for Evidence-Based Arguments.
    a. Activity 4.3 Student Target Performance: Students (a) use data from their investigations to develop evidence-based arguments about matter movements, matter changes, and energy changes when ethanol burns; and (b) identify unanswered questions about matter movement, matter change, and energy change that the data are insufficient to address.
    b. Why is this important? Scientists use evidence from data as the basis for their claims. The unanswered questions here provide students with a *need* for information at the atomic-molecular scale.
5. Use *Systems and Scale* Activity 4.3: Evidence-Based Arguments for Ethanol Burning to engage teachers as learners.
    a. Engage in a complete Discourse Routine around the Evidence-Based Arguments Tool
        i. Activity 4.3 PowerPoint, slides 4-9

        ii. 4.3 Evidence-Based Arguments Tool: What Happens to Ethanol When it Burns?
    b. Discuss the importance of "Unanswered Questions" providing a need for information at the invisible, atomic-molecular scale.
        i. Activity 4.3 PowerPoint, slide 10
6. Notice and choose to use and discuss now; provide an overview of now; or return later to other components of Activities 4.1, 4.2, and 4.3, including the Learning Tracking Tool for *Systems and Scale*; Student Exit Tickets; and a Driving Question Board.
7. Notice and choose to use and discuss now; provide an overview of now; or return later to the Assessing documents available through the *Carbon TIME* Assessment site.
8. Use the Teacher Target Performance Tool for *Systems and Scale* to engage teachers in a reflective discussion.
    a. Activity Chunk: Activities 4.1-4.3; Students as Investigators
    b. Target Performance for Activities 4.1-4.3: Students develop hypotheses about how matter moves and changes and how energy changes when ethanol burns and make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter; they record data about changes in mass and BTB when ethanol burns and reach consensus about patterns in their data; and they (a) use data from their investigations to develop evidence-based arguments about matter movements, matter changes, and energy changes when ethanol burns; and (b) identify unanswered questions about matter movement, matter change, and energy change that the data are insufficient to address.
    c. Assessing Tools and Strategies: Discuss and record teacher ideas for, What tools and strategies can you use for formative assessment, summative assessment, or student self-assessment?
    d. Scaffolding Tools and Strategies: Discuss and record teacher ideas for, What tools and strategies can you use to scaffold students' successful engagement in the target performance?
9. If needed, support for making and using Bromothymol Blue (BTB) is available in that section of the *Carbon TIME* Library's Cross-Unit Teaching Tools.

Activities for Module 2, Session 3: Students as Explainers

Module 2, Session 3 provides an opportunity for teachers to engage as authentic learners through the last part (down the triangle) of the *Systems and Scale* unit. In this way, teachers have an opportunity to experience the unit as their students will – engaged in using molecular models to see the hidden chemical change when ethanol burns and then using those experiences to construct model-based explanations. The session also overviews other Lessons in *Systems and Scale* (Lessons 3 and 5).

1. Use *Systems and Scale* Activity 4.4: Molecular Models for Ethanol Burning to engage teachers as learners.
    a. Read and discuss the 4.4: Molecular Models for Ethanol Burning Reading.
        i. Activity 4.4 PowerPoint, slide 3
    b. Use the animation to observe and discuss differences in molecules at the bottom and top of the flame.
        i. Activity 4.4 PowerPoint, slides 4-6
    c. Use the 4.4 Molecular Models for Ethanol Burning Worksheet and related molecular modeling materials to show the hidden chemical change when ethanol burns.
        i. Activity 4.4 PowerPoint, slides 7-24 (these include animations supporting the identification and tracing of atoms in molecules through the chemical change).

        ii. All molecular modeling resources – including detailed information for purchasing and making kits – are available in the *Carbon TIME* Library Cross-Unit Teaching Tools section titled, "Materials for molecular modeling."
    d. Some teachers may notice simplifications we have made related to chemical changes and energy. Individual teachers – or the professional learning group together – may find the *Carbon TIME* Content Simplifications helpful in understanding our student-learning-based rationales.
2. Introduce the Student Target Performance for Explanations.
    a. Activity 4.5 Student Target Performance: Students explain how matter moves and changes and how energy changes when ethanol burns (connecting macroscopic observations with atomic-molecular models and using the principles of conservation of matter and energy).
    b. Why is this important? Through drawing and writing, students connect their macroscopic observations with the atomic-molecular model of combustion and use the principles of convservation of matter and energy to explain the unit driving question.
3. Use *Systems and Scale* Activity 4.5: Explaining Ethanol Burning to engage teachers as learners.
    a. Engage in a complete Discourse Routine around the Explanations Tool.
        i. Activity 4.5 PowerPoint, slides 4-14
        ii. 4.5 Explanations Tool for Ethanol Burning
    b. Notice and choose to use and discuss now – or provide an overview of now – other scaffolds supporting students' construction of model-based explanations.
        i. The Three Questions Explanations Checklist (page 2 of the Three Questions Handout)
        ii. 4.5 What Happens When Ethanol Burns? Reading
        iii. 4.5 Matter Tracing Tool
        iv. Example *Systems and Scale* Explanations Handout
4. Provide an overview of activities in Lesson 5 – Other Examples of Combustion, which provide additional practice with examples of combustion, as well as returning students to the initial demonstration of water and ethanol (Activity 5.3) to distinguish between organic and inorganic materials.
    a. Activity 5.1 and Activity 5.2 provide students with additional opportunities to use molecular modeling kits and Explanations Tools, now to explain what happens when methane burns.
    b. Activity 5.3 provides students an opportunity to distinguish between organic and inorganic materials on the basis of both their functions and the chemical structure of their molecules.
        i. This activity allows students to return to and explain the initial unit demonstration (Why did ethanol burn, even though it looks like water?) while also providing **foundational knowledge** about organic and inorganic materials, **necessary for future units**.
    c. Activity 5.4 provides students opportunities to read about and explain (with less scaffolding) what happens when other organic fules burn, including (a) wood burning in a fireplace, (b) propane burning in a gas grill, and (c) octane burning in an internal combustion engine.
    d. Activity 5.5 is the *Systems and Scale* Unit Posttest.
5. Provide an overview of Lesson 3 – Investigating and Explaining Soda Water Fizzing.
    a. Lesson 3 provides students with a complete investigation and explanation sequence for Soda Water Fizzing. This is a simpler chemical change, as students address the Movement Question and the Matter Change Question, but not the Energy Change Question, and is provided earlier in the unit to support students in tracing matter through chemical changes. This Lesson is optional.

6. Provide an overview of the *Systems and Scale* Community Connection: Combustion in our Community Activity.
    a. These one- or two-Activity Lessons are available in most *Carbon TIME* units, and extend unit-level ideas into personal and community contexts and decision-making.
    b. In Combusion in our Community Connection (Activity 2), students design infographics to make their community aware of how it uses combustion to power its lifestyle and of the environmental impacts of those uses
7. Notice and choose to use and discuss now; provide an overview of now; or return later to the Assessing and Grading documents available through the *Carbon TIME* Assessment site.
    a. Assessing worksheets include common student responses at various Learning Progression levels. Grading worksheets include goal student responses, as well as suggestions for assigning points.
    b. See the Purposes of Assessment in *Carbon TIME* for additional information about the use of assessments for accountability, insight into students' ideas, and students' self-assessment.
8. Use the Teacher Target Performance Tool for *Systems and Scale* to engage teachers in a reflective discussion.
    a. Activity Chunk: Activities 4.4-4.5; Students as Explainers
    b. Target Performance for Activities 4.4-4.5: Students use molecular models to explain how carbon, oxygen, and hydrogen atoms are rearranged into new molecules during the oxidation of ethanol (the chemical change that happens when ethanol burns) and explain how matter moves and changes and how energy changes when ethanol burns (connecting macroscopic observations with atomic-molecular models and using the principles of conservation of matter and energy).
    c. Assessing Tools and Strategies: Discuss and record teacher ideas for, What tools and strategies can you use for formative assessment, summative assessment, or student self-assessment?
    d. Scaffolding Tools and Strategies: Discuss and record teacher ideas for, What tools and strategies can you use to scaffold students' successful engagement in the target performance?

Activities for Module 2 – Resources and Preparing to Teach

Two of the goals for this session involve exploring the *Carbon TIME* website to locate resources as well as engaging in essential advance preparation, including locating or ordering materials and making decisions about what optional activities to teach. Here, we outline some specific suggestions for reaching these goals by using the *Systems and Scale* Unit Front Matter, which is also available by using each of the unit homepage tabs. These tabs are organized into five steps involved in planning and preparing to teach a *Carbon TIME unit*: Read the unit overview (and students' learning progression reading); choose your activity sequence; review the unit instructional model and storyline; prepare materials; and dig into lessons.

1. ***Systems and Scale* Unit Overview** - available through the *Systems and Scale* "Unit Overview" tab, as well as in the Unit-Specific Resources section of the *Carbon TIME* Library.
    a. Unit Overviews are short readings available for each unit that orient teachers to the Unit Driving Question, students' roles and science practices, using the Three Questions to explain the unit's natural phenomena, and addressing how much detail is appropriate for meeting three-dimensional student performance goals.
2. **Students' Learning Progressions for the *Systems and Scale* Unit** – available through the the Unit-Specific Resources section of the *Carbon TIME* Library
    a. Students' Learning Progressions readings provide a unit-specific overview of the *Carbon TIME* learning progression research on which the curriculum is based.

Learning progressions are descriptions of the informal and then successively more sophisticated (scientific) ways that students reason about phenomena.

3. ***Systems and Scale* Unit Sequence** and teaching decisions – available through the *Systems and Scale* "Unit Sequence" tab
    a. *Carbon TIME* units are designed to support diverse learners and classrooms, and not all activities may be appropriate for your students. Review the Unit Sequence to make decisions about optional activities or lessons; orange text and the the word (Optional) in parentheses indicate decisions to make.
    b. In other units, you will see repeating activities (marked with circular arrows) indicating these activities are available (and identical) in multiple units. You will likely want to omit these activities once students have completed them in one unit.
    c. In other units, you will also see 2-turtle activities (marked with stacked turtles ), which place a higher demand on students. The *Carbon TIME* Turtle Trails Document provides further information about choices for making units more or less demanding, depending on your students' needs.
4. **Unit Materials** – available through the *Systems and Scale* "Unit Materials" tab
    a. *Carbon TIME* units were designed to require materials that are easily purchased or already available in most schools. This Materials to Purchase List, available in the *Carbon TIME* Library General Resources section, compiles materials needed across all units.
    b. Many kinds of molecular modeling kits will work. As outlined in Module 2, Session 3, our suggestions are available in the *Carbon TIME* Library Cross-Unit Teaching Tools section titled, "Materials for molecular modeling".
5. **Talk & Writing Tables** – available in the Lesson-level "Talk and Writing" tab (ex: *Systems and Scale* Lesson 1)
    a. Talk and Writing tables provide specific talk and writing goals as well as strategies teachers can use in talk and writing to support these goals. Talk and writing goals differ across the unit, so the lesson-level tables provide suggestions specific to that part of the unit. Talk and writing prompts are also available in the notes section of each Activity PowerPoint.
    b. The Talk and Writing Educator Resource provides additional information.

Returning to Module 1

As described in the *Carbon TIME* Professional Development Module 1, we recommend regularly revisiting the PD Course of Study's Driving Question: *How do I support my students in three-dimensional engagement with natural phenomena, in order for them to achieve environmental science literacy?*

- Have teachers review and update their ideas and questions.
- See the Using a Driving Question Board Educator Resource for support.

Additionally, using or revisiting suggestions listed in *Carbon TIME* Professional Development Module 1, "Activities for Teachers' Foundational Knowledge about *Carbon TIME* website and unit design" may be helpful.