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Conceptualization and Development of a Performance Task for Assessing and Building Elementary Preservice Teachers' Ability to Facilitate Argumentation-Focused Discussions in Science: The Modeling Matter Task

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Abstract

In this research memorandum, one of a series of eight such reports, we describe the development process by which we produced a series of performance tasks designed for preservice elementary teachers for formative assessment use in the context of teacher education programs. Each performance task provides an opportunity for preservice elementary teachers to practice facilitating an argumentation-focused discussion targeting a student learning goal in elementary mathematics or science. One unique aspect of this work is that the discussions take place within an online simulated classroom environment that consists of five upper elementary student avatars. This report documents the development process at three levels. First, we define the overarching teaching competency that each task targets—the ability to facilitate argumentation-focused discussions—by describing the general approach and processes used to develop the full set of eight tasks and the key components embedded within each task. Next, we describe the academic content addressed in the subset of four science tasks and how the content conceptualization supports the use of the tasks individually or as a set. We then discuss the specific task that is the focus of this research memorandum, outlining how it was designed to capture evidence of the targeted teaching competency.

Keywords: performance task, elementary education, simulated classrooms, virtual reality, discussion, argumentation, preservice teachers, teacher education, science, matter and its interactions

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The development of these performance tasks, especially the interactor training materials, was enhanced by the feedback from the talented group of Mursion interactors who worked on this project and who served as the human-in-the-loop during these simulated discussions. In addition, we are grateful for the advice and critical review of these tasks from our advisory board members, assessment developers, and research colleagues. Finally, we are appreciative of the teacher educators and preservice teachers who provided substantive feedback on how to improve these tasks for future use in teacher education.

Preface

This research memorandum is one of eight reports in which we describe the development process by which we produced a series of performance tasks designed for preservice elementary teachers for formative assessment use in the context of teacher education programs. The following table provides an overview of the eight performance tasks.

Descriptions of the Eight Performance Tasks

Task name	Task description
	Mathematics
Ordering Fractions	The teacher leads a discussion of three student-generated strategies for ordering a set of given fractions from least to greatest.
Fractions Between	The teacher leads a discussion with the students about an unconventional student-generated method for generating fractions between two given fractions. The discussion is focused on the strengths and weaknesses of the strategy, and its applicability to other situations.
Birdseed	This discussion is grounded in students' work on a story problem in which they have used fraction multiplication. Prior to the discussion, the students individually critiqued one another's work, making the critique aspect of argumentation more clearly available to the teacher.
Eight Divided By One-Fourth	This discussion focuses on students' work to generate meaningful understandings and representations of division by a fraction.
	Science
Mystery Powder	This discussion focuses on reaching group consensus around the identity of an unknown powder based on its properties and what is known about a set of common powders. In addition to identifying the mystery powder, students discuss which properties are most useful and why.
Conservation of Matter	In this task, the teacher supports the students in discussing whether the amount of matter is conserved during a physical change, in this case the mixing of ingredients to produce lemonade.
Modeling Matter	This task focuses on critiquing and revising visual models for explaining what happens after a drop of red food coloring is dropped into a cup of water.
Changing Matter	This discussion builds on students' prior work mixing together different combinations of substances and forming claims about whether each combination produced a new substance, with an emphasis on using evidence to support those claims.

Each report is dedicated to a singular task and provides a full description and corresponding appendix text for that particular task. All of the reports include a description of the general development process that applies to the full set of tasks. Additional materials to support the use of the performance tasks, such as interactor training and scoring documentation, are not included in these reports but are archived and publicly available through the Qualitative Data Repository housed at Syracuse University (https://data.qdr.syr.edu/dataverse/go-discuss).

The first section of this report details the development of the performance tasks, including a description of the construct, the task type, and the process used to develop each of the eight tasks. In the second section, we discuss the content focus of the set of science tasks and of the Modeling Matter task in particular. In the final section, we describe the resulting set of materials that make up the stable components of the task itself and use examples from the Modeling Matter task to illustrate what these components look like and how they function together in the performance task.

Section 1: Development of the Performance Tasks

In this section of the report, we share our conceptualization of the teaching practice of facilitating argumentation-focused discussions, describe what a simulated teaching performance task is, and explain how our use of the performance task maps onto the conceptualization of the teaching practice. We finish by outlining the process steps that we used to develop the tasks.

Construct Definition: Facilitating Argumentation-Focused Discussions

Our construct of interest is the teaching practice of facilitating discussions that engage students in argumentation, or what we refer to as “facilitating argumentation-focused discussions.” We focused on this teaching practice for a number of reasons. First, facilitating argumentation-focused discussions is an ambitious teaching practice that is critically important for teachers to learn how to do well in order to support student conceptual learning within content areas (Kazemi & Stipek, 2009; Russell et al., 2017; Stylianides et al., 2016; Walshaw & Anthony, 2008). Second, this practice is hard to learn how to do it well, and many teachers—even experienced teachers—tend to have had little opportunity to learn how to do it well (Barkai et al., 2002; Reid & Zack, 2009). Finally, the focus on argumentation was purposeful. Although teachers may facilitate many kinds of discussions with K–12 students, both the *Common Core State Standards* and *Next Generation Science Standards* (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; National Research Council, 2013) identify argumentation as one of the key mathematical and scientific practices that K–12 students need to master.

To define the construct that we were aiming to measure—preservice elementary teachers' ability to facilitate argumentation-focused discussions—we began by reviewing the empirical and practitioner literature as well as the current student standards in mathematics and science to identify the core aspects of this teaching practice. Building on this review, we identified five dimensions of high-quality, argumentation-focused discussions: (a) attending to students' ideas, (b) developing a coherent and connected storyline, (c) encouraging student-to-student interactions, (d) developing students' conceptual understanding, and (e) engaging students in argumentation. Table 1 provides details about the specific focus of each dimension.

Table 1. Dimensions of a Scoring Rubric to Evaluate Preservice Teachers' Ability to Facilitate Argumentation-Focused Discussions

Dimension	Description: Degree to which the teacher. . .
Attending to students' ideas	. . . is being responsive to students, with a focus on making sure the discussion is grounded in the ideas the students bring with them
Developing a coherent and connected storyline	. . . is able to shape a coherent discussion, with a focus on building and connecting ideas toward an instructional goal
Encouraging student-to-student interactions	. . . organizes the classroom community and the social interactions so students respond directly to one another's thinking
Developing students' conceptual understanding	. . . makes productive decisions about how to address particular ideas, especially students' misunderstandings
Engaging students in argumentation	. . . emphasizes disciplinary argumentation (e.g., consideration of opposing claims; facilitates critique and rebuttals; encourages students to draw upon evidence and reasoning)

Note. Adapted from "Using Performance Tasks Within Simulated Environments to Assess Teachers' Ability to Engage in Coordinated, Accumulated, and Dynamic (CAD) Competencies" by J. N. Mikeska, H. Howell, and C. Straub, 2019, *International Journal of Testing*, *19*(2), pp. 138 (https://doi.org/10.1080/15305058.2018.1551223). Copyright 2019 by Taylor & Francis.

The first dimension, attending to students' ideas, focuses on the extent to which teachers are responsive to students' ideas in equitable ways, ensuring that the discussion is grounded in students' ideas and that all students are engaged in meaningful aspects of the discussion. The second dimension, developing a coherent and connected storyline, targets the degree to which the teacher can shape a coherent discussion by building and connecting ideas toward a learning goal. The third dimension, encouraging student-to-student interactions, pays attention to how teachers facilitate the discussion so students are the ones responsible for interacting directly with each other and engaging with one another's ideas. The fourth dimension, developing students' conceptual understanding, targets the extent to which the teacher and students are involved in evaluating the accuracy and validity of key ideas and how well the teacher productively addresses students' misunderstandings. The fifth dimension, engaging students in argumentation, emphasizes the degree to which students are invited to and engage in argument construction and critique during the discussion.

Simulated Teaching Performance Tasks

The overall goal of our research was to develop a set of simulation-based performance tasks that could be used to assess and build preservice elementary teachers' ability to facilitate argumentation-focused discussions. We conducted this work in the context of an innovative, mixed reality platform (see Figure 1)—an upper elementary simulated classroom composed of five student avatars.

Figure 1. Image of an Upper Elementary Simulated Classroom

Credit: Image courtesy of Mursion

The student avatars are controlled on the back end by a human in the loop, called an *interactor*, who is trained to respond as each of the five student avatars during the discussion. The preservice teacher does not see the interactor but instead views the student avatars on a television or computer screen and can interact with the student avatars in real time during the discussion. We hypothesized that the simulated classroom could serve as a practice-based space for preservice teachers to hone their skill in this teaching competency. Each performance task was designed to be deployed within the upper elementary classroom environment.

The teaching competency of facilitating argumentation-focused discussions is one that involves complex interactions between a teacher and students around specified content. It requires a practice space that provides opportunities for extended interactions to unfold over time, as a teacher's ability to engage in this practice is observable only across these patterns of interactions (Mikeska et al., 2018). In earlier writing, we describe this competency as one that is "coordinated," "accumulated," and "dynamic" (Mikeska et al., 2018, p. 132–133). By *coordinated*, we mean that the teacher is required to manage multiple, sometimes competing, considerations simultaneously—for example, trying to balance the goal of engaging students in argumentation with addressing students' erroneous conceptual understanding. *Accumulated* refers to the nature of the evidence that needs to be captured, as the teaching competency is observed over time across the patterns of interactions and not by examining individual, disparate interactions. By *dynamic*, we mean that this teaching competency is observed as teachers respond to the constantly changing nature of various task conditions. Each one of these aspects has implications for task design.

First, to ensure that we were adequately measuring this teaching competency, we had to ensure that our task design afforded teachers the opportunity to manage various considerations at the same time. Second, we had to ensure that the tasks provided substantial opportunities to capture evidence at various time points. For example, the tasks needed to provide us opportunity to observe how teachers prompt (or fail to prompt) direct student dialogue and the ways that students begin to engage in specific behaviors more (or less) frequently based on this teacher prompting over time. Finally, we had to create variable task situations so that the teacher would be required to respond to the changing nature of the situation over time, for example, creating dynamic student profiles where students can "learn" based on their interactions with other students and the teacher, as described in the final section of this report. In the next section, we explain our process for developing each performance task, which includes both the preservice teacher–facing task materials and the interactor-facing task materials.

Overview of the Task Design Process

Because the overall goal of using these tasks was to be able to make valid inferences about preservice teachers' ability to facilitate discussions that engage students in the practice of argumentation, we drew upon the process of evidence-centered design (Mislevy et al., 2002) to develop our evidence model. We then used this evidence model to inform the overall design of each performance task. Our first step was to use our construct definition to develop an evidence model to articulate the observable behaviors that could serve as evidence of preservice teachers' ability to engage successfully in each dimension. For example, for the first dimension—attending to students' ideas—we identified three indicators of that dimension of this overall teaching practice, including the preservice teachers' abilities to incorporate ideas from the students' written prework into the discussion, to elicit substantive ideas from all students, and to make use of students' ideas to move the lesson forward in regard to the discussion's specified student learning goal. We further elaborated each one at three levels of proficiency—beginning novice, developing novice, and well-prepared novice—to describe the observable behaviors one would gather evidence about to inform assessment of that indicator. For example, for the previously discussed dimension, attending to students' ideas, under the second indicator, eliciting substantive ideas, the observable behaviors specified (Figure 2) indicate that elicitation of substantive ideas from students is related both to the teacher's sustained efforts to elicit such contributions and to the teacher's success in eliciting such contributions from all students. Substantive ideas are defined as those that go beyond yes/no statements or restatements of the work the student completed before the discussion.

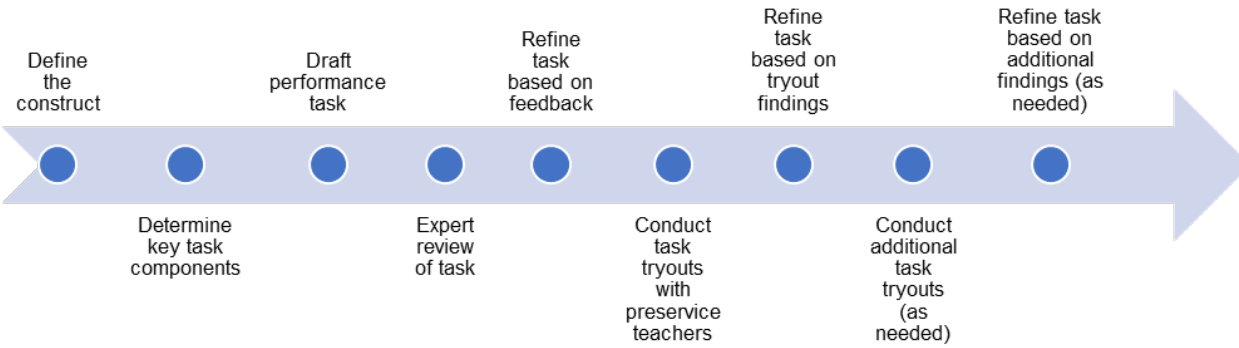
Figure 2. Example of Observable Behaviors for Indicator 1b: Elicits Substantive Contributions

Indicator	Level 1 Beginning Novice	Level 2 Developing Novice	Level 3 Well-Prepared Novice
1b. **Elicits Substantive Contributions**	The teacher does not probe students for substantive contributions or does so only once or twice. OR The teacher interacts with only one student from each group.	The teacher probes students for substantive contributions intermittently during the lesson. AND The teacher does not elicit a substantive contribution from at least one student.	The teacher probes students for substantive contributions consistently throughout the lesson. AND The teacher succeeds in eliciting one or more substantive contribution from **every** student.

Our project's advisory board, made up of teacher educators, content specialists, and researchers in mathematics and science teacher education, conducted an expert review of these dimensions and indicators. Their goal was, first, to ensure that they were adequately aligned to the construct and previous literature in mathematics and science teacher education and, second, to provide feedback on whether our characterization of high-quality discussions in the context of disciplinary argumentation adequately addressed the ways in which this teaching practice is used, valued, and characterized within each of the disciplines (elementary mathematics and science). The advisory board also identified and offered suggestions for any aspects of our construct definition that were missing, misrepresented, or not sufficiently addressed. Finally, they considered whether the progressions seemed logical, comprehensive, and scoreable and captured the most important observable teacher behaviors for each dimension and indicator.

In the design of the performance tasks themselves, we used a design-based research approach (Design-Based Research Collective, 2003) in developing and refining the task materials[1] at multiple stages and leveraging various expertise from teacher educators, researchers, preservice and in-service teachers, content experts, and assessment developers (Figure 3). After defining the construct of interest, including the specific dimensions and indicators of this teaching practice, the next step in our task design process was to determine the key task components that would provide opportunities for the preservice teachers to engage in these dimensions of this teaching practice and support us in capturing adequate evidence across all five dimensions.

Figure 3. Progression of the Design-Based Research Process



The task materials include two types of components: the preservice teacher–facing and the interactor training materials. The preservice teacher–facing materials include a written document that provides information to the preservice teacher about the simulated discussion's student learning goal, where this discussion fits into a larger instructional sequence, and what the instructional activities are that the student avatars engaged in prior to this discussion. This document also shows the preservice teacher written work samples that the student avatars generated prior to the discussion, which provides the preservice teachers with insight into the students' sense-making about the specific mathematics problem or science investigation that is the focus of the discussion. In addition, we developed materials to train the interactor. These training materials are designed to help the interactor learn about the student avatars' initial ideas and understandings related to the mathematics problem or science investigation that is the focus for the discussion. These materials also support the interactor in learning about the circumstances under which the student avatars can arrive at new understandings based on ideas and arguments that the preservice teacher or the other students make during the discussion. This level of training is also critical in helping to support the standardization of opportunity across preservice teachers so that experiences in the simulated classroom are comparable in the level and nature of challenge each preservice teacher encounters (Howell & Mikeska, 2021). We describe specific components for these task materials, including how we designed them to capture adequate evidence of the five dimensions of this teaching competency, in the final section of this manuscript.

The next step in our task development process included an expert review of the performance task materials to ensure that the task components (both preservice teacher and interactor facing) worked synergistically to gather observable evidence of the preservice teachers' ability to facilitate argumentation-focused discussions. Reviewers included our advisory board members and assessment development experts, who reviewed the preservice teacher–facing materials to ensure that (a) the task provided opportunities for the preservice teachers to engage the student avatars in the practice of mathematical or scientific argumentation; (b) the written student work samples captured a range of typical responses for upper elementary students regarding the specific mathematics problem or science investigation that was the focus of the discussion; and (c) the educative features in the task would be useful to support preservice elementary teachers in learning how to facilitate high-quality, argumentation-focused discussions centered around these student learning goals. Reviewers also considered whether each of the preservice teacher–facing task components—such as the student learning goal, specific instructional scenario, task description, and student profiles—were clear, appropriate, and sufficient for the intended audience. In terms of the interactor training materials, reviewers focused on ensuring that we identified reasonable responses for the interactor to use as the discussion unfolds in the simulated classroom and that the responses did not limit or misrepresent the preservice teachers' ability to engage in this teaching practice. Our research team then revised these task materials based on the experts' feedback. These revisions included a variety of different changes across these tasks, such as more clearly articulating the discussion's student learning goal, modifying the written student responses to better align with grade-level expectations, refining the teaching tips to provide more robust educative supports for the preservice teachers, and updating the lesson overview and background sections to ensure that the preservice teachers understood where they were being dropped into a larger instructional sequence.

Once we had developed task materials that we hypothesized would allow us to make valid inferences about preservice teachers' ability to facilitate argumentation-focused discussions, we then engaged in a set of tryouts for each performance task. For each tryout, we recruited five to 10 preservice teachers to pilot the task with us within the simulated classroom.

Prior to each tryout, our research team trained interactors on how to enact the student avatars' responses in alignment with the student thinking profiles developed for each task. During the interactor training, we systematically gathered additional information to inform revisions of those materials, assigning a team member as a dedicated observer for each section of training to document where the interactors needed additional support.

For the tryouts, each participating preservice teacher reviewed the preservice teacher–facing task document to prepare for their simulated discussion and then facilitated a discussion for up to 20 minutes with the five student avatars in the simulated classroom. Our research team video recorded these discussions and later scored each one based on the scoring rubric we had developed from the five dimensions of our construct and the progression levels for each dimension. We also gathered self-reported data from each preservice teacher via a task survey and semistructured interview to learn about their perceptions of the task authenticity, interactions with the student avatars, their discussion performance, and the usefulness of the simulated teaching experience integrated within mathematics and science elementary method courses. Our research team analyzed these data sources to identify patterns in the preservice teachers' perceptions of these task materials and their discussion performances and then used the tryout findings to refine the task materials and our scoring rubric further.

These revisions, like those that took place after expert review, included attention to the clarity of wording throughout the preservice teacher–facing materials, which involved simplifying wording and presentation, refining the teaching tips to call attention to points that had been misunderstood, and in a few cases, revising the core content of the task to better fit the 20-minute time limit. We also revised interactor training materials to provide more support in areas that we had observed to be difficult and to refine language where we had observed it to be confusing to one or more interactors during training. For four of the eight tasks, the resulting revisions were substantial enough to warrant a second round of tryouts using a similar process of data collection, analysis, and task refinement.

Once we finalized the task materials and scoring rubric based on the tryout findings, we then used them in the research project's main study within multiple sections of elementary mathematics and science courses at three different universities in the United States.

Section 2: Content Focus of the Performance Tasks

Each set of performance tasks in mathematics or science is grounded in a single high-leverage content area, which, as described in Martin-Raugh et al. (2016), is operationalized following the model of Ball and Forzani's (2011) high-leverage practice framework to include content of the student curriculum that is foundational, spans multiple grade levels, and makes up a significant component of the student curriculum and in which students often struggle absent strong instruction. In other words, it is the content that is most consequential for students to learn well and, therefore, most important for teachers to teach skillfully. In science, the content area of focus is matter and its interactions; in mathematics the content area of focus is fractions and operations with fractions.

Content Focus of the Science Tasks

In 2018, Martin-Raugh et al. identified matter and its interactions as one of the high-leverage content topics within the elementary science curriculum via a systematic analysis of the science performance expectations in the Next Generation State Standards (National Research Council, 2013) and a survey of elementary teachers and faculty members. Research literature has also widely acknowledged that matter and its interactions is a difficult content area for teachers to learn how to teach; however, there exists a broad empirical research base on which to model common student understandings and misunderstandings (Smith et al., 2006; Stevens et al., 2010).

One goal of this focus on high-leverage content was to create a coherent and connected set of performance tasks that would fit together across the time span of a semester, make sense in sequence, and include core content that teacher educators likely would have made a focus of instruction in their work with preservice elementary teachers. Within the set of science performance tasks, the Mystery Powder performance task, unlike the others, was designed to be used as a pre and post measure at the beginning and end of an elementary methods course and therefore needed to be conceptualized such that it would be reasonable for preservice teachers to engage in before and after the other three tasks. Identifying materials based on their properties is a topic that teachers often return to at different points of the curriculum and in which students can engage with different levels of sophistication across multiple grades, making it a good fit to this purpose. The other three performance tasks—Conservation of Matter, Modeling Matter, and Changing Matter—were designed to be presented in order across the semester, as this was our envisioned use case, while still standing alone if used individually outside of this sequence.

The Conservation of Matter task focuses on determining whether matter is conserved when combining sugar, water, and lemon juice to make lemonade and deciding what observations to use as evidence to make that determination. The Modeling Matter task is organized around three different drawn models showing what happens when a drop of food coloring is added to a container of water and involves the students in coming to a consensus about the features of an improved model that would better describe and explain this phenomenon. The Changing Matter task is grounded in the question of what evidence indicates that a new substance has been formed and involves the students in considering whether a new substance was formed when mixing different substances together (baking soda and pepper; white vinegar and baking soda; and white vinegar and milk).

This ordering of ideas meets two prespecified criteria. First, this sequence allows the student avatars to appear to advance through a typical science instructional sequence by moving from a focus on considering the structure and properties of matter during physical changes to then considering specific properties of matter and how they can be used as evidence to differentiate between physical and chemical changes. Second, the specific science of each task does not depend directly on the science of the prior task, minimizing instances where a preservice teacher might expect a particular student avatar to remember the exact content of the prior task. The Mystery Powder, Conservation of Matter, and Changing Matter tasks are described in detail in other reports in this series. In the following section we describe in more detail the Modeling Matter task, which is the focus of this report.

The Modeling Matter Science Task

The Modeling Matter performance task is focused on having students construct an argument about the strengths and weaknesses of models that represent what happens to a drop of food coloring when it is added to a container of water. Prior to the discussion, the students engaged in a few different class activities that involved developing and using models to represent ideas and explanations. First, the students completed the Salt Water Investigation, where they made observations of an uncovered container of salt water over the course of 10 days. After conducting these observations, the students watched a short video showing the movement of particles in solids, liquids, and gases and engaged in a kinesthetic activity to model the movement of water particles in the Salt Water Investigation. Then, the students worked together to generate a consensus model showing what happened on Days 1, 3, and 5 of the Salt Water Investigation as the water evaporated from the container. In addition to these activities as part of the Salt Water Investigation, the students observed what happened to a drop of food coloring when it was added to a container of water. Each student group then selected which model, from a set of three different models (Model A, B, or C) drawn by students in another class, best represented what they thought was happening in the Dye Drop Investigation. Each student group also completed a written prompt in their science notebooks explaining why they selected the model they did.

The preservice teacher is provided a packet of materials (the preservice teacher–facing materials) prior to facilitating the discussion in the simulated classroom following a template used across the full set of tasks. The packet describes the work that five students have already completed on the science investigation, including showing written work from each student or group of students. For this particular task, two students, Carlos and Emily, worked together, and Mina, Will, and Jayla worked together in a group of three.

Carlos and Emily thought that Model A best represented what happened in the Dye Drop Investigation at the 0-, 5-, and 10-minute marks after the drop of food coloring was added to a container of water. They liked how Model A showed the food coloring as continuous strands of matter that spread throughout the container over the 10 minutes and incorrectly inferred that the food coloring “strands” were “melting” into the water. The other group, Mina, Will, and Jayla, selected Model B as the one that best represented what happened in the container of water in the first 10 minutes after adding food coloring to the container. These students focused on how this model showed the red food coloring particles spreading throughout the water container, although they incorrectly believed that the food coloring particles were replacing the water particles over time.

Each model, including the one that was not selected by either group, offers useful aspects for consideration. In addition, the various evidence-based reasoning processes the students use are variably useful for justifying their model selection. This intentional variation across the two groups provides opportunities for the preservice teacher to guide the students in critiquing and comparing their model selection, to elicit justifications for their claims about which model best represents this scientific phenomenon, and to guide them toward consensus about an improved model that better describes and explains this phenomenon.

Section 3: The Generalized Task Design

As referenced previously, one of the outcomes of the design-based research process described in the first section was the development of a stable set of task components to be used across all eight (four science and four mathematics) tasks and designed to support a consistent experience for preservice teachers. The resulting template can be used to support future development by providing a structure for newly developed tasks with different content and is described here in the context of the Modeling Matter task.

Each task is made up of two types of components: the preservice teacher–facing materials and the interactor training materials. Table 2 lists the task components of the preservice teacher–facing materials, which includes three documents for each task. The Introduction to the Simulated Classroom and the Warm-Up Task are separate handouts that are used in common across all eight performance tasks and provide an overview of how the simulation works and a brief familiarization exercise to get the preservice teacher started before they lead the discussion. The main document is the performance task itself (see the appendix for the full text of the Modeling Matter performance task), which is designed to help the preservice teacher plan for and lead the discussion. Task components included in the preservice teacher–facing task document include the sections Introduction to the Task, Lesson Overview, Student Responses, Making Sense of the Student Work, Shared Workspace Pages, Features of High-Quality Discussions Focused on Argumentation, and Video Examples of High-Quality Discussions Focused on Argumentation. Teaching tips appear throughout the document rather than as a separate section.

Table 2. Components of the Preservice Teacher–Facing Task Materials

Component	Purpose
Introduction to the Simulated Classroom (separate handout)	This stand-alone handout acquaints the preservice teacher with the basic functionality of the simulated classroom as well as introduces them to each of the five students via short bios. It also includes links to short videos in which the students introduce themselves.
The Warm-Up Task: Taking the Students' Lunch Orders (separate handout)	The warm-up task, which takes about five minutes, is a scripted task in which the preservice teacher takes the students' lunch orders. It is intended to allow the preservice teacher to become accustomed with the simulated environment before starting the discussion.
Introduction to the Task	This task component orients the preservice teacher to the task. It includes a clear statement of the student learning goal and what the preservice teachers should aim to do during the discussion.
Lesson Overview	This task component situates the 20-minute discussion within the larger lesson and instructional sequence, describing students' background knowledge as well as what transpired in the class before the discussion began.
Student Responses	This task component provides each student group's written work, which was generated prior to the discussion.
Making Sense of the Student Work	This task component complements the student responses and provides explanatory text to help the preservice teacher understand the students' written work. The explanatory text identifies salient features of the students' ideas that might inform the discussion.
Shared Workspace Pages	This task component includes copies of the written student work and any other relevant reference material (e.g., class data table). It can be printed out for use during the discussion.
Features of High-Quality Discussions Focused on Argumentation	This task component is a short list of the key features of high-quality discussions as we have defined them and includes a set of questions about each feature. The preservice teacher can use the questions before or after the discussion to support them in considering how well their discussion will or did meet the task's specified student learning goal.

Component	Purpose
Video Examples of High-Quality Discussions Focused on Argumentation	This task component provides links to publicly available examples of classroom discussions that illustrate some of the features of high-quality argumentation-focused discussions. The preservice teacher can use the examples to better understand these features and how to incorporate them into their discussion.
Teaching Tips	This task component is embedded throughout the preservice teacher–facing materials and includes teaching tip bubbles that call attention to important ideas about how the discussion might be planned and enacted.

Table 3. Components of the Interactor Training Materials

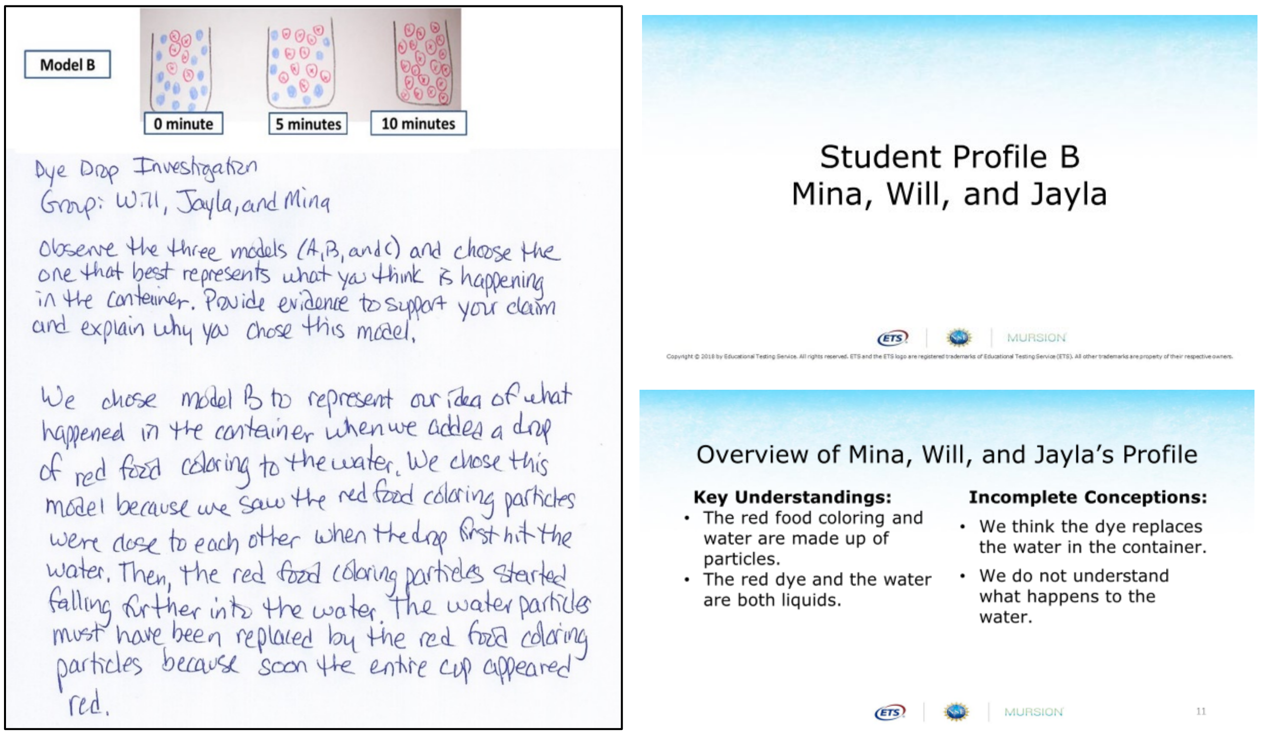
Component	Purpose
Non-Task-Specific Training	The non-task-specific training materials cover the discussion construct, direct interactors in how to be responsive to teacher prompts to engage in student-to-student interaction, and include the "testing the waters" guidelines. This component also includes independent study of the warm-up activity materials and culminates with an interactive practice session between the interactor and a trainer.
Task-Specific Lessons 1 & 2	For each task, Lesson 1 is an overview of the task and Lesson 2 is an overview of the student profiles for that task, including independent video-guided study of what each student thinks initially as well as how their thinking may shift over time.
Task-Specific Lesson 3: The Student Profile Check Out	Lesson 3 is a face-to-face session in which the trainer leads the interactor through a standardized set of questions to ensure adequate mastery of the student profiles for the task.
Task-Specific Lesson 4: The Observational Workshop	For Lesson 4, the interactor meets with two trainers, one of whom plays the part of a teacher and enacts four separate practice discussions while the second trainer provides targeted feedback on the interactor's performance. The four teacher profiles are carefully constructed to represent the breadth of discussion approaches the interactor is likely to encounter.
Task-Specific Lesson 5: The Final Check Out	Lesson 5 is also a face-to-face session with a trainer who enacts two more teacher profiles. Recordings of the session are uploaded and scored by the trainer for adequate fidelity to interactor training guidelines.

Table 3 lists the components of the interactor training materials, including a series of lessons that combine self-study modules with planned interactive practice with a content expert or trainer in order to help the interactor master the delivery of the task in the simulated classroom.

The content of the preservice teacher and interactor components are deeply intertwined. For example, a core part of the preservice teacher–facing materials is the presentation of student work that the student avatars have completed in advance of the simulated discussion (component: Student Responses). Every task includes this component, although the number of student groups varies. For each task, then, this necessitates a parallel component of the interactor training (component: Task-Specific Lessons 1 & 2) in which the interactor learns the student avatars' initial ideas and the work they have done prior to the discussion as well as their dynamic content profiles that dictate how their understandings would change over time in response to the teacher's (or other student avatars') statements or questions. For example, for the Modeling Matter task, the written student work explains which model Mina, Will, and Jayla selected as the one that best represents what they thought was happening in the container of water with the food coloring added (Model B), as well as provided their evidence and reasoning to support their model selection. The accompanying interactor training specifies that they understand that the food coloring and water are both liquids and made of particles, although their understanding about what is happening to the water in the container over time could use some revisions (Figure 4).

All components were designed, to the greatest extent possible, to be uniform in ways that are adaptation-friendly, allowing for the insertion of new content as needed to create new tasks. We next discuss some of the critical design considerations that informed our design of the task components using specifics from the Modeling Matter task to illustrate how some of these considerations are taken up and addressed in this performance task.

Figure 4. Linked Components of Materials Include Student Work (for the Preservice Teacher) and Instructional Videos (for the Interactor)



Design Consideration: Knowing Where to Start

The stand-alone Introduction to the Simulated Classroom as well as the Introduction to the Task and Lesson Overview components of the preservice teacher–facing materials are collectively intended to support the preservice teacher in knowing how to begin the discussion. In early tryouts, we realized that one of the logistical elements of the simulation we needed to manage was launching the preservice teacher straight into the discussion, as each teacher has only 20 minutes of simulation time and needs to use it for the intended interactive work of facilitating a discussion. A preservice teacher who spends time doing something else might well use up the full 20 minutes without engaging in the intended content discussion. For example, a natural starting point for preservice teachers encountering new students is to review prior knowledge, but reviewing what they already know takes time away from addressing the student learning goal in the task during the discussion. The Introduction to the Simulated Classroom, Introduction to the Task, and Lesson Overview components acquaint the preservice teacher with the students' prior knowledge and describe exactly what has come before the discussion so that the preservice teacher has a clear sense of where they are to begin the discussion.

Design Consideration: Understanding the Task Purpose

One area in which we found it necessary to build in substantial support across task components was helping the preservice teachers understand that they should be encouraging students to interact with one another directly. Many novice teachers struggle to engage students in this way. In contrast, a frequent and less productive pattern of engagement is known as the initiate—respond—evaluate (IRE) response pattern (Cazden, 1988) in which the teacher interacts with individual students in turn, intervening at each step. One goal of these performance tasks is to support preservice teachers in learning to avoid this pattern. However, if the preservice teachers interpret the instruction to "facilitate a discussion" as asking them to engage in IRE, they may not realize that they are not attempting to meet the intended goal. Paired with a technology environment in which a preservice teacher may not realize the students can speak to one another directly, there is some risk of misdirection on the preservice teacher's part. That misdirection would have represented a source of measurement error for us as it would be difficult to distinguish performances in which the preservice teacher was unable to elicit student interaction from those in which the preservice teacher did not understand that student interaction was possible.

We sought to counter this challenge in several ways across components of both the preservice teacher–facing and interactor training materials. First, we clarified the discussion goal across all tasks to make it clear that student-to-student interaction was possible and desirable. For example, Figure 5 shows text from the Introduction to the Task component stating, "You can encourage the students to talk to one another, ask one another questions, and respond to one another's ideas." Along with this instruction is a teaching tip bubble that cautions the preservice teacher to allow wait time for students to respond.

Figure 5. Text From the Introduction to the Task Component Supporting Student-to-Student Dialogue

TEACHING TIP:
The student avatars are not computer programmed, so it may take them a little time to think and respond.

You will have up to 20 minutes to lead this discussion in a simulated classroom environment made up of five upper-elementary student avatars. The students will be able to hear and see you, and they will respond in real time just like students in a real classroom. You can encourage the students to talk to one another, ask one another questions, and respond to one another's ideas.

Depending on how the discussion unfolds, you may or may not reach a satisfying conclusion by the end of the session time, and it is fine if you do not. If you do not reach a satisfying conclusion, just wrap up the discussion and indicate that you will pick the discussion up during the next class.

Then, on the interactor side, we built in two deliberate instances of student-to-student dialogue intended to help make sure the preservice teacher is aware that direct student interaction is possible (both of these instances are addressed as part of non-task-specific training as they are common across all eight tasks). First, during the warm-up task, one student jumps in and speaks directly to another student. Second, at some point during the first few minutes of the discussion, the interactor is instructed to engage in what we call "testing the waters," by having one student jump in and engage in a brief back-and-forth dialogue with another. In general, the interactor will not have the students engage in this way without prompting, as the preservice teacher is supposed to be learning how to elicit such interaction. But for testing the waters, the interactor makes an exception. This dialogue serves two purposes: First, it is an additional reinforcement to the preservice teacher that students can speak directly with one another, and second, it gives the interactor valuable information about the preservice teacher's initial stance toward how student centered they would like the discussion to be. If the preservice teacher tries to quiet the students or asks them to raise hands, these are signs that the preservice teacher may be discouraging direct student-to-student interaction. However, if the preservice teacher encourages or praises the students or tries to build on the interaction, these are signs that the preservice teacher may be encouraging it.

Design Consideration: Support in Unpacking Student Thinking

Each task is designed on the premise that students have already worked on a given science investigation in advance of being called together to discuss their work. The students' written work is provided ahead of time (task component: Student Responses) so that the preservice teacher can review and plan the discussion based on it. In addition, we provide information to the preservice teacher to help them make sense of the written student work (task component: Making Sense of the Student Work). This text specifies, for example, whether the claim the students have given is correct, partially correct, or incorrect and what they might have been thinking about and calls attention to important things the preservice teacher might notice or pay attention to in planning the discussion.

Figure 6. Making Sense of the Student Work Component for Mina, Will, and Jayla

Making Sense of Mina, Will, and Jayla's Work

Is the claim correct?

- The group's claim that model B is the best model is partially correct.
- They are correct when they initially describe the food coloring and water as particles.
- They are also correct when observing that the model represents the spread of the particles of food coloring through the water particles.
- However, the students are not correct when they claim that the food coloring "replaces" the water particles. Their argument does not attend to the fact that both the water and the food coloring particles are still present in the container, which is not shown in model B.

Things to notice about Mina, Will, and Jayla's observations of the movement of food coloring through the water and the model that they chose:

- They accurately applied what they learned in the earlier activities, insofar as they understand that the food coloring and water are made up of different types of particles, which they learned about from the Salt Water Investigation.
- They describe the movement of the particles of food coloring as "falling" through the water particles.
- They chose model B because it shows only red particles at the end of the investigation. They incorrectly describe the food coloring as "replacing" the water because the entire cup appears red at the end of 10 minutes.

Things to notice about Mina, Will, and Jayla's explanation:

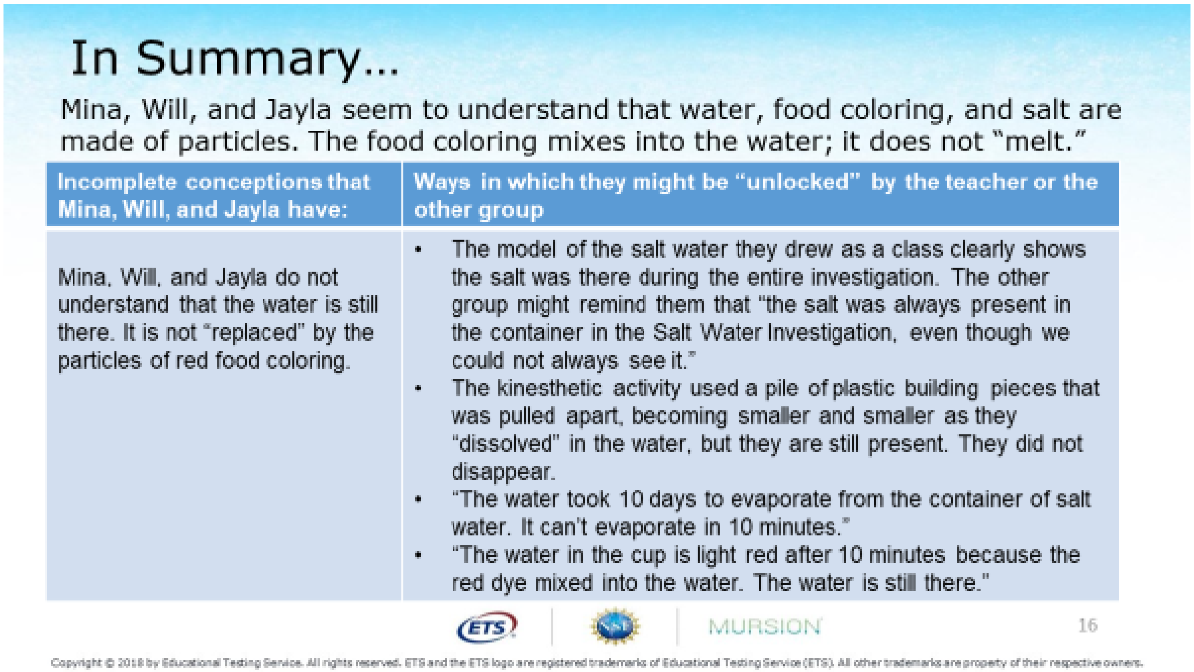
- The group's explanation demonstrates that the students see the food coloring and water as being two different types of particles. They understand that both the food coloring and the water are liquids and that the particles are in motion.
- Their description of the food coloring as "falling" through the water is based on the movement of the red coloring that they can see, eventually creating a light red liquid in the cup at the end of the 10 minutes.
- They are not able to explain what happens to the water particles since the cup appears light red in the end, so they incorrectly state that the food coloring replaces the water particles in the cup.
- They do not use the evidence they learned in the Salt Water Investigation (e.g., that the salt was still present, even when it could not be seen) to consider whether this makes sense.

For example, for Mina, Will, and Jayla's work discussed previously, this text states that their claim is partially correct and the evidence-based reasoning they used to justify the model they selected was partially supported by their observations and what they learned from their previous class activities (Figure 6). Further, it directs the teacher to notice that Mina, Will, and Jayla understand that the food coloring and water are composed of particles, but that they are not correct in their thinking that the food coloring particles "replace" the water particles over time.

Design Consideration: Static and Dynamic Student Profiles

As mentioned previously, interactor training includes both static profiles for students' personalities and initial content ideas as well as dynamic profiles reflecting their likely patterns of change. One characteristic of these tasks is that the students will contribute most of the key ideas if the preservice teacher is facilitating the discussion in a productive way. This means that interactors need training in both when to introduce those ideas and how the individual student avatars should respond to those ideas or sets of ideas, whether presented by the preservice teacher or by other students in response to the preservice teacher's prompting. In the Modeling Matter task, for example, one group, Mina, Will, and Jayla, proposed a partially correct claim and evidence-based reasoning for selecting and justifying the model that best represents what happened in the Dye Drop Investigation. The interactor training (Figure 7) notes specific ways in which their thinking would (and would not) shift, including noting that just seeing the other students' claims and evidence-based reasoning would be insufficient for them to change their thinking. The interactor training materials specify key ideas that would need to be addressed during the discussion to shift Mina, Will, and Jayla's understanding. For this group, they would need to understand that the water is still there after 10 minutes and the food coloring particles are not replacing the water particles over time. Changes to their understanding about what is happening to the food coloring and water particles in the Dye Drop Investigation could occur in a few different ways. For example, the other students or the teacher could refer to the empirical evidence from the earlier Salt Water Investigation showing how the water in the uncovered container took 10 days, not 10 minutes, to evaporate. Alternatively, they could mention how the model they generated and kinesthetic activity they did to illustrate what happened in the Salt Water Investigation showed how the salt particles were still present and did not “disappear” or were replaced.

Figure 7. Slides From the Interactor Training: Unlocking Mina, Will, and Jayla’s Thinking



Conclusion

The preservice teacher–facing materials for the Modeling Matter task can be found in the appendix. Our goal in this project was to create a set of simulation-based performance tasks that can be used to support preservice teachers in learning how to facilitate argumentation-focused discussions in two content areas: mathematics and science. In that project work, we video recorded each preservice teacher’s discussion session for each task and provided detailed written feedback as well as access to the video to both the preservice teacher and the course teacher educator. We hypothesized that that preservice teacher would be supported on multiple levels. First, there is an aspect of experiential learning, as the preservice teacher sees the student avatars engage in response to their prompts during the simulation. Second, the preservice teacher learns from the written feedback. Although we provided feedback to the preservice teachers, that feedback could also come from a teacher educator or coach, or the preservice teacher could be guided in self-reflection. Third, the performance tasks provide a type of formative assessment information to the teacher educator who can see, in looking across the videos or the feedback, patterns in class or the individual performance that allow the teacher educator to adjust instruction within the methods course.

Our design process was deliberately systematic and was intended to support productive adaptation of the task materials that resulted. Although our work took place in the context of preservice teacher learning and for use with the Mursion simulated classroom environment, the tasks could easily be used for professional development and adapted for use in other simulation environments using other technologies or nontechnological approaches. For example, a teacher educator or coach might use the materials for the basis of live role playing and adapt the interactor training materials to help preservice teachers play the role of students. The full set of project materials, including interactor training materials and guidelines for scoring the discussions, is archived in an online repository (https://data.qdr.syr.edu/dataverse/go-discuss) and is publicly available for use and adaptation.

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Appendix: The Modeling Matter Preservice Teacher–Facing Task Materials

ETS Research Study on Facilitating Student Discussions

The Modeling Matter Discussion Task

Credit: Image courtesy of Mursion

Table of Contents

Note: The materials provided in the following sections are designed to help you plan for your discussion and should help you understand what you are supposed to do. You will also find teaching tips embedded throughout the document. An additional document, "An Introduction to the Simulated Classroom and Student Avatars," is also available for your use.

TEACHING TIP:
The teaching tips are designed to enhance your understanding of the task and your performance. You are not required to use them; instead, they are here for you to use however you wish.

Introduction to the Modeling Matter Task

What is the student learning goal for this discussion?

Student Learning Goal

Students will construct an argument about the strengths and weaknesses of models that represent what happens to a drop of food coloring when it is added to a container of water. Based on the identified strengths and weaknesses, they will build consensus on an improved model that better describes and explains this phenomenon.

What will you do?

You will lead a discussion during which you will guide students to use evidence and reasoning to come to consensus about a model that best represents what happens to a drop of food coloring when it is added to a container of water.

TEACHING TIP:
Be sure to have students focus on constructing, defending, and critiquing their own and others' claims using scientific evidence and reasoning.

Your focus should be on engaging the students in discussion with one another and in the practice of argumentation. During the discussion, be sure to have students focus on considering multiple perspectives and coming to a shared consensus.

TEACHING TIP:
The student avatars may take a little time to think and respond. Provide wait-time, just as you would in a classroom.

You will have up to 20 minutes to lead this discussion in a simulated classroom environment made up of five upper elementary student avatars. The students will be able to hear and see you, and they will respond in real time just like students in a real classroom. You can encourage the students to talk to one another, ask one another questions, and respond to one another's ideas.

Depending on how the discussion unfolds, you may or may not reach a satisfying conclusion by the end of the session time, and it is fine if you do not. If you do not reach a satisfying conclusion, just wrap up the discussion and indicate that you will pick up the discussion during the next class.

Lesson Overview

Student Learning Goal: Students will construct an argument about the strengths and weaknesses of models that represent what happens to a drop of food coloring when it is added to a container of water. Based on the identified strengths and weaknesses, they will build consensus on an improved model that better describes and explains this phenomenon.

TEACHING TIP: Everything you do in planning for and leading this discussion should help the students make progress toward the student learning goal.

Background: The students are in fifth grade. They have experience, but may not be proficient in, the following:

- Making, recording, and analyzing qualitative and quantitative observations of matter
- Making claims and supporting those claims, using evidence and reasoning
- Developing and using models as helpful tools for representing ideas and explanations

Note: Not every student has the same level of understanding or ability with the content ideas and practices noted above, but these are the learning opportunities that all students in this classroom have previously experienced.

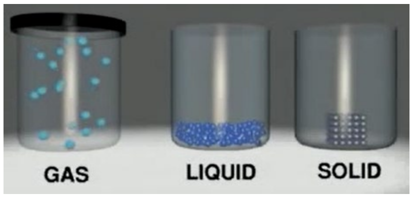
TEACHING TIP: At the fifth-grade level, students are familiar with the terms solid, liquid, and gas. Most students understand that water can change form; however, they might not fully comprehend what happens to the particles of water during evaporation.

Prior to this lesson: Over the course of a series of lessons, students worked on modeling the changes they observed in an uncovered container of salt water at room temperature. The Salt Water Investigation involved a few different activities, including the following:

- Students dissolved salt in water and then set it out at room temperature in a shallow pan to evaporate. They recorded observations as a class:

Day	Salt Water Investigation Observations
1	Before adding the salt to the water, we observed with a hand lens and noticed that the pieces (crystals) of salt were small cubes, all about the same size. After stirring, the salt was no longer visible.
5	Water level appeared to drop slightly. Some very small (<0.5 mm) crystals appear to be forming in the salt water.
10	Water is gone. A crust of solid salt crystals formed in the pan. Some of the salt crystals are square and much larger than the crystals that were poured into the water on Day 1.

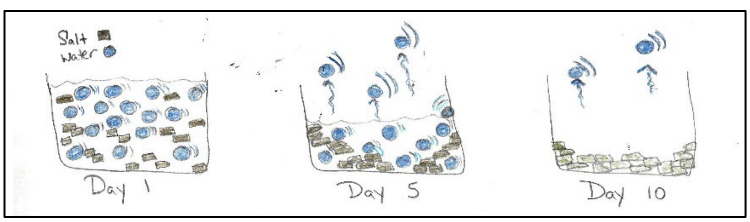
- Students then watched a video about the arrangement of particles in solids, liquids, and gases. This video explains that matter is made of particles that vibrate in place in the solid state, move more freely in the liquid state, and spread out to fill a container in the gas state.



TEACHING TIP: Understanding the particulate nature of matter is difficult for fifth-grade students. It is a common misconception that particles in solids are completely still. By viewing the video and engaging in the kinesthetic activity, students should gain a better understanding of the movement and arrangement of particles in these phases.

- After viewing the video, the students engaged in a kinesthetic activity to model the movement of water particles in the Salt Water Investigation. They began by standing inside a large circle in the gym. When told to model the movement of the water particles, the students moved around randomly but stayed contained within the circle. The instructor then placed a pile of plastic building blocks in the center of the circle to represent the salt particles. Students were told to model the dissolution of the salt into the water. The students each picked up one of the blocks and carried it around with them as they continued their random motion within the circle. Finally, the students were told to model the gradual evaporation of the water. The students placed the blocks on the floor and then moved out of the circle, one by one, leaving only the building blocks (salt particles) inside.

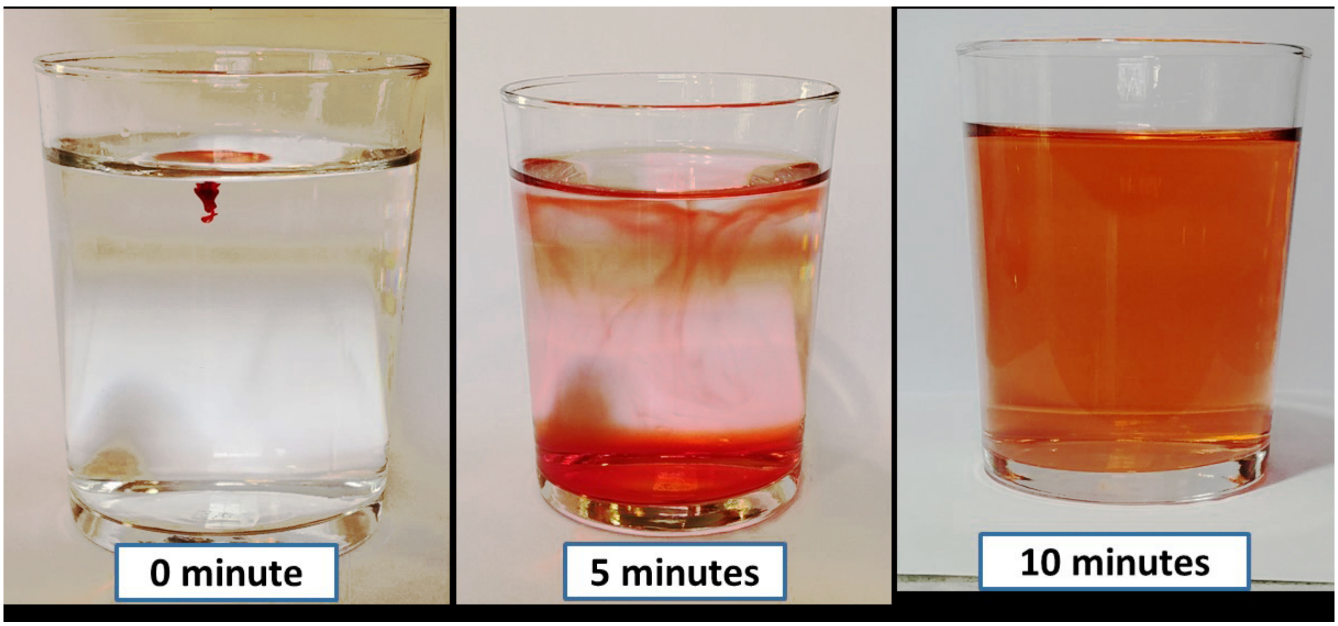
- The students concluded that when salt was stirred into the water, it dissolved and was still in the container, even though it was no longer visible. Over time, the water evaporated from the container, leaving the salt behind. The class worked together to draw models detailing the changes they observed on Days 1, 5, and 10 and came to a consensus on the model below:



TEACHING TIP: All models have inherent strengths and limitations. While this model does not accurately show the shape, size, or number of particles, it does indicate particle movement and the evaporation of the water from the container. It also clearly shows that the salt is present in the container throughout the investigation.

Dye Drop Investigation: Following the lessons from the Salt Water Investigation, the students were asked to work in small groups to study what happens to a drop of food coloring when it is added to a container of water.

- Carlos and Emily worked together, and Mina, Will, and Jayla worked together.
- Each group of students was given a container of water and given time to allow the container to rest on a stable surface.
- One drop of food coloring was added to each container of water (kept stationary on the table) and was photographed over a 10-minute period:



- The students were provided with three models of the Dye Drop Investigation that were drawn by another class (see Models A, B, and C below). They were asked to respond to the following prompt in their science notebooks:

  Observe the three models (A, B, and C) and choose the one that best represents what you think is happening in the container. Provide evidence to support your claim and explain why you chose this model.

The students wrote their work on the shared workspace in preparation for sharing with the class. (The models and the students' written work are shown in the following sections, and their work will be available to you to display and write on during your discussion with the students.)

Model A

Model B

Model C

The three models (A, B, and C) have different strengths and weaknesses, including the following:

	Strengths	Weaknesses	Ways to improve
Model A	Shows the food coloring diffusing through the water. It uses arrows to indicate movement.	Shows both liquids as continuous rather than as made up of individual particles.	Show both liquids as individual particles. Show a consistent number of food coloring particles and water particles in all three drawings.
Model B	Shows both the water and the food coloring as made up of particles. Shows the total number of particles (food coloring and water particles together) is conserved.	Shows the water particles being replaced by food coloring particles over time.	Show a consistent number of individual food coloring particles and individual water particles in all three drawings. Show the movement of particles.
Model C	Shows water particles in all three drawings.	Shows the food coloring as one large clump that breaks up into smaller pieces over time.	Show the food coloring as made up of the same number of small particles in all three drawings, dispersing into the water over time. Show the movement of particles.

An improved model might include some of the following key features:

- Show both the water and the food coloring as made up of particles.
- Show the number of water particles and the number of food coloring particles conserved throughout all three drawings.
- Show the food coloring particles as having moved randomly through and mixing with the water particles over time.
- Show the mixing of particles increasing with time.

TEACHING TIP:
There are many ways that you can guide the students to develop a consensus model. For example, you could have students do the following: (a) revise Models A, B, or C on the shared workspace; (b) draw a new consensus model on a blank page of their shared workspace; (c) make a list of the key features they would want to include in the class consensus model; and/or (d) develop a graphic organizer to show the key features of a consensus model.

Student Responses: Carlos and Emily's Work

Model A

Dye Drop Investigation
Carlos & Emily

Observe the three models (A, B, C) and choose the one that best represents what you think is happening in the container. Provide evidence to support your claim and explain why you chose this model.

Model A is the best model for what we observed because it shows what we saw happening in the container of water. The food coloring started at the top of the glass. The food coloring started out as strands and strings. The strands got thinner and thinner as they spread into the water. As the strands spread into the water, we see them melting into the water. After a few minuets, the strands had spread all through the container and the water changed color and became a lighter-colored version of the food coloring.

TEACHING TIP: Students will often imprecisely use common scientific terms such as "melting." Melting is the change of a substance from a solid into a liquid. This group does not consider that the food coloring is already a liquid and will not undergo a change of state when it is added to water. In addition, this group seems to have the misconception that matter is continuous, comes in every form all around us, and could be divided and subdivided into smaller and smaller pieces without limit. They do not yet grasp that all matter is made of fundamental, indivisible particles.

Making Sense of Carlos and Emily's Work

Is the claim correct?

- The group's claim that Model A is the best model is partially correct.
- Their claim that food coloring is a set of strands of matter—as shown in Model A— is not correct. The food coloring is made of particles of matter, just as the water is.
- Their claim that the food coloring spreads all through the container is correct, but the food coloring is already a liquid and does not "melt," as the students claim.

Things to notice about Carlos and Emily's observations of the movement of food coloring through the water and the model that they chose:

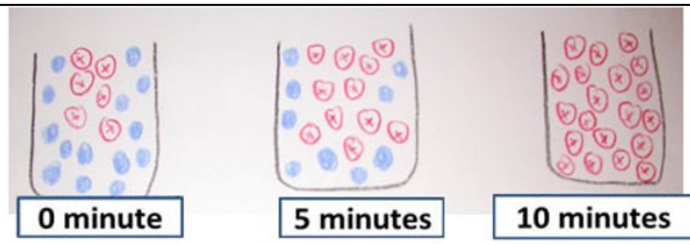
- They do not recognize that the food coloring is composed of many small particles that are in motion. The students' observations led them to infer that the food coloring was made up of strands.
- They claim that the strands of food coloring seem to get smaller and smaller as they spread out and "melt" into the water. They are misapplying the concept of melting, interpreting the spread of the food coloring into the water as something similar to the melting of a substance. The visual similarity to melting may have produced a misconception about the process taking place.
- They see both water and food coloring as continuous substances; they do not apply information from the Salt Water Investigation to their thinking about this new phenomenon.

Things to notice about Carlos and Emily's explanation:

- This group does not understand that water is made up of small particles in motion.
- They claim that the food coloring is made up of strands based solely on what they see; they are not using the evidence they learned in the Salt Water Investigation that showed them that matter is made up of particles too small to be seen.
- They characterize the movement of the food coloring as melting into the larger volume of water. This observation is consistent with their belief that matter is a continuous structure and not composed of small pieces or particles. They do not provide any evidence for why the food coloring (a liquid) would "melt" in water.
- They recognize that the "strands" seem to get smaller (thinner), which makes them hard to see separately, causing the water to take on a new color as the thin strands of food coloring spread out through the water.
- They notice that the model uses arrows to indicate the movement of the food coloring as it spreads through the water.

Student Responses: Mina, Will, and Jayla's Work

Model B



Dye Drop Investigation
Group: Will, Jayla, and Mina

Observe the three models (A, B, and C) and choose the one that best represents what you think is happening in the container. Provide evidence to support your claim and explain why you chose this model.

We chose model B to represent our idea of what happened in the container when we added a drop of red food coloring to the water. We chose this model because we saw the red food coloring particles were close to each other when the drop first hit the water. Then, the red food coloring particles started falling further into the water. The water particles must have been replaced by the red food coloring particles because soon the entire cup appeared red.

Making Sense of Mina, Will, and Jayla's Work

Is the claim correct?

- The group's claim that Model B is the best model is partially correct.
- They are correct when they initially describe the food coloring and water as particles.
- They are also correct when observing that the model represents the spread of the particles of food coloring through the water particles.
- However, the students are not correct when they claim that the food coloring "replaces" the water particles. Their argument does not attend to the fact that both the water and the food coloring particles are still present in the container, which is not shown in Model B.

Things to notice about Mina, Will, and Jayla's observations of the movement of food coloring through the water and the model that they chose:

- They accurately applied what they learned in the earlier activities, insofar as they understand that the food coloring and water are made up of different types of particles, which they learned about from the Salt Water Investigation.
- They describe the movement of the particles of food coloring as "falling" through the water particles.
- They chose Model B because it shows only red particles at the end of the investigation. They incorrectly describe the food coloring as "replacing" the water because the entire cup appears red at the end of 10 minutes.

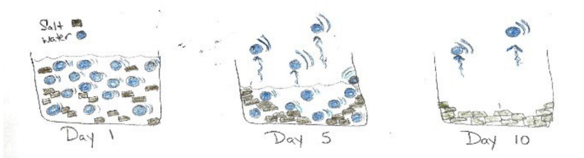
Things to notice about Mina, Will, and Jayla's explanation:

- The group's explanation demonstrates that the students see the food coloring and water as being two different types of particles. They understand that both the food coloring and the water are liquids and that the particles are in motion.
- Their description of the food coloring as "falling" through the water is based on the movement of the red coloring that they can see, eventually creating a light red liquid in the cup at the end of the 10 minutes.
- They are not able to explain what happens to the water particles because the cup appears light red in the end, so they incorrectly state that the food coloring replaces the water particles in the cup.
- They do not use the evidence they learned in the Salt Water Investigation (e.g., that the salt was still present, even when it could not be seen) to consider whether this makes sense.

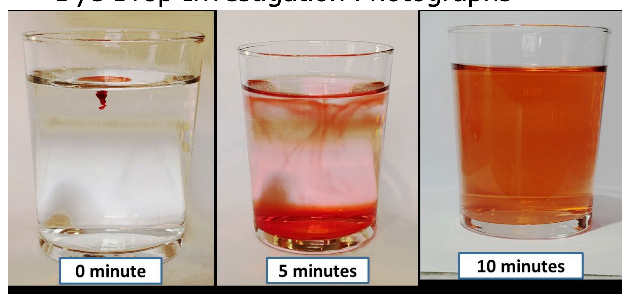
Shared Workspace Pages

The following are images of the shared workspace pages that will be available on the tablet. You and the students will be able to access and interact with these pages during the discussion. The tools on the toolbar can be used to draw or write on the pages. Blank pages are also available for you to use during the discussion.

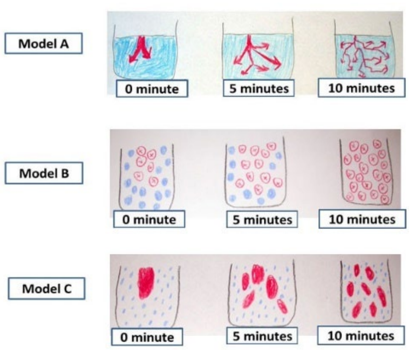
Salt Water Investigation Model



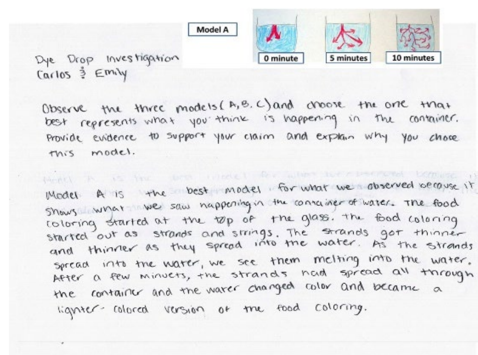
Dye Drop Investigation Photographs



Dye Drop Investigation Models



Carlos and Emily's Student Work

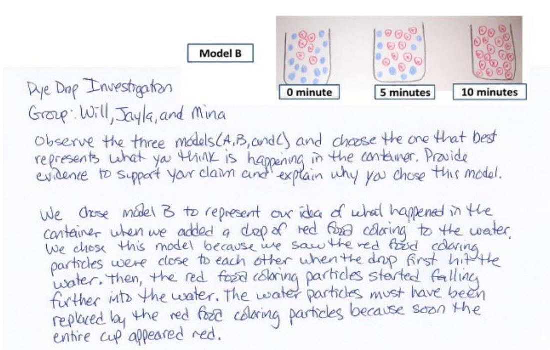


Dye Drop Investigation
Carlos & Emily

Observe the three models (A, B, C) and choose the one that best represents what you think is happening in the container. Provide evidence to support your claim and explain why you chose this model.

Model A is the best model for what we observed because it shows what we saw happening in the container of water. The food coloring started at the top of the glass. the food coloring started out as strands and strings. The strands got thinner and thinner as they spread into the water. As the strands spread into the water, we see them melting into the water. After a few minuets, the strands had spread all through the container and the water changed color and became a lighter-colored version of the food coloring.

Mina, Will, and Jayla's Student Work



Dye Drop Investigation
Group: Will, Jayla, and Mina

Observe the three models (A, B, and C) and choose the one that best represents what you think is happening in the container. Provide evidence to support your claim and explain why you chose this model.

We chose model B to represent our idea of what happened in the container when we added a drop of red food coloring to the water. We chose this model because we saw the red food coloring particles were close to each other when the drop first hit the water. then, the red food coloring particles started falling further into the water. The water particles must have been replaced by the red food coloring particles because soon the entire cup appeared red.

Blank Pages

Features of High-Quality Discussions Focused on Argumentation

The discussion task you have been asked to complete is complex, and there are multiple approaches that you might take. The following list is a series of reflection questions for you to consider as you plan to lead a productive **discussion focused on engaging students in the practice of argumentation**. These features identify the main characteristics of high-quality discussions focused on argumentation. You might expect a helpful observer, such as a coach, peer, or instructor, to provide feedback on these features when observing your teaching in order to help you reflect on and learn from the experience.

1. **Attending to Students' Ideas:** Did I make sure every student's voice was heard and that all students' ideas were valued?
    - Did I give every student an opportunity to participate in meaningful ways?
    - Did I make sure to include all ideas that students shared in their previous work?
2. **Facilitating a Coherent and Connected Discussion:** Did the discussion make sense and feel organized and purposeful to the students?
    - Did I help the students make connections and build toward a shared understanding?
    - Did I help the students make sense of the discussion so that they could summarize the main takeaways and know what was learned?
3. **Encouraging Student-to-Student Interactions:** Did I succeed in getting students to engage in discussion with one another?
    - Did I encourage students to speak to one another directly?
    - Did I provide opportunities for students to pose questions to one another or comment on and critique one another's ideas?
4. **Developing Students' Conceptual Understanding:** Did I support students in developing a correct content understanding during the discussion?
    - Did I represent science concepts correctly?
    - Did I give students opportunities to evaluate the correctness of content ideas so that they could learn how to be part of the process of critiquing those ideas?
    - Did I consider any science content errors students had during the discussion and support students in working together to address those areas of confusion?
5. **Engaging Students in Argumentation:** Did the discussion allow students to engage in argumentation?
    - Did I focus the discussion on ideas that were worth debating?
    - Did I provide opportunities for the students to make claims or conjectures, support them with reasoning or evidence, and consider and critique their own and others' ideas?

TEACHING TIP: In order to engage students in the practice of scientific argumentation, your goal should be getting students to talk to one another and to critique and build on one another's claims, evidence, and reasoning.

Video Examples of
High-Quality Discussions Focused on Argumentation

Learning how to facilitate discussions focused on argumentation can be challenging. Observing examples of students and teachers engaged in these types of discussions can be helpful. The following video links will allow you to see what it looks like and sounds like when elementary and middle school students engage in productive argumentation in science classrooms. We have also provided you with some questions to think about as you view these video examples and prepare to lead a productive **discussion focused on engaging students in the practice of argumentation**.

Video focus	Things to notice	Video link[a]
Promoting student-to-student interaction	• How did the students engage in discussion with one another? • How did the teacher promote student interaction?	Student Interaction
Promoting students' evaluation and critique of competing claims	• How did the students question and critique each other's ideas? • What activities and strategies did the teacher use to help students address competing ideas?	Competing Claims
Encouraging students' use and evaluation of the quality of evidence	• How did the students use evidence to support their claims? • How did the teacher encourage students to consider the appropriateness and sufficiency of their evidence?	Quality Evidence
Supporting students in making their reasoning clear	• How did the students use scientific ideas to connect their claim and evidence? • What activities and strategies did the teacher use to help students explain their reasoning?	Reasoning

[a]These video examples are part of the Argumentation Toolkit website at www.argumentationtoolkit.org

Notes

[1] The development of the simulated environment also included feedback from multiple stakeholders, including our advisory board, and a compilation of reviews and iterative refinements to the students' physical appearance as well as their voicing, background, and personality profiles. Although this development process happened concurrently, it is not described in this report.