The 8 Stages of ADI

Stage 1. Identify the Task and the Guiding Question

The teacher begins an ADI lab investigation by identifying a phenomenon to investigate and a guiding question for the students to answer. The goal of the teacher at this stage of the model is to capture the students' interest and provide them with a reason to design and carry out an investigation. This stage provides students with an opportunity to use disciplinary core ideas and crosscutting concepts to figure out how things work or why things happen.

Stage 2. Design a Method and Collect Data

The teacher groups the students into small research teams. The teams are then directed to design a method that they can use to collect the data they will need to answer the guiding question. The teams then use their method to collect data after the teacher approves it. This stage gives students an opportunity to learn how to design and carry out an investigation in science.

Stage 3. Develop an Initial Argument

Students analyze the data they collected and then develop an initial argument. The argument consists of a claim, evidence in support of the claim, and a justification of the evidence. This stage helps students learn how to analyze and interpret data, develop and use models, use mathematics or computational thinking, construct explanations, and argue from evidence in science.

Stage 4. Argumentation Session

The students share their initial arguments and critique the arguments of their classmates. At the end of the argumentation session, each team has an opportunity to revise their arguments in order to make them better. This stage helps students learn how to argue from evidence, ask questions, and obtain, evaluate, and communicate information in science. It also helps students develop their communication and presentation skills.

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Stage 5. Explicit and Reflective Discussion

The teacher should encourage the students to share what they know about the disciplinary core ideas they used during the investigation and their ideas plans for designing better investigations in the future. The teacher should also encourage students to think about how they used one or more crosscutting concepts of science during the investigation or concepts related to the nature of scientific knowledge or the development of scientific knowledge.

Stage 6. Write an Investigation Report

Each student writes an investigation report to share the goal of the investigation, the method used during the investigation, and his or her final argument. This stage helps students learn how to analyze and interpret data, develop and use models, use mathematics or computational thinking, construct explanations, argue from evidence in science, and communicate information in science. It also helps students develop their ability to write in science.

Science and engineering practices 1. Asking Questions and Defining Problems 2. Developing and Using Models 3. Planning and Carrying Out Investigations 4. Analyzing and Interpreting Data 5. Using Mathematics and Computational Thinking 6. Constructing Explanations and Designing Solutions 7. Engaging in Argument From Evidence 8. Obtaining, Evaluating, and Communicating Information

Crosscutting concepts 1. Patterns 2. Cause and Effect: Mechanism and Explanation 3. Scale, Proportion, and Quantity 4. Systems and System Models 5. Energy and Matter: Flows, Cycles, and Conservation 6. Structure and Function 7. Stability and Change

Disciplinary core ideas for the physical sciences* • PS1: Matter and Its Interactions • PS2: Motion and Stability: Forces and Interactions • PS3: Energy • PS4: Waves and Their Applications in Technologies for Information Transfer * These disciplinary core ideas represent one of the four subject areas in the Framework and the NGSS; the other subject areas are life sciences, earth and space sciences, and engineering, technology, and applications of science. Source: Adapted from NRC 2012 and NGSS Lead States 2013.

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Teachers should begin the explicit and reflective discussion by asking students to discuss what they know about the core idea they used during the investigation

1. What do we see going on in this image? 2. Does anyone have anything else to add? 3. What might be going on that we can't see? 4. What are some things that we are not sure about here? You can then encourage students to think about how CCs played a role in their investigation. There are at least two CCs that students need to use to determine how the surface area of a parachute affects the force due to air resistance as an object falls toward the ground: (a) Systems and System Models and (b) Structure and Function (see Appendix 2 [p. 527] for a brief description of these CCs). To help students reflect on what they know about these CCs, we recommend asking them the following questions:

1. Why is it useful to define a system and then make a model of it in science? What were the boundaries and components of the system you studied during this investigation? 2. What models did you use during the investigation? What were some of the limitations of these models? 3. The way an object is shaped or structured determines many of its properties and how it functions. Why is it useful to think about the relationship between structure and function during an investigation? 4. Why was it important to examine the structure of a parachute in order to determine its ability to slow the acceleration of a falling object? Why is an understanding of the relationship between the structure and function of parachute more useful than simply knowing which parachute works the best? You can then encourage the students to think about how they used all these different concepts to help answer the guiding question and why it is important to use these ideas to help justify their evidence for their final arguments. Be sure to remind your students to explain why they included the evidence in their arguments and make the assumptions underlying their analysis and interpretation of the data explicit in order to provide an adequate justification of their evidence.

Reflecting on Ways to Design Better Investigations It is important for students to reflect on the strengths and weaknesses of the

Hints for Implementing the Lab • Allowing students to design their own procedures for collecting data gives students an opportunity to try, to fail, and to learn from their mistakes. However, you can scaffold students as they develop their procedure by having them

fill out an investigation proposal. These proposals provide a way for you to offer students hints and suggestions without telling them how to do it. You can also check the proposals quickly during a class period. For this lab we suggest using Investigation Proposal C. • Allow the students to become familiar with the equipment and materials as part of the tool talk before they begin to design their investigation. Giving them 5–10 minutes to examine the equipment and materials will let students see what they can and cannot do with them. • If too much mass is added to the parachute, this may result in the parachute ripping or breaking. The limit on the mass to be added to the parachute is dependent on the type of plastic. The thicker the plastic, the more mass it can support. In general, a mass of 50 g–250 g will be sufficient. • Students will sometimes create parachutes that are rectangles to make it easier to calculate the surface area. As a result, they may create parachutes that are too long and thin to work well. Figure 9.1 (p. 204) shows an example of how students might create their parachutes, but there are other ways that they can design them. • The higher up the students can be when they drop their parachutes, the more pronounced the effect. We suggest having students drop the parachutes from the top of the bleachers at the football field or from a balcony two stories

Argumentation Session The argumentation session allows all of the groups to share their arguments. One or two members of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the other arguments. This is similar to what scientists do when they propose, support, evaluate, and refine new ideas during a poster session at a conference. If you are presenting your group's argument, your goal is to share your ideas and answer questions. You should also keep a record of the critiques and suggestions made by your classmates so you can use this feedback to make your initial argument stronger. You can keep track of specific critiques and suggestions for improvement that your classmates mention in the space below.