Positioning Students at the Center of Sensemaking: Productive Grappling with Data

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ABSTRACT

The purpose of this chapter is to disrupt traditional approaches to science teaching in elementary grades, which range from hands-on activities to explanations provided to students by the teacher and/or text. One productive entry point to reconceptualizing elementary science as a collaborative sensemaking process is to examine how teachers engage students in making decisions about how to generate, record, and analyze data. A vignette of an elementary teacher is utilized to illustrate sensemaking moments in which she uses her understanding of the content storyline and students' ways of knowing to invite equitable and productive participation in scientific discourse and practices fundamental to making sense of phenomena. This "image of the possible" highlights the ways in which data discussions can serve as a lever for shifting away from step-by-step activities toward more meaningful science learning opportunities that share epistemic authority with students. The important role of collaborating with teachers to craft content storylines is proposed as a mechanism for further advancing responsive, sensemaking instructional practices.

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Introduction

As part of a unit on energy, Ms. Medina and her 4th graders (10 year olds) were investigating phenomena related to energy and energy transfer using roller coasters. The teacher's goal was to support students in making sense of the cause–effect relationships between the height of the track's starting point and the rolling marble. Ms. Medina created the context for investigation by showing a short video of a cart moving along a roller coaster track through loops, inclines, and drops. She invited students to discuss their observations and questions. Together the class framed the question: How does the roller coaster have enough "power" to go all the way? Ms. Medina then introduced an initial semi-structured investigation in which students manipulated long tracks made from pipe insulation, adding dictionaries underneath the ramps to systematically adjust the height of the starting point. Students measured the distances the marbles rolled at each height and used a prepared data table to record their results. Ms. Medina encouraged students to collect the most accurate data possible, but did not impose specific conditions. During the investigation, she moved from group to group attending to students' observations and questions. She noticed that students were talking about both the distances the marbles traveled and their speed. What did Ms. Medina do with these new insights?

The predominant use of hands-on activities in elementary school science is difficult to disrupt, especially given the outward appearance of student engagement. Children clearly enjoy working in small groups, interacting with materials, and playing games. They often participate more actively in hands-on science activities than in instruction associated with other subject areas. As long as there is a science topic, a plethora of activities are readily available that require little modification to implement in the classroom. But what does it really mean for children to be engaged in scientific discourse and practices as part of rigorous, equitable and consequential science learning?

In this chapter we delve deeper into how teachers can engage students with data in productive ways – what counts as evidence, why and how data are collected, how data can be organized and represented in order to recognize patterns and relationships, and how data are transformed through analysis to construct claims. Moreover, we seek to frame generating and making sense of data as an invitation to participate in making sense of the world and how it works as part of school science. We extend and utilize the vignette of ***Ms. Medina and Marbles in Motion*** to illustrate sensemaking moments in which she used her understanding of a coherent science content storyline (Reiser, 2013; Roth and colleagues 2011, 2016), which she co-designed with teachers and researchers, and students' ways of knowing to create an equitable and productive context for participation in scientific discourse and practices. This "image of the possible" highlights the ways in which data discussions can serve as a lever for shifting away from step-by-step activities toward more epistemically rich science learning opportunities.

Sensemaking in Elementary School Science

If coming to understand the world by engaging in scientific discourse and practices is the centerpiece of next generation science learning, then creating equitable access for students to participate productively in the intellectual work of sensemaking is the hallmark of effective science teaching. Scholars have characterized sensemaking in science as attending not only to what students understand about the world, but also their ways of and processes for knowing (Rosebery & Warren, 2008). Children are capable of asking testable questions about how the world works and engaging in the kinds of scientific reasoning necessary to make sense of phenomena (Duschl, Schweinberger & Shouse, 2007; Metz, 2000). The implications for elementary teachers are daunting. Not only must they understand and be pedagogically fluent with core ideas in science and scientific practices, they also need to place children's ideas and thinking at the forefront of their short-term and long-term planning, responsiveness during teaching, and formative assessment practices (Hammer, 1995).

Claims-Evidence-Reasoning and Sensemaking

In the period since *What's Your Evidence? Engaging K-5 Students in Constructing Explanations in Science* (Zembal-Saul, McNeill & Hershberger, 2013) was published, our thinking and pedagogical practices related to crafting, enacting, and analyzing coherent and consequential science learning opportunities for children have continued to evolve. We have persisted in our school-based work with preservice and practicing elementary teachers with the explicit intention of moving beyond a focus on activities toward sensemaking in science, which requires giving priority to evidence (Avraamidou & Zembal-Saul, 2005). However, the challenges associated with this work have been well documented (Davis, Petish & Smithey, 2006).

The publication of *What's Your Evidence? (WYE)* was timely in that it coincided with the release of *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and*

Core Ideas (NRC, 2012) and the *Next Generation Science Standards: For States, By States* (NGSS Lead States, 2013). *WYE* focuses on pedagogical and assessment practices for use by elementary teachers as they learn to engage their students in arguing from evidence and constructing scientific explanations for phenomena. The approaches featured in *WYE* align with several essential shifts that serve as the foundation for a new vision for students' meaningful science learning and scientific practices. Central to this vision is making sense of the natural and designed world (Duschl et al., 2007; Hammer, 1995; NRC, 2012) in ways that interconnect science content and scientific practices and build in sophistication over time.

Not only does *WYE* align with the *Framework,* it provides "images of the possible" of classroom science teaching (e.g., vignettes and videos). The book grew out of research and practice associated with funded projects on scientific argumentation and explanation-building at Boston College (McNeill) and Penn State University (Zembal-Saul). The Claims–Evidence–Reasoning (CER) framework (McNeill & Krajcik, 2008) was employed as a powerful scaffold for working with preservice and practicing teachers when planning, teaching, assessing, and analyzing science learning opportunities. These shifts in understanding and pedagogy are challenging for many educators, especially at the elementary level where teachers are prepared to teach all subject areas and whose teaching responsibilities have targeted priority areas for high stakes assessment (i.e., mathematics and literacy).

While we continue to view CER as a powerful framework for co-constructing evidence-based explanations – one that is both accessible and reasonable to elementary teachers and students – our initial conceptualization for constructing explanations in elementary school science have evolved. For example, we now emphasize the use of the CER framework as a heuristic for evidence-based arguments (Zembal-Saul, 2018b; Zembal-Saul et al., 2013). In practice, multiple iterations of negotiating, interrogating, and refining sequences of evidence-based claims taken together build toward explaining phenomena. Ideally, these sequences have predictive power for more sophisticated questions and explanations, as well as potential for making connections across units of instruction. In addition, CER provides consistency for engaging in scientific discourse and practices when it is used to inform instructional supports for sensemaking, such as talk moves, writing heuristics, explanation mapping tools, and attention to developing classroom norms. Finally, we frame content storylines based on CER sequences as productive tools for teacher decision-making prior to, during, and after instruction.

Our work with content storylines (Zembal-Saul et al., 2013) was inspired by the results of the TIMSS Video Study (Roth et al., 2006) and the overwhelming emphasis of discrete activities in school science in the United States. In their conceptualization of a coherent science content storyline, Roth and colleagues (2011, 2016) make a strong case for learning goals, coherence, and sequencing – an intentional move away from an activity orientation to teaching science. Reiser (2013) further elevated the role of content storylines in providing coherence for phenomena-based, three-dimensional science teaching and learning.

Interestingly, in our early work with CER-based science storylines, we underestimated their potential as a vehicle for turning over responsibility from teachers to students for the intellectual work of constructing explanations. It is this last point that the case of Ms. Medina serves to address.

Beyond Activities and Vocabulary

Scientists, philosophers of science, and science educators agree that the lock-step "scientific method" portrayed in school science does not accurately represent the work of scientists and engineers. A focus on "final form science and textbook-driven instruction" (Duschl et al., 2007, p. 13) is characteristic of "doing school" rather than authentic, productive participation in science (Duschl, 2000; Lemke, 1990). Moreover, it does not acknowledge students as being capable of participating productively in scientific practices and knowledge-building. An activity focus can direct students through discrete experiences with features of scientific processes. However, activities tend to promote emphasis on academic vocabulary through the well-meaning approach of bringing scientific topics to life (Hooper & Zembal-Saul, this volume). While a "flashy hook" may capture students' attention in the moment, without the robust intellectual work of puzzling with data, this approach accomplishes little in the way of advancing the vision for students' sensemaking in science.

The teachers with whom we collaborate recognize the power of prioritizing the construction of explanations from evidence and the importance of shifting the work of knowledge building from teachers to students, especially during class discussions (Schoerning, Hand, Shelley, & Therrien, 2015). As our collaborations and co-design progressed, some teachers experimented with handing over other aspects of doing science to their students, such as asking scientific questions, making decisions about what data to collect and how, as well as organizing and representing data in multiple ways to uncover patterns and relationships. Scholars refer to control over knowledge and knowledge building as *epistemic authority* and concur that teachers should position students as being capable of this challenging intellectual work as part of productive sensemaking (Carlone, Haun-Frank, & Webb, 2011; Stroupe, 2014).

When collaborating teachers invited students to assume greater responsibility for sensemaking, they also began to place less emphasis on vocabulary and more emphasis on informal formative assessments (e.g., classroom discourse, drawings/diagrams and written explanations) in order to better understand students' ideas and the ways in which they were making sense of phenomena. Acceptance of "kid talk" during sensemaking advances the aim of shifting power dynamics to be more inclusive of students' diverse ways of knowing and thinking. Next, we share an example of this kind of work on the part of a teacher to shift epistemic authority for sensemaking from her to students.

From the Classroom

Recall Ms. Medina and her class from the beginning of the chapter. Ms. Medina is an experienced fourth grade teacher who consistently uses CER to frame science teaching and learning. She is active professionally at the local and national levels with science reform, and she has participated in ongoing professional learning focused on science teaching, learning, and assessment. We developed the vignette from video of classroom practice taken from a larger research project and professional development partnership (Zembal-Saul, Badiali, Mueller & McDyre, this volume) in which there is a shared commitment to practitioner inquiry (Cochran-Smith & Lytle, 2009; Dana & Yendol-Silva, 2009).

When we left the initial vignette, Ms. Medina's class was investigating the relationship between the height of the ramp and the effect on the rolling marble. She noticed that students were observing and discussing differences in both speed and distance, even though the table she provided for recording data focused on distance. Although there is much about science teaching and learning to consider through this vignette, we highlight how Ms. Medina used phenomena to create equitable access to productive participation in scientific practices; anticipated and leveraged opportunities that invited student input in generating and analyzing data; and addressed core science ideas and associated academic vocabulary when students were ready to pursue causal explanations. We view the teacher's co-design and use of a CER-informed content storyline as being critical to her ability to shift responsibility for sensemaking from herself to students.

Ms. Medina and Marbles in Motion

The day after students' initial investigation, Ms. Medina gathered the class together for a science talk with the goal of analyzing data and making claims about how the height of the ramp affected the distance the marble rolled. She projected a sample data sheet on the whiteboard (Figure 1), and students reviewed the data their groups had recorded in their science journals. The teacher guided them to look for patterns in the data set. Recall that even though Ms. Medina did not impose strict criteria for data collection, she did provide a data table that allowed for systematic attention to the height of the ramp (in dictionaries) and the distance traveled by the marble.

Figure 1.1 here

Teacher: *Open up [your science journals] to your data collection sheet. Turn and talk with people around you. What claims can you make from the data to address the question of the impact of the height of the track on the distance the marble rolled?*

(Students talk in their small groups, discussing their claims and writing them on their data sheets. Ms. Medina circulated around the class listening to students' discussions, sometimes asking them questions and looking at the claims their group made.)

Teacher*: Who would like to share the claim your group made? S1?*

S1*: The marble went further each time.*

Teacher*: Does anybody agree with S1? S2 can you read what you wrote for your claim?*

S2*: It goes faster and further as we added more.*

S3*: It goes faster and further as we added more dictionaries.*

Teacher*: Do you guys agree with her? She says that it went faster and further as the height increased. What are your thoughts on that?*

S1*: We don't know for sure if it rolled faster, but we just saw that it went further each time.*

Teacher*: Why are you saying we don't know for sure?*

S4*: Because we didn't use a stopwatch or one of those things that can detect the amount of speed it went.*

Teacher*: What does your chart show?*

S5*: It just shows evidence that it went further each time but it never showed evidence that it went faster.*

Because she had circulated around the classroom and listened to the students' discussions about the claims they could make from their data, Ms. Medina knew that some groups had included both distance and speed in their claims, while others only used distance. She intentionally invited students to share examples of differing claims during the science talk. When one student read a claim that included both speed and distance, the teacher did not correct it. Rather, she turned it back to the class by restating the claim and asking students to respond. Ms. Medina repeatedly asked students what their data showed. Students were able to agree that the first investigation only showed how the distance the marble traveled increased as the height of the top of the track increased. Ms. Medina accepted students' colloquial use of the term "speed."

Because Ms. Medina knew that students were talking about both distance and speed as they investigated the marble rolling down the ramp, she intentionally planned to use the class discussion for students to negotiate parameters for a subsequent investigation of how fast the marbles rolled down tracks of varying height. As the science talk continued, the class crafted the new wondering: *How does the height of the roller coaster affect how fast the marble goes?* Students were especially interested in whether to time the marble when it stopped rolling or at the end of the ramp. In fact, they were divided on this point. As the students talked through when and how to stop measuring time, several of them asked to use the whiteboard to make their thinking visible through drawings and diagrams – a practice familiar to them from their science journals.

The class was actively engaged in making decisions about how data would be generated, and many members of the class participated in the discussion. After listening carefully to other students' ideas about how to record how fast the marble traveled down the track, they worked together to create a way to stop the marble and established a common distance from the end of the track to take their time measurement. Ms. Medina redirected students to data they had already collected to make informed choices about how to design the investigation. After negotiating these decisions, students addressed how to record their data. They decided to use a data table with multiple trials similar to the one from the initial investigation (Figure 1). Students then used their first data set to predict that the marbles would go faster as the ramp height increased. In this way, Ms. Medina's data table served to support both how students designed their investigation and thought about collecting data in a systematic way. Equally as important, the initial investigation also informed students' predictions about the relationship between the height of the ramp and time. It was not until the next day that they actually conducted the investigation and went through another iteration of analyzing data from which they negotiated the evidence-based claim: *As we increased the height of the top of the track, the marble went faster.* At this point, Ms. Medina introduced the scientific terminology that students had derived through their investigation – speed is the distance traveled per unit of time.

At this point in the unit, Ms. Medina's students began asking questions about *why* the height of the track influenced the speed and distance of the marble. Put another way, students' investigation of patterns in data and basic relationships among variables created the need to explain. Ms. Medina recognized the transition in students' questions and timed the introduction of energy (previously called power by students) as necessary for the class to use as reasoning in the co-construction of their CER sequences – connecting the speed of an object to its energy (NGSS, 4-PS3-1). The rest of Ms. Medina's content storyline also capitalized on students' emerging interests in understanding the how and why of energy transfer and transformation.

Discussion: Inviting and Sustaining Sensemaking

Here, we highlight four main features that address the importance of sharing epistemic authority with students to puzzle with data as they learn science concepts, as well as how to participate productively in other scientific practices. These themes focus on what the teacher is intentionally doing during instruction: *(1) preparing a content storyline to guide responsive pedagogy; (2) using phenomena to create equitable access and productive participation in scientific practices; (3) anticipating and leveraging opportunities that invite student input in generating and analyzing data;* and *(4) addressing core science ideas and associated academic vocabulary when students are ready to pursue causal explanations.* The role of the CER framework is addressed as an important feature in each of these themes.

The Role of Content Storyline

Ms. Medina does not operate from an activity-based orientation. Rather, she used the CER framework as a way to organize her planning and teaching, as well as establish norms for talking and doing science with students. She co-designed the content storyline for this unit collaboratively with colleagues who used the *NGSS* performance expectations (4-PS3-1, 4-PS3-2) to frame what students need to understand and be able to do by the end of the unit of instruction (Appendix A). She intentionally identified an anchor phenomenon (i.e., roller coasters staying on the track and making it to the end) that provided a captivating context for sustained investigation of energy transfer and transformation. With these bookends in place, Ms. Medina and her colleagues were able to consider the kinds of experiences with phenomena and data students would need in order to make sense of core science ideas, as well as the sequence in which the resulting claims would be useful to students as they developed a scientific explanation appropriate to fourth grade.

In working with practicing teachers who are in the early stages of moving away from an activity-based approach to science teaching, we have found that co-designing a content storyline with more experienced others is a powerful process for learning (Appendix A). By thinking through CER sequences based on core ideas and anchored in explaining real world phenomena, teachers' attention shifts to the kinds of evidence students will require for a complete explanation. They also begin to attend to how the explanation will build over time and the extent to which they can move students toward a scientific understanding. Many teachers who do this work carry their storylines with them during instruction as a tool for bringing them back to the core ideas and scientific practices in the midst of the hustle and bustle of interactive, student-centered investigations and data-based discussions. While content storylines are valuable to those involved in their co-design, they are not necessarily readily passed along to those outside the process of creating them.

Phenomena as a Vehicle for Equitable Access

Scholars have documented that teachers have reduced expectations for who they perceive to be "low ability" students (e.g., Zohar, 2007). This trend extends to students who live in poverty or differ culturally and linguistically from dominant groups in science and engineering fields (Duschl et al., 2007; Lee & Buxton, 2010). Lee, Quinn and Valdés (2013) address the inherent challenges of achieving the vision for students' science learning from the *Framework* given the linguistic demands of the scientific practices. The authors emphasize that science and engineering practices are highly interrelated, and they suggest that successful engagement in one of the practices creates opportunities for effective engagement in others (see also Bismack & Haefner, this volume).

The vignette of Ms. Medina's class illustrates that productive engagement in scientific practices for every child begins with opportunities to interact with phenomena in ways that create shared experiences from which scientific questions can be collaboratively generated and investigated. Ms. Medina was intentional about *how* she introduced students to energy through moving objects. She was aware that defining energy at the beginning of the unit was not likely to be fruitful, so she engaged students in making observations using the roller coaster video that elicited their questions, ideas, and ways of knowing about objects in motion. The teacher then prepared a semi-structured investigation that invited every child in her class to experience marbles in motion on tracks of varying heights. This can be viewed as *leveling the playing field* from an equity standpoint (Zembal-Saul, 2018a). "Playing" with the homemade roller coasters provided a shared experience and gave every student access to emergent patterns associated with increasing the height of the top of the track. By doing this, Ms. Medina increased the likelihood of greater student participation and ownership in discussions of data.

Placing Students at the Center of Sensemaking in Science

Sharing more responsibility for the intellectual work of doing science, both what to investigate and how, as well as accepting students' ways of knowing, are fundamental to the sensemaking process (Rosebery & Warren, 2008). It is not that Ms. Medina relinquished all responsibility for learning to students; rather, she created inclusive opportunities for sensemaking before and during instruction, and she proactively invited students to take greater responsibility for making sense of phenomena during the lessons. The practice of noticing and responding to sensemaking moments during the act of teaching is a high-leverage practice (Ball & Forzani, 2009) that novice and experienced teachers alike find challenging (NASEM, 2015; Levin, Hammer, & Coffey, 2009).

Ms. Medina is a responsive teacher (Radoff & Hammer, 2016). She intentionally balanced her understanding of the terrain of unit content with students' contributions, questions, and struggles. Whenever possible, she used her knowledge of students to plan opportunities for them to notice and ask questions about aspects of the phenomenon that would be productive in building a scientific explanation over time (Arias, this volume). While teaching, Ms. Medina didn't just walk from group to group to see if students were on task and/or provide procedural feedback; rather, she actively watched and listened to their ideas to inform subsequent instruction and explanation construction. In this vignette, more specifically, she listened for ideas that could spur debate, as well as negotiation, about what new data were needed and how to generate them. Put another way, she embraced uncertainty, improvised, and gave students opportunities to make decisions about how to make sense of marbles in motion (Manz, 2016; Schoerning et al., 2015).

Ms. Medina also sought out opportunities for disagreement and argumentation as invitations for sensemaking – about science ideas and scientific practices – as opposed to signals for her to explain the normative answers or scientific methods. Importantly, she accepted "kid talk" and a variety of ways of representing knowledge, such as drawings and diagrams, during sensemaking discussions. Her goal was the productive participation of as many students as possible, with an emphasis on what they were understanding as opposed to whether they were using appropriate academic vocabulary. This broadens the class' concept of what it means to be scientifically proficient, supporting a more equitable instructional experience. This kind of responsiveness is not possible without a sophisticated sense of the science storyline, as well as a worldview that values individual students' contributions for advancing the sensemaking of the entire class.

Toward Causal Explanations in Elementary Science

Explaining phenomena is central in the work of scientists. The *Framework* states, "A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts" (NRC, 2012, p. 84). Translating this into practice in school science has proven to be challenging (Braaten & Windschitl, 2011), especially at the elementary level. To this point, we find it compelling that Ms. Medina orchestrated opportunities for questions that require *how* and *why* accounts to emerge from students' experiences with the homemade roller coasters and the investigation of simple relationships. The class became dissatisfied with relationships between the height of the track and the speed at which the marble moves. Ms. Medina recognized this moment as one in which students are ready for the introduction of energy as a core science idea to help advance their understanding of the phenomenon. Until that time, she accepted "kid talk" (e.g., power for energy) in framing the questions and in sensemaking discussions of how to generate and analyze data.

While CER is useful as a heuristic in the development of causal explanations, Ms. Medina's use of this approach was completely non-algorithmic. She moved fluidly between questions, evidence, claims, and reasoning in response to her students' ideas, questions, and interests. She did this with a deep understanding of the content and practices, as well as the storyline. Moreover, Ms. Medina was intentional about not only engaging students in collecting data, but also representing those data in ways that allow patterns to become visible and usable in the sensemaking process. The complexity of this work on the part of Ms. Medina should not be underestimated (Arias, this volume).

CONCLUSION

From the beginning, the focus of our work has been to disrupt traditional, activity-centric approaches to teaching science in elementary grades. The question, *What's your evidence?*, emerged from classroom-based research with preservice and practicing teachers, and represents the importance of pressing for evidence in the construction of scientific explanations (Zembal-Saul, 2009). This chapter began with the goal of addressing the rest of the story – what comes *before* negotiating claims from evidence as fundamental to the sensemaking process. Ms. Medina's vignette highlights the potential of engaging students with phenomena and puzzling through what data to collect and how to record and analyze them as an invitation to equitable and productive participation in science practices and as a means of shifting epistemic authority from teachers to students (Stroupe, 2014).

Throughout the chapter, we have foregrounded the importance of teachers having a strong grasp of both the phenomenon students will be working to understand, as well as the scientific explanation they intend for students to construct. Engaging teachers in the co-design of content storylines is a powerful mechanism for professional learning and the development of "near horizon vision" (e.g., unit level; adapted from Ball, Thames & Phelps, 2008). Such vision requires moving away from day-to-day, hands-on activities toward organizing learning opportunities that build coherently throughout a unit, are sequenced to explain phenomena in increasingly complex ways, and are epistemically sound. Additionally, near horizon vision is essential in becoming a more responsive teacher – one who anticipates, attends to, and leverages students' ways of knowing, even when they disagree with one another and/or deviate from canonical science in the moment. Recall how Ms. Medina created the space for students' thinking about speed and distance to persist while guiding them to recognize the need for additional investigation.

It is an exciting time to be engaged in research and practice with elementary teachers' as they embark on the challenging journey of shifting from traditional science instruction to positioning students to assume more authority in the process of sensemaking. The scientific practices are deeply interconnected, and making progress with one practice creates opportunities to make progress with others (Lee et al., 2013; see also Bismack & Haefner, this volume; Cody & Biggers, this volume). We hope that Ms. Medina's story inspires you to consider how to invite students to grapple with data as part of the sensemaking process in science.

Appendix A: Science Content Storyline Planning Guide

NGSS Performance Expectation:

The process of building the science content storyline is non-linear and iterative. Begin by considering what students will understand and be able to explain about the phenomenon by the end of instruction. *Unpack and review DCIs, SEPs and CCCs.*

What is the phenomenon that students will investigate?

Describe the phenomenon and how students will engage with it? Why do you think it will be interesting to students? What is the complete explanation you intend for students to construct?

What prior knowledge, local knowledge, lived experiences, and interests are students likely to have? How will you uncover this information and create opportunities to build upon it?

Question (A)	Claim (B)	Evidence (C)	Reasoning (D)	Notes (E)

Claims are based on the big science ideas necessary to explain the phenomena. *What are these ideas and is there a way to sequence them coherently (B)? What might an age-appropriate version of the claim/statement sound like (B)?*

Claims should be grounded in evidence and respond to a question that students are investigating about the phenomenon. *What questions will you use to drive instruction (A)? How might you elicit students' questions for this purpose (E)? Which questions require descriptive answers and which require causal explanations (A, E)?*

Whenever possible, young students should engage directly with phenomena and collect and analyze data necessary to explain it. When raw data are transformed through the process of analysis and sensemaking, they become useful as evidence. Claims emerge from evidence and in response to questions, not the other way around.

Once the science ideas needed for the explanation are identified and sequenced, consider how students will collect data for each CER sequence (C). If an activity does not serve the purpose of generating data that will help students understand and explain the phenomena, drop it! Data collection opportunities should be intentionally designed for the storyline. Whenever possible, consider how students can be included in making decisions about how to collect, organize, and analyze data (C, E).

Reasoning is used to further make connections between evidence and claim (D). Sensemaking discussions play an important role in making students' reasoning visible. *What might it sound like for students to elaborate on how data support a claim they are negotiating? What science terms might be useful for this purpose and when/how will you introduce them? What questions will you ask to facilitate reasoning, support negotiation of claims, and prompt arguing from evidence (E)?*

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