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Start With Phenomena

Engaging elementary students in science practice: Strategies for helping children plan investigations

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Abstract: This article presents a tool that teachers can use to support children in planning science investigations. Using an extended example from a second-grade investigation into seed dispersal, we describe strategies for structuring conversations that anchor investigations in phenomena and provide opportunities for students to be involved in making decisions about what materials to use in an investigation, how to use materials, and what to look for or count as evidence. These teaching strategies can support children to engage deeply in science practice, while also keeping activity manageable for students and their teachers. Our goal is that this article will provide teachers and curriculum designers with a tool that they can use to support children to engage in joyful, meaningful, and productive science investigations.

Keywords: K–2, 3–5, *NGSS*, planning and carrying out investigations, science and engineering practices, cooperative groups, notebooks/journals, plant structures, functions, seeds

Children in Ms. Lacy's second-grade class have been exploring how seeds travel. Now, four children are developing a test of whether grass seed could travel by sticking to animals and people. As Ray starts to place a seed on a piece of fabric, the seed sticks onto his shirt. He gasps excitedly, drawing his group's attention.

Kameron: How is it sticking like that?

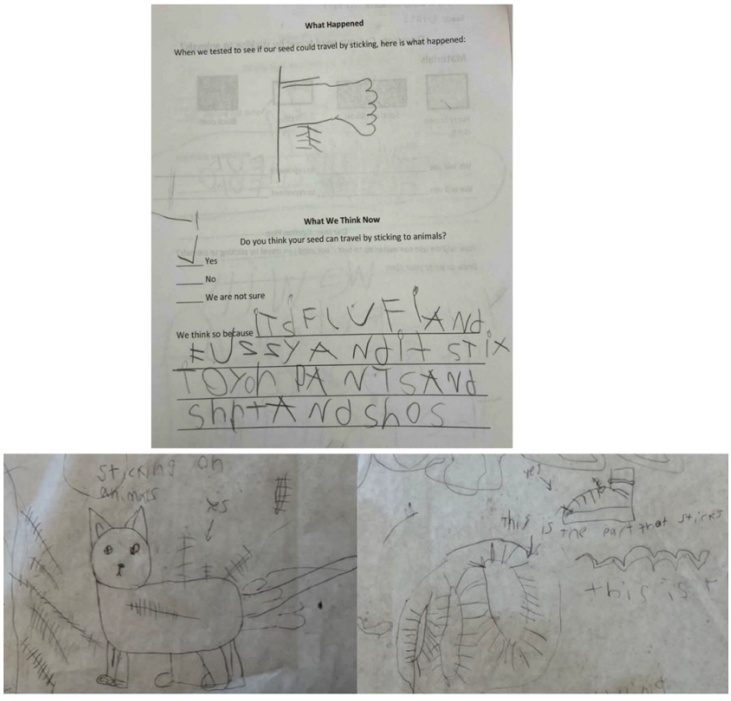
Ray: Let's pretend the animal is moving!

Ray moves his arm back and forth. The seed stays for a few moments, then falls. Ella and Catherine repeat his movements, using their shirt sleeves and then the fabric pieces. In their notebooks, they draw the seeds sticking to the fabric and clothing, emphasizing the small protuberances that hook into the fibers. They claim that grass seeds can travel by sticking, using the evidence that the seeds stuck to the fabric even when they moved it back and forth.

Later, developing posters that explain how their seed could travel to a new place, they claim that grass travels by wind and by sticking on animals, drawing which parts of the seed help it stick and what it can stick to ***(shown below in Figure 1).***

FIGURE 1

Examples of student work explaining how seeds travel.



Here, young children (ages seven and eight) participate in science and engineering practices as they develop and carry out an investigation. They represent phenomena, gather evidence, and generate claims. As they work together, they express joy and excitement. Further,

they make progress on understanding science concepts, such as structure/function and interdependent relationships in ecosystems (NGSS Lead States 2013).

Investigations are essential to science and are emphasized in the *Next Generation Science Standards* (*NGSS*) (Duschl and Bybee 2014; Manz et al., 2020). Elementary-aged children are capable of planning and carrying out investigations, but they need to be provided with sufficient support to do so (NASEM 2022). In this article, we explore the specific classroom structures and moves that Ms. Lacy used, sharing a tool that our researcher-teacher partnership developed to guide our work with classroom investigations.

Experiments and other empirical investigations are ways that scientists represent phenomena so that they can figure something out. Planning an investigation involves making choices about how to represent the process you are trying to understand. In this investigation, students make decisions like: Can fabric represent an animal? What do we have to do with the fabric and seed to see if the seed could stick to animals? Investigations also require decisions about what to pay attention to, measure, and use as evidence. These are decisions that children should be helped to understand and be involved in making, but they also bring challenges: Will children be ready to make these decisions? What if they make different decisions (than each other or what the teacher planned) and end up with results they can't make sense of? These challenges can make it difficult for teachers to incorporate investigations into science instruction in ways that are meaningful and manageable. As a result, teachers may feel hesitant to provide children opportunities to make decisions as they plan investigations or may struggle to manage conversations where children plan investigations.

Over five years, our partnership has studied how to support children to engage more meaningfully in planning, conducting, and making sense of science investigations. We developed investigations, videotaped classroom conversations, and examined video and children's work together. We sought to understand what productive engagement in planning and conducting investigations can look like, what supports children need to plan investigations, and what challenges teachers face.

Our work is driven by a desire to support students from all backgrounds and identities to engage meaningfully and joyfully in science practice. The urban district we work within is racially, socioeconomically, and linguistically diverse: 60% of students are nonwhite, 50% are low-income, and 50% speak a home language that is not English. Twenty percent have a

diagnosed disability. We report these demographics not to reinforce deficit-based orientations, but because they have significance for the ways we designed instruction and made sense of data. For example, we included strategies to support multilingual children and to develop equitable access to the phenomena under study.

Context for the planning investigations tool

Our tool incorporates the lessons our group has learned about how to balance student choice and discussion with providing resources for students and predictability for teachers. It focuses on two aspects of teachers' practice: (1) Preparing for a lesson in which students will plan an investigation, and (2) Components of conversations that help children move from wondering about a phenomenon toward conducting an investigation.

We exemplify the tool using Ms. Lacy's seed dispersal investigation. This investigation occurs midway into a plant growth unit near the beginning of the school year. Students have become curious about how seeds on plants and on the ground might get to new places. In small groups, they study one seed, conduct several investigations, and make claims about how it might grow in a new place (2-LS2-2: Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants).

Teacher preparation

Our tool is designed for use with phenomena-based instruction after teachers and children have developed initial explanations and recognized puzzles about the phenomenon. Teachers may be working from established curricula, adapting materials, or developing new materials.

Regardless, the preparation described in Figure 2 is helpful.

FIGURE 2

Preparation for working with students to plan an investigation.

TO PREPARE FOR AN INVESTIGATION PLANNING CONVERSATION

Prior to engaging in the investigation planning conversation:

- ❑ Reflect on students' questions and wonderings from earlier lessons (e.g., when they initially explored the phenomenon). Whose questions can you elevate and refer to as you introduce the investigation?
- ❑ Decide what is or should be set (decided) for students in the investigation and what decisions you want to support students to make and discuss.

Things to consider:

Is it okay if students do different things in the investigation and/or come to different conclusions? How will you later work with those differences?

First, consider students' prior discussions: Have students posed a question that can guide the investigation or is discussion needed to motivate a question? Ms. Lacy's students had begun to wonder if their seeds could stick to animals or clothing, but they had not yet discussed how exactly their seeds might travel by sticking. Next, consider what parts of the investigation are already set (decided on) or that you will decide for children, and which parts you would like *students* to make decisions about. Setting some parameters, such as the materials available, can focus planning. Early in our work, teachers asked children, "What can we use to see if the seeds can stick?" This question proved too broad— students volunteered ideas that were impossible or unproductive and teachers then needed to discount these ideas. Finally, consider where allowing differences in student decisions will support results that promote discussion, or alternatively, prove too difficult to manage. For example, we found that students using the fabric differently (some groups brushing the seed against it, some shaking it), led to them asking each other productive questions as they made sense of results.

Components of planning investigations conversations

Our tool describes four components of working with children to plan investigations (Table 1), which we illustrate here through conversations Ms. Lacy had with her students **(all**

student names are pseudonyms).

TABLE 1

Components of investigation planning conversations.

		What you might say	Consider or explore
1	**Establish a shared goal or question.** Support students to develop a shared understanding of the phenomenon and generate questions that will motivate the investigation.	*"Yesterday, we had a lot of questions about..."* *"The question we are going to focus on today is..."* *"What ideas do you have about...?"*	Use a shared book, photograph, or video to provide a visual representation of the phenomenon. Write the question on the board or chart paper so that it is visible throughout the investigation.
2	**Introduce the investigation as a tool for making progress on student questions.** Connect the investigation to students' uncertainties so they understand why they are doing what they are doing.	*"It seems that we have a lot of different ideas about what is happening here."* *"We can design an investigation to help us figure this out."*	Facilitate a discussion that highlights students' disagreements and uncertainties. Support students to consider what they already know and what they are still wondering about as they develop the investigation.
3	**Introduce or discuss what is already set (decided on) in the investigation.** Explain the parameters of the investigation	*"We are going to use X to represent Y. How do you think using X will help us understand...?"*	It might feel tempting to ask students "How can we investigate this?", but this question can be so broad that you get into a "guessing game" pattern where students are trying to guess what the teacher already has in mind.
4	**Introduce and discuss decisions that students will make in the investigation.** Explore ideas about what materials to use, how to use them, and/or what to pay attention to during the investigation.	*"Do you think we should use X or Y to help us figure out...?"* *"How can we use A to represent B?"* *"If we see Z happen in our investigation, what would that tell us?"*	Consider asking students to make a choice between two materials. Students can develop initial ideas in partners and then share with the whole class. Consider providing an "outrageous idea" and have students explain why this is not the best choice.

1. ***Establish a shared question or goal.***

Ms. Lacy says, "Today, we're going to focus on how seeds could travel by sticking, what are the parts that help them travel by sticking, and how we could make predictions about our own seeds." She projects a page from the book From Seed to Plant *(Gibbons 1991) that shows a seed sticking onto a person's clothing and asks how the seed can do this. Catherine explains that the hooks allow it to stick, and Elena adds that the seed sticks to get to a "better place." Yonas wonders why not all the seeds in the picture are sticking to the person and Felisa suggests the seeds will only come off the parent plant if the person brushes against them.*

Here, students deepen their shared understanding of seeds sticking, leading them to wonder which of *their* seeds can travel by sticking. Ms. Lacy accepts all ideas, supports students as they respond to each other, and highlights questions and puzzles. We have repeatedly found that even if children have already developed a general question, it is helpful to return to the phenomenon, establishing key aspects and questions, before introducing and planning the investigation. This supports students to connect the phenomenon to the investigation, providing resources for their planning.

2. ***Introduce the investigation as a tool for making progress on student questions.***

After establishing that some seeds may be able to travel by sticking to people or animals, Ms. Lacy highlights the uncertainties and disagreements that have come up in the discussion. She revoices points students have made about what allows the seeds to stick. Maya says that seeds can only stick if they are very sharp, but Catherine isn't sure. Kameron says that fluffy seeds like milkweed might also stick on clothing. Ms. Lacy says, "Maybe we need to do some investigating to figure this out."

By emphasizing students' varying ideas, Ms. Lacy establishes uncertainty about the phenomenon. When she suggests that students could figure out what causes seeds to stick, she shows that the investigation builds from students' ideas and questions. Students are more likely, then, to feel that their questions, uncertainties, and disagreements are purposeful. Further, they experience the investigation as connected to the phenomenon rather than as a stand-alone activity. This allows them to draw on and deepen their understanding of the phenomenon as they plan and make sense of their investigation.

3. ***Introduce or discuss what is already set (decided on) in the investigation.***

The next day, Ms. Lacy says, "Yesterday, we talked about what might make a seed good at sticking, and we talked about the seeds being able to stick to fur or fabric. Today, we are going to talk about how we could design a test to see if our seed can travel by sticking. She presents four pieces of fabric with different colors and textures. One is brown and fuzzy, another is made of black felt, the third is tan cotton, and the fourth is leopard-print and smooth. Ms. Lacy explains that they will use the fabric to represent animals and clothing and figure out which of their seeds can travel by sticking.

As described earlier, setting some investigation parameters can focus children's activity. However, the rationale behind investigation materials and procedures are often not apparent to children, so it is important for the teacher to spend time explaining them. In this case, the teacher explained that the fabric pieces could represent animals and people and provided students with four materials. Then, children discussed which fabrics would best represent an animal, supporting connections between the texture of animals' fur and seed structures.

4. ***Introduce and/or discuss decisions students will make.***

Ms. Lacy asks if they could use a piece of tape instead of the fabric. Some students say yes, but Sienna emphatically shakes her head. Ms. Lacy asks Sienna to elaborate, and she responds that they're trying to see if their seeds can stick, not if they can make them stick. Felisa adds, "It's not really going to give you that much information about the seed," and Yonas agrees, "Even if there were no spikes on the seed, it would still stick." Students agree that the tape will not represent how seeds stick outside or help them answer their question.

Ms. Lacy says, "We've now talked about which materials we are going to use, but I'm wondering how we want to use them to test if our seeds can travel by sticking." Hiroshi suggests brushing the fabric against the seed to see if it sticks, and Yonas adds that this is like an animal running past the plant.

When students make decisions, they feel invested and are primed to understand how their results help them understand their question. Children can discuss decisions about what materials to use, how to use materials, and what to count as evidence. Ms. Lacy asked students to consider how to use the fabric to answer their question, supporting them to explore the processes through which seeds stick. Later, she asked what they should look at to decide if the seed was a "sticker." Children volunteered ideas such as the amount of time the seed stuck and whether it stayed on when the fabric moved.

Teachers can structure discussion to illuminate important facets of the phenomenon and of investigation practice. For example, teachers can introduce options selected to provide important contrasts (e.g., fabrics with different textures). Another strategy is to present an unproductive investigation choice and to ask children to evaluate it. Ms. Lacy introduced tape, sparking a discussion about the purposes of the investigation and what to count as evidence.

Students engaged with materials' properties (2-PS1-2) and seed travel (2-LS-2) as well as cross-cutting concepts such as cause and effect and the practice of scientific modeling.

Conclusion

The tool presented in this article can be used to structure classroom investigations in which students both have agency and engage deeply in important aspects of science practice, while also keeping activity manageable for teachers and students. We have used it in a variety of grade levels and content areas. We hope that teachers and curriculum designers will find it useful toward the goal of children engaging in joyful, meaningful, and productive science investigations.

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Online Resources

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