Collaborating for Success

A schoolwide science museum highlights science practices with help from community partners.

By Eleanor Miele and Stephanie Bennett

The PTA science committee wanted to improve science teaching at their school and turned to our college for help. As coordinator of childhood science education at Brooklyn College, I found an able partner in the school's assistant principal for instruction. How could we jump-start a change in science teaching culture? We suggested introducing research-based science teaching practices that emphasize doing science like scientists. The *Next Generation Science Standards* (NGSS Lead States 2013) recommends building science curriculum around science and engineering practices, with one practice being "asking questions and defining problems" (p.4). Gallas (1995) has shown that student achievement can be boosted by letting students express their opinions and evaluate other students' arguments. How could we use these ideas to make science more student centered?

To successfully implement changes in teaching culture, school community stakeholders need input and ownership of the process. A team of parents, teachers, administrators, and college science-education faculty met together over the course of several weeks to collaborate on our plan. We decided to have a science museum with informative exhibits that would coincide with the final PTA meeting of the school year. Through collaborative inquiry, it would be based on the core science curriculum with an emphasis on modeling science practices as specified in the *NGSS* (see Table 1). The science museum would provide a structure for changing teacher practice in an engaging, schoolwide project that would allow participation of all of the stakeholders involved—teachers, students, and families.

TABLE 1.

Science and Engineering Practices

1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computation
6. Constructing explanations
7. Engaging in argument from evidence
8. Evaluating and communicating information

NGSS Appendix F (NGSS Lead States 2013, p. 1)

The implementation of the process was informal, as it was developed by a team of parents and teachers to support a PTA initiative. The planning group prepared a simple science museum process:

- Select an **essential question** from the science scope and sequence to pose to the class.
- Record the **students' questions** about the essential question using a variation on the familiar KWL format.
- Emphasize **what children want to find out** rather than what they want to know.
- Conduct at least one related **hands-on inquiry** with the class as a collaborative investigation.
- Encourage students to contribute ideas when planning the investigation(s).
- Prepare physical **artifacts** from your investigation(s) for your classroom science exhibit.
- Help children select **content-rich readings** to get answers to their questions.
- Prepare and post **students' written text** based on individual research.

Each teacher had the freedom to

follow the process in their own way. We only asked that at the end of the six weeks of preparation, each classroom would have at least one hands-on exhibit of artifacts and each child would have created their own curriculum-based writing in response to content-based readings.

We wanted the science museum to support in-class inquiry through discussion, investigation, reading, and writing. Incorporating science discussion, reading, and writing in the plan had the added benefit of supporting the *Common Core Standards for English Language Arts* (NGAC and CCSSO 2010) in science teaching.

We saw creating the science museum as an alternative to a science fair, the latter of which focuses on individual accomplishment outside of school (McComas 2011). Unlike a science fair, the science museum is dedicated to curriculum-based work in the classroom, so it would directly assist teachers in teaching core science concepts. The purpose of the museum was collaborating to do science and communicate about science, not judging for a prize or competition. Table 2 compares a science museum to a science fair. Since our primary aim was to get inquiry happening in an informal context, there was no rubric for student assessment. At the museum, every student was celebrated as a "scientist" and every teacher as a "lead scientist."

Asking Questions

Asking questions is an *NGSS* science and engineering practice. Our process asked each teacher to identify one overarching question from the learning objectives of the science curriculum. This question was used to engage students in initial discussions. The students then generated their own specific questions.

This change in focus from teacher-generated questions to student-generated questions inspired a fundamental shift in teaching practice at the school. Teachers were initially resistant to letting the children ask their own questions. They were surprised and pleased to discover that the questions that their students asked were usually the very same questions that the teachers hoped to answer. The teachers were also surprised to discover that the students were more interested in finding the answers when the students themselves had come up with the questions.

One parent on the planning team commented, "My son is so excited that there is going to be a science museum, but I'm not sure all of the children have heard about it." To facilitate awareness among all community stakeholders and spur discussion about the science museum, we asked teachers to post their inquiry questions on their classroom doors. Within a week, the halls were filled with evidence of the children's science questions (see Figure 1).

Reading for Information

Once the children's questions were asked and recorded, students found answers using informational texts. Children then created their own informational texts for their science exhibit based on their research in trade books, periodicals, and the internet. This allowed even early childhood students to practice obtaining, evaluating, and communicating information using grade-appropriate informational texts, an *NGSS* prac-

TABLE 2.

Science museum vs. science fair.

Science Fair	Science Museum
Focuses on...	*Focuses on...*
Work at home	Work in school
Individual work	Student collaboration
Parent facilitation	Teacher facilitation
Individual choice of topic	Curriculum-based topics
Topic of student's choice	Standards
	In-class discussion
	Content reading
	Collaborative hands-on investigation
	Writing

tice. Kindergarteners made pictures about plants needing water and light to grow (*NGSS* performance expectation K-LS1-1 Use observations to describe patterns of what plants and animals [including humans] need to survive; NGSS Lead States 2013, p. 6) based on read-alouds, while first graders made one-page illustrated informational texts about extreme weather (1-ESS1-1 and Common Core ELA/Literacy W.1.7.) based on independent and team reading of informational texts.

To provide more structure for engaging in argument from evidence (an *NGSS* science practice), the fifth-grade teachers decided to use the Reading and Analyzing Nonfiction (RAN) strategy (Stead 2006). Beginning with what students think they know and what they wonder about, they pursued research on the internet to find reliable evidence to confirm or refute their ideas.

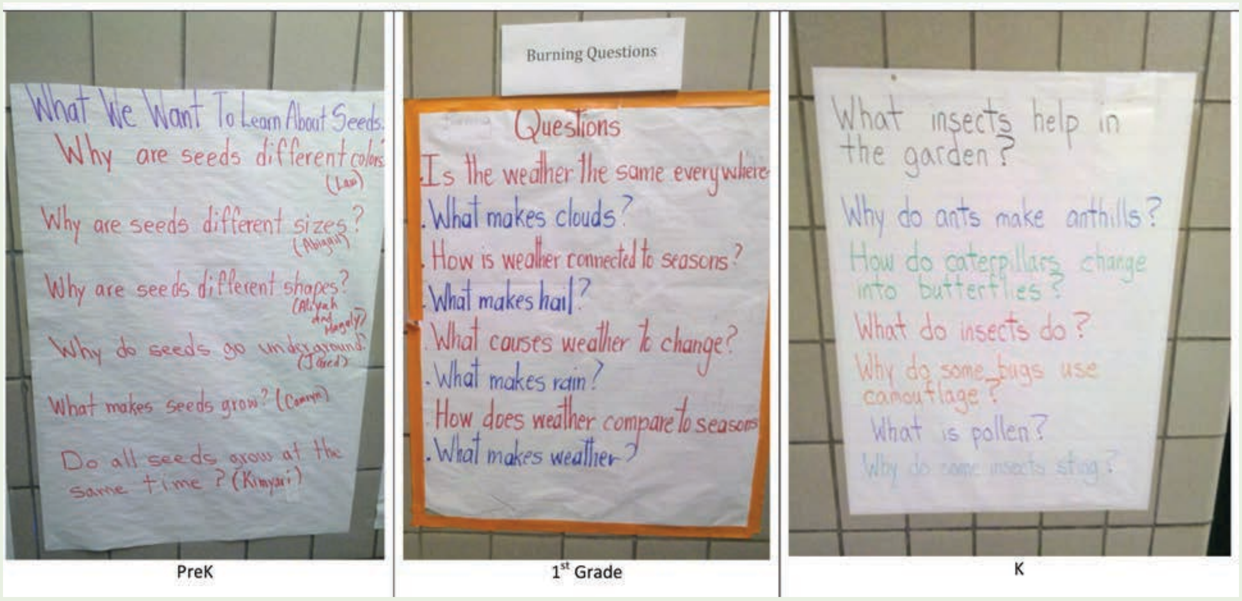
Conducting Investigations

Getting teachers to begin conducting investigations was a primary aim of this project. To facilitate the transition from lecture to hands-on science, all teachers participated in one professional development session in which they were given the opportunity to experience collaborative inquiry for themselves. A session on sinking and floating invited groups of teachers to freely explore material interactions with water, making their own observations and generating their own questions and hypotheses. This experience was designed to help teachers understand that science investigations begin with a question and use a variety of methods, tools, and techniques (Appendix H, NGSS Lead States 2013, p.5). At this session, teachers were provided with a guide to science inquiry for children, including questioning and notebooking strategies, inquiry activities, and hands-on science safety information (Miele 2012).

To reinforce the *NGSS* science practices of planning and carrying out investigations and analyzing and interpreting data, we asked the teachers to plan on doing one or more hands-on investigations related to their essential question. To facilitate this, the members of the core team agreed to help in identifying

FIGURE 1.

Sample student questions posted in the hall.



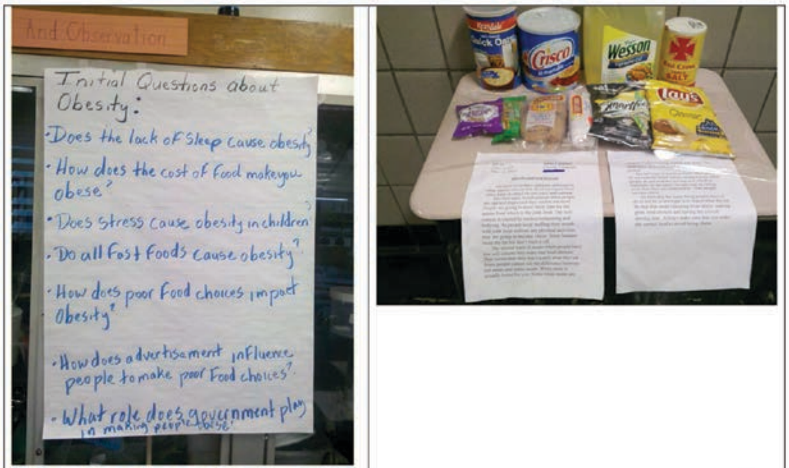
and planning appropriate investigations. For example, we suggested that the fifth-grade teachers review the FOSS Food and Nutrition module (Lawrence Hall of Science 2012) for possible investigations relating to their questions on obesity. The fifth grade then planned and carried out a test of foods for the presence of fat based on the FOSS Food and Nutrition module (see Figure 2). To participate in experiences involving analyzing and interpreting data and using mathematical thinking, two *NGSS* practices, they also analyzed the nutrition content of their favorite foods using the nutrition facts on product labels.

Conducting investigations provided for engaging in science practices and strategies, but just as important, they allowed students to talk together and to discuss and evaluate evidence. The requirement that the science museum have artifacts generated from hands-on investigations introduced collaborative inquiry to a school that had depended upon teacher lecture for science instruction.

At the end of the six weeks of preparation, the children created an exhibit in their classroom based on their research, readings, and writings. Some children presented their exhibit as "exhibit docents" to other students, teachers, and parents.

FIGURE 2.

Fifth-grade investigation on nutrition.



"...empowering children to have an impact on society..."

Some materials for analyzing nutritional labels for fat and calorie content, also used for fat test investigation.

Progress in Two Classrooms

Teachers on the planning team provided some insight into the process as it unfolded in classrooms. One teacher of a first-grade inclusion class said, "At first the process was intimidating. Inquiry is brand new for us. But we're really enjoying it... getting kids to generate those questions. We don't know where our inquiry is going to go. We are still asking questions. We have already done two activities—dissecting lima beans and flowers—and they have just generated more questions."

This comment was evidence that the simple changes we were encouraging were already helping to develop a culture of inquiry. A student teacher in this classroom wrote, "It has been an amazing eight weeks visiting the school and learning from Ms. A and Ms. M. I gained a great admiration for their efforts to create inquiry-based science lessons." These teachers were new to inquiry but were already modeling instruction based on science practices for the next generation of teachers.

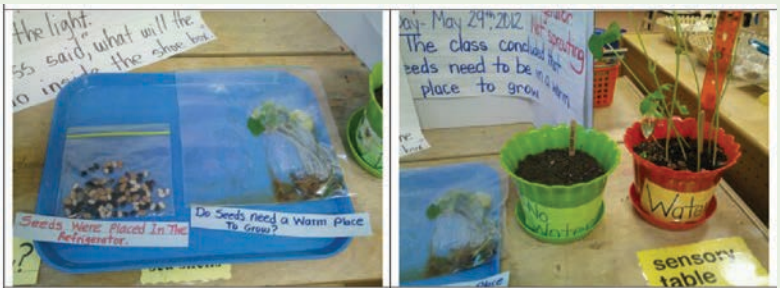
The fifth-grade teachers said that the heightened interest of their students was really motivating to the teachers. They were excited about how their students had begun to think about their essential question, "Why should we care about obesity?" They reported that their students were already engaged in rich discussions about the obesity epidemic in America. One teacher said that she could see that the project has the potential to "shape their thinking of what kind of adult they are going to be ....We are not just teaching science but also empowering children to have an impact on society."

Results

The big day came. Each classroom visited the other classes' museum exhibits, allowing the students to teach and learn from each other based on a carefully planned sched-

FIGURE 3.

PreK investigation on plants.



Seeds need a warm place to grow. | Seeds need water to grow.

ule for interclass visitation. This was the first time that many teachers had visited other teachers' classrooms. That evening, the families toured each classroom, listening to the children explain their investigations. The classrooms and hallways were filled with student work, science artifacts, and science talk. Adults and children moved from classroom to classroom listening to student docents explain their investigations and what they had learned. The upper-grade teachers were astonished to hear two preK students explaining how their investigations showed that seeds need warmth and water to grow (see Figure 3), an example that builds toward the *NGSS* performance expectation K-LS1-1. First-grade students demonstrated their cloud in a bottle, demonstrating the *NGSS* science practice Developing and Using Models. Expectations for what children (and teachers) can accomplish were changed.

The public nature of the event held all teachers accountable to the entire school community. In the end, every single classroom had a science exhibit to be proud of, with student-created artifacts and proud young scientists on hand to explain their work. Some modeled exemplary science inquiry and others demonstrated a creditable first foray into inquiry science.

As a result of her research and museum exhibit, one fifth-grade student was excited because she could see herself having an impact on others. "I made models and our song to help the oceans. Making our song was very fun, and every time we sing that song people get excited about it." Another fifth-grade student commented that "the science museum was very good, but some students could have used more time to," in his words "add more details to make their projects have more textual evidence."

One parent's reflection on the science museum points out its strengths and weaknesses as they played out in one classroom:

"I thought the science museum was very good. It was obvious that the stuff was done completely by the kids … This is vitally important. Kids need to do the stuff. Even if the results wobble a bit, this is the way to go.

"My daughter didn't have the reading or writing skills to engage the project as assigned, which made it very frustrating for her.... She was pretty miserable because it was the first time she was asked to DO something with her reading/writing skills (investigate a topic) …. Once we arrived, however, our daughter did a wonderful job talking about hail. She knew the stuff really well and could talk about it in front of a group! So, the obvious lesson here is to keep the entire project as multimodal as possible—her oral presentation redeemed the entire experience and was very affirming for her.

"I'm very excited about this happening again next year. These are the sorts of things our school needs to do all the time. Our best teachers have fun with this stuff, and our weak teachers need to know that this kind of high-energy pedagogy will be the standard at the school and they need to rise to that standard.

"Thank you so much for working so hard to make this event happen at our school! It was really inspiring and in the end; a great experience for my daughter."

Figure 4 shows her daughter's work with her first-grade class.

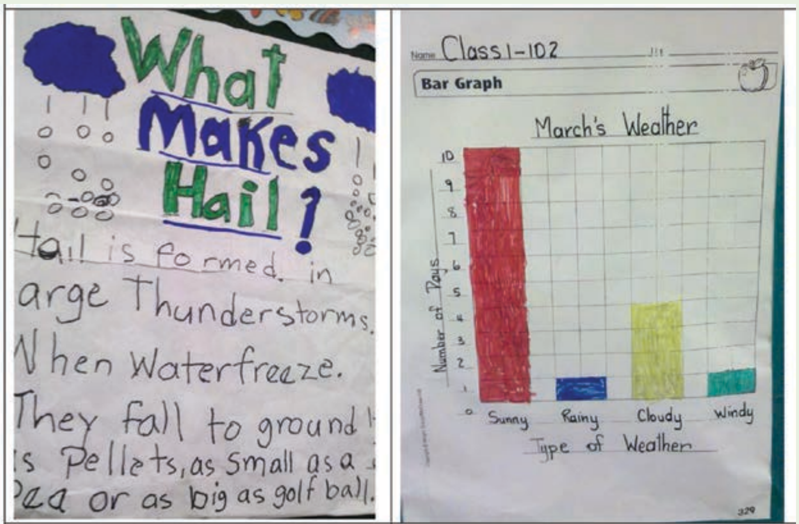
Challenges Along the Way

The greatest challenge was overcoming teacher anxiety. Teachers who did not participate in the planning felt pressured and insecure. We wondered: How could we provide scaffolding for teachers new to inquiry? How could teachers of inclusion classes get the extra support they needed? How could teachers find the thinking time necessary for children to identify their own questions in the limited time allocated to science?

To help meet some of these challenges, science education interns from the college were placed in each lower-grade classroom for two hours per week. Teachers were also encouraged to use time allocated to English language arts as part of the science museum project for both the science talk time and for reading and writing informational texts. Some children had trouble finding content-rich readings to help them find answers to their questions. The PTA asked for guidance to purchase more content-rich trade books to support science inquiry for each classroom. Suggested life-science readings are provided online (see NSTA Connection). These texts are factually accurate with exceptional use of poetic style and captivating illustrations.

FIGURE 4.

First-grade museum investigation on weather.



A student writes about her question on hail. | The class collected data collaboratively in school.

Lessons Learned

The science museum provided a low-stakes, community-centered structure for the introduction of research-validated teaching strategies in every classroom. A new paradigm for science instruction was introduced to the whole school community. Teachers noticed that their students were more motivated and involved and this made them more willing to use these new inquiry-based approaches to teaching.

Student interns were placed in every classroom from preK through grade 5 the following September to help scaffold the process for year 2. They reported that many of the teachers began each science unit with a session in which students generated their own questions. Collaborative work and inquiry became regular parts of the classroom culture. Throughout the year, teachers asked for ideas for more hands-on lessons and the materials in the science resource room were borrowed regularly. Teachers adopted much of the science museum process as part of everyday science instruction. They took ownership of planning for the second annual science museum, which was even more successful than the first. The science museum has become part of a new school culture that celebrates science inquiry.

The simple steps of the science museum process helped this school begin to teach science for all students with a better focus on science practices. The path we chose is not the only path. The first step is to find like-minded partners from your school community and begin planning. ■

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NSTA Connection

Visit *www.nsta.org/SC1402* for a list of suggested life-science readings.