SEED Papers: Published Fall 2010

Inquiry-Based Science in Seattle Preschools

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Abstract

Preschool children in Seattle are engaged in meaningful scientific exploration through an inquiry-based science program that uses carefully designed and researched science units. Because teachers are provided science materials, professional development, and in-class support, they are able to successfully teach inquiry-based science to their young students. The program defined expectations that are developmentally appropriate for preschoolers. They are realistic and can be tailored to the strengths, interests, and needs of individual children. Three- to 5-year-old children are learning how to make predictions, observe, conduct brief investigations, participate in science talks, and record observations in science notebooks. They are receiving a strong foundation in science so that they are better prepared when they enter kindergarten. Through this research-backed, inquiry-based science program, students are able to investigate scientifically, construct and acquire conceptual understandings of their world, develop positive scientific attitudes, and become scientifically literate.

What We Are Doing

Even the youngest of students can engage in rich, in-depth, scientific inquiry. The Seattle Public Schools science department's mission statement states: "All students are able to investigate scientifically in order to construct and acquire conceptual understanding of their world, develop positive scientific attitudes, and become scientifically literate. This is accomplished through a collaborative, interactive, rigorous science program responsive to the needs of diverse learners." In Seattle, we have developed an inquiry-based science program using carefully designed and researched science units. Consequently, many preschool students in Seattle are engaged in meaningful scientific exploration.

The preschool science program in Seattle began in the fall of 2000 when two preschool teachers requested that a science unit be made available to them. Their K-5 teaching peers were participating in a project funded by the National Science Foundation and were implementing science units for their grade levels, and they wanted to do the same for their preschool students. Karen Worth and Ingrid Chalufour of the Education Development Center (EDC) provided drafts of *Building Structures with Young Children* to them. In addition to the curriculum, these two teachers received classroom support from a district science coach in order to teach the unit.

The following year, 10 teachers participated in a field study of the instructional materials that EDC was developing—*Building Structures with Young Children* (Chalufour & Worth, 2004) and *Exploring Water with Young Children* (Chalufour & Worth, 2005). Over the next three years, the number of teachers trained in the two science units continued to grow. In 2005, the Mental Wellness Foundation awarded the science program a three-year grant for a half-time preschool science coach, and the Commonweal Foundation provided funds for materials. In addition to the science coach, a preschool teacher was invited to

participate as a lead teacher. The lead teacher works with the coach to provide initial-use classes and promote best practices in early childhood science.

Today, we continue to have a quarter-time preschool science coach funded through a Seattle Early Reading First grant and a preschool lead teacher funded through local resources, as well as some continued additional support from the Commonweal Foundation. We provide professional development for Head Start, Seattle Public School District prekindergarten, and private preschool teachers in two science units—*Building Structures* and *Exploring Water.* In the 2010-2011 school year, we will add a third unit—*Discovering Nature.* Three- to 5-year-old students in Seattle are experiencing rich inquiry-based science and are becoming part of a community of science-literate children. Providing professional development to those who teach students before they enter our public schools helps ensure that these children get a head start.

In order to strengthen inquiry-based science instruction in preschool classrooms, we focus on five essential elements—instructional materials, materials support, assessment, administrative and community support, and professional development. All instructional materials are provided for teachers in the two units, which are based on state and national science standards. Materials support is offered through the Science Materials Center, where the kits are inventoried each trimester and consumables are restocked. The science units offer many opportunities for both formative and summative assessments of what students have learned. Data and observations from classrooms are also used to evaluate the effectiveness of the program. We receive support from both school district and city administrators, collaboration from university scientists, and in-kind and financial resources from various organizations, institutions, and businesses. Finally, a critical piece of our program is professional development. These five components help to achieve Seattle Public School's vision: "All students become scientifically literate."

Teachers are required to take the science initial-use classes provided by the science coach and lead teacher before they can teach the curriculum. The coach is fully released from the classroom in order to design and implement the professional development classes, to create instructional materials, and to work with teachers in the classroom. Along with the lead teacher, they define and expand best practices in inquiry-based science and implement them, both in the lead teacher's classroom and in professional development classes. The professional development classes focus on inquiry, scientific content, science talks, and science writing.

There are two professional development sessions for each unit—a 3.5-hour initial-use class, focusing on the implementation of the unit, followed by another 3.5-hour session where teachers collaborate on their successes and challenges of teaching the unit. Through these classes, teachers develop the confidence and enthusiasm to teach science and to use science notebooks in order to improve student learning. Emphasis is placed on science talks, where teachers facilitate students' scientific discourse in both formal and informal settings, and on how to successfully use science notebooks.

Not only is training essential before using the kits, we have found that teachers want to attend. Teachers are excited to learn about the science units, to teach them, and to receive support. We have received positive feedback from site supervisors and teachers attending the trainings and using the kits. Teachers report that "the training helped me to understand the connections between the materials provided, science, and literacy." They notice that "implementation was much easier thanks to the training and the materials provided," and that "the lessons are a huge success with the kids and easy to implement."

What We Are Finding

All students, even the youngest of those being served, are engaged in scientific inquiry. And they are excited about science! Students are learning scientific concepts, thinking, and skills in developmentally appropriate lessons designed to promote inquiry. They are encouraged to make observations, ask questions, investigate, and draw conclusions.

The lessons of the inquiry-based science units allow for differentiation in classrooms with children of different ages, as well as among the students' varying abilities within each classroom. For example, in one

of the *Building Structures* lessons, students are challenged to build an enclosure for an animal. Play animals of different sizes (from chickens to giraffes) are offered to the students. They pick an animal and are asked to build a house or barn for that animal. As students begin building, teachers ask questions that vary depending on the student's ability, such as "How will your animal get inside/outside?"; "What will your animal do if it rains?"; "Where will your animal eat?" These questions are designed to encourage dialogue between the student and teacher and among students. They are also asked, in order to help students plan their structure, to present new challenges to students and to increase reflection on the building process. These questions also set the stage for science talks.

Science talks are a critical piece of the inquiry-based lessons. After the students have explored with the materials, it is important to have them talk about what they did. These discussions are necessary for students to learn to articulate their observations and discoveries. Students need to hear how scientific language sounds. This will help them learn to think and speak scientifically, which will then help them when drawing and writing in their science notebooks. Before they can write independently, they need to practice using the language. This is critical because students cannot write what they have never heard and spoken. Science talks happen both formally, as a group, facilitated by the teacher, and informally, student to student and student to teacher, as exploration is taking place.

During a formal science talk, the teacher has an idea or concept that she or he wants the students to focus on. Formal science talks are opportunities for the whole group to explain their discoveries, explore ideas together, solve problems, and engage in new explorations. An example of this would be after working with the tubing in the *Exploring Water* unit. The teacher would gather the students along with the water materials. The teacher might ask, "Can anyone tell us what they found with these tubes?" As students volunteer to demonstrate, the teacher would listen and ask clarifying questions, such as "Where did the water go? Can you show us?" She would repeat what the student said, using the student's language while clarifying it. For example, if a student said, "I put the water here (pointing to the end of the tube), and I did this (holding up the tube), and it came out here (pointing at the other end)", the teacher would repeat what the student said using more-precise language. "So you put the water in the hole at the top while you held the tube straight up, and the water came out of the hole at the bottom." Scientific language and vocabulary needs to be modeled for students.

Informal science talks are just what they sound like; they are informal conversations between teacher and student and among students while they are exploring with materials. The conversations vary in length and content, based on the student(s) involved. Teachers ask questions and repeat student responses. They also present new challenges; for example, "I wonder what would happen if you put a block on top of that?" It is up to the students to decide whether or not they will investigate this new idea.

The teacher's role is in supporting student language. It is important that the teacher provide as much time as needed for student thought. It is not the teacher's role to explain what is happening or to provide answers to the student. The teacher is there to give support and help guide the student, through thoughtful questioning, to figure out the answer on his own.

As students explore, the teacher is able to conduct formative assessment on student progress. Teachers are encouraged to take notes and document student work. As the student is working, the teacher may ask herself the following questions: *Is the student building with the same blocks each time? Does the student build one type of structure (enclosure/tall) most often? If a structure collapses, what is the student's response? Does she fix it using the same materials or using new materials, or does she abandon the structure?* From these observations, teachers can set goals for individual students and monitor student growth.

Science notebooks are provided, and strategies are discussed and modeled in the professional development. The goal is to learn how to use science notebooks, just as adult scientists do, to record their scientific thinking and understanding. What we have seen in the classroom is that both teachers and students are succeeding. Preschool students primarily draw pictures to show their observations and thinking. Some just scribble, while others are able to do more accurate scientific illustrations and add a few words, but from early on, they all are learning how to use and make entries in a science notebook.

The introduction of the science notebooks and the word wall requires a great deal of teacher support in the beginning. The word wall flows naturally from the formal and informal science talks occurring in the classroom. As new materials are introduced and identified, the teacher tells the students, "I want us to remember that! Let's write that word down." As the teacher is writing the word, he asks for help from the students. For example, he may say, "Let's write Kapla. [k] [k] What letter do we need for [k]?" This allows those students familiar with sounds to help spell the word while exposing others in the class to sound/letter correspondence. The teacher also adds a picture or draws a representation next to the word so that students are able to "read" the words. The word wall includes vocabulary words for the materials and tools that students are working with as well as words for properties (e.g., shapes and colors) and ideas (e.g., sink, flow, and tall).

When introducing science notebooks, teachers tell their students that the notebooks are for science. We encourage teachers to convey the message: "We are writing our science in these notebooks so that if another scientist were to look inside, they would know what we were working on." Teacher modeling is an important part of the process. To avoid students becoming discouraged, we emphasize doing "your best work." In one classroom, students were so used to this that they would encourage both their teacher and fellow classmates by saying, "Wow! That's your best job!"

As the teacher models how to draw scientific illustrations, she talks out loud, detailing what she is doing. For example, while drawing a structure, the teacher might say, "I have a rectangle at the bottom. Let's see, it has one, two (counting with class) long sides and one, two short sides. Okay." She then draws a rectangle and continues in the same manner until the drawing is finished. As students become more comfortable with using the notebooks and are developmentally ready, they begin to add words from the word wall to label their drawings. For some students, this may look like scribbles, while for others, it may include accurate labels. Some students may ask the teacher to record their dictation in their science notebook. This is okay, as long as the writing remains scientific rather than telling a story. For example, "I used two squares and a triangle" instead of "This is a castle where a princess lives."

Students are also introduced to the logistics of using science notebooks. They learn that each new entry is started on the next blank page in the notebook. Students are encouraged to date each entry as well. In some classrooms, teachers offer students the use of a date stamp. In other classrooms, where the date (numerically) is being written daily and students are capable, students may write the date themselves.

Furthermore, preschool students are being exposed to their first scientific investigations. They learn how to make predictions, observe, conduct brief investigations, participate in science talks, and record observations in their science notebooks. Teachers model for their students the use of various graphic organizers for collecting and recording data so that students begin to learn how to organize their thinking. A box and T-chart is used for making comparisons:

Foam Block and Wood Block

Both have corners. Both can be stacked. Both have the same shape—rectangle.

Foam Block	Wood Block
Soft	Hard
Blue	Brown
Light	Heavy
Squishy	Can't be squished

They also use T-charts for recording data:

Results

Float	Sink
Stick	Penny
Cube	Paperclip
Plastic bear	Rock

Figure 1 shows a prekindergarten student's results of a Sink/Float investigation. The student was able to successfully use a T-chart to record which objects sank and which ones floated. Figure 2 shows how a kindergarten student also uses a T-chart to record his data. In addition to showing which woods absorb and repel water, he has a concluding statement, "I observed that the cedar repel[ed] the water." Preschool teachers lay the foundation for success in later grades. Throughout elementary school, students continue to use these organizational tools to record data and then use them to write simple scientific conclusions.

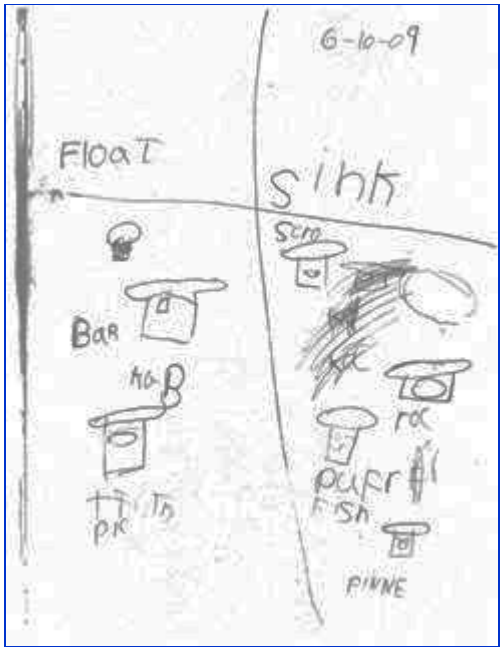

Figure 1. A prekindergarten student recorded the results of a Sink/Float investigation.

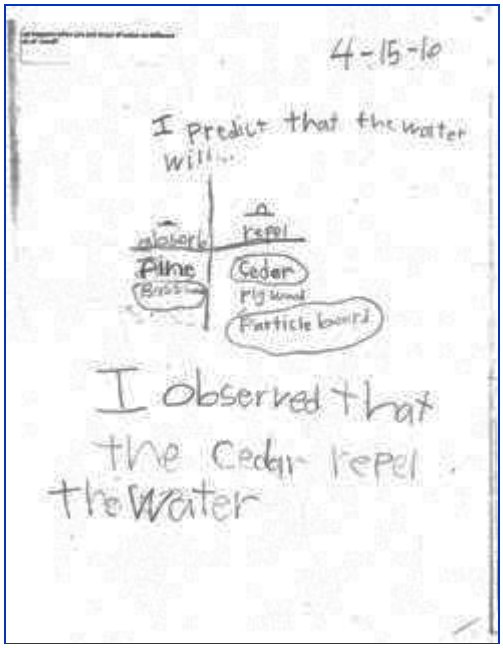

Figure 2. A student used a T-chart to record his data.

As students gain experience, they record their observations independently in their own science notebooks. In Figure 3, a prekindergarten student has drawn and labeled the tools she used during her *Exploring Water* exploration. She clearly shows the difference in how the water looks when it squirts out of the eyedropper (notice the solid black line) as compared to when it makes drops (dotted line).

Figure 3. A student drew and labeled the tools she used during her exploration of water.

Many of the skills being learned in the science units transfer to other parts of the students' day. The word wall developed during science lessons empowers students to use their environment to read and write. We have seen students use other labels in their environment to help them communicate both in writing and verbally, connecting the written word with a particular object.

We have also seen students who speak a language other than English at home benefit from these approaches. Students are working with concrete materials and, thus, are learning new vocabulary in the context of their explorations. Science talks provide additional opportunities for students to be exposed to rich vocabulary. Furthermore, science notebooks are an opportunity for them to communicate to other scientists using pictures and diagrams. Because the word wall offers pictorial cues to vocabulary, it is easy for them to begin to add words and labels to their drawings.

A common challenge that we hear from teachers is lack of confidence in teaching the science units. As one preschool teacher expressed, "I'm worried that I don't know the right thing to say to the students. I'm not sure that I am being effective." In general, it takes teachers three years of working with the materials and teaching the lessons to feel comfortable. It is no surprise then, in a field with high turnover rates among instructors, that most teachers are not getting to the comfort stage. We continue to encourage these teachers to do their best, follow the lead of their students, and attend professional development classes. In addition, classroom support is offered to teachers. The preschool science coach and lead teacher are both available to help with planning, observations, and demonstration lessons.

As the group of teachers using these units expands to include community preschools and child care centers, we hope to see more students entering kindergarten with a foundation in science. In kindergarten and throughout elementary school, students follow the same inquiry-based cycle used in the preschool units; therefore, those students with exposure to inquiry-based science and science notebooks in preschool come to school better prepared.

What We Believe

We believe that science can and should be taught in the early childhood classroom. In classrooms where

teachers have been trained and the science units are being implemented consistently, even the youngest learner is being exposed to scientific language and inquiry. We believe that all 3- to 5-year-olds can successfully experience rich, in-depth, scientific inquiry, as well as learn how to use science notebooks.

Science should draw from children's experiences, be interesting and engaging, and be explored directly and deeply over time. We have defined expectations that are developmentally appropriate for preschoolers. They are realistic and can be tailored to the strengths, interests, and needs of individual children. Children learn from one another. Discussion, expression, and documentation in science notebooks are all critical ways in which children reflect on and develop theories from their active work. For this to work, teachers must take on specific roles to actively support and guide children's science learning.

We do not believe that science should be rigidly structured and scripted. Play is an important part of early childhood. In fact, research has shown that free, imaginative play is crucial for normal social, emotional, and cognitive growth. Students also tend to use more sophisticated language when talking freely with peers than with adults. Our science units provide many opportunities for free exploration of the materials and conversation among students. We believe that the pace of the lessons should be based on the students in the class. Each class will have a different experience based on the children's own exploration of the materials. The important thing is to keep students interested in the materials and lessons.

There has been debate around age appropriateness and the use of science notebooks. Preschool is and should be different from kindergarten, and therefore the expectations of student work must be modified as well. However, we believe that science notebooks can be used in a way that is both enriching and developmentally appropriate for preschoolers. As noted earlier, the expectation is that preschool students will primarily draw pictures to show their observations and thinking. This leaves a lot of room for variation based on student ability. Students should be encouraged to record in their notebooks to the best of their ability, with the teacher encouraging each child to challenge herself a little each time. It is important for students to have many opportunities to use and make entries in their science notebooks.

A common concern of teachers is how to get a class of 3-, 4-, and 5-year-old students to engage in the science activity and then use the science notebook. The answer is expectations. Teachers are asked to have the expectation that all students can successfully participate in the lessons. It is also true that expectations grow and change over time. At the beginning, students may not spend as much time documenting in their notebooks as they do with exploring the materials. As time passes and students have more experiences, expectations increase. We believe that all students are capable of successfully participating in a teacher-defined science lesson.

The following is an example of how important expectations are. The lead teacher was invited to teach a science lesson in a district prekindergarten classroom. The classroom teacher said that the students had very little experience with the science kits, had used their science notebooks only once, and had no experience with a word wall. She also explained that she struggled to keep the students on task during science lessons. The lead teacher chose to teach a lesson that involved choosing both the building materials and what to build. She began by telling the students what they were going to do for the day, which included beginning a word wall and using the science notebooks.

The lead teacher began with the word wall. She made word cards for the names of the three different building materials and the four colors of the blocks. The students were then told that they would have 10 minutes to build. As they were building, the teacher built alongside the students, while also moving around the group, offering support, encouraging dialogue, and redirecting off-task students with questions and guidance. She gave time warnings throughout so that students knew how much longer they had to build. Finally, she had the students write in their science notebooks. When students struggled with the drawings of their buildings, the lead teacher suggested different strategies, such as tracing the building material, asking a friend for help, or picking one shape to focus on. Students were allowed as much time as they needed to finish. When they were done, they showed the teacher their work and briefly discussed it. Some students finished in a few minutes, while others spent more than 10 minutes on their "writing." In the end, the lesson was about 30 minutes long. Because of the lead teacher's expectations, students were on task the entire time and were able to successfully complete the whole lesson.

There is a lot of time, training, and research backing inquiry-based science, and we have seen preschool students have success with the inquiry-based science units and science notebooks. We often hear from kindergarten teachers that their students cannot do the science writing, but we have seen the preschoolers be successful. It is discouraging when the youngest students get a strong foundation in science only to see it disappear in kindergarten and beyond. We would like to see increased support and accountability for inquiry-based science. We believe that science is worth spending money on, and we would like to see it made a priority at the district, state, and national levels.

Thoughtful, research-backed, inquiry-based science is an important part of the preschool curriculum. We are building a community of science-literate individuals, beginning with the youngest of students. By providing science materials, professional development, and in-class support, teachers are successfully teaching inquiry-based science. We know that students of all different backgrounds, learning stages, and abilities are experiencing success in science. Open exploration and guided lessons allow students time and space to explore, wonder, and make discoveries. Formal and informal science talks provide opportunities for students to hear how scientific language sounds and to practice using the language of science. Science notebooks and word walls build on the language of science, where students can communicate their scientific thinking through pictures and words. Consequently, all students are able to investigate scientifically, construct and acquire conceptual understandings of their world, develop positive scientific attitudes, and become scientifically literate.

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