Open-Ended Inquiry in the Schoolyard

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Abstract

We hypothesized that early elementary-aged children are capable of successfully engaging in open-ended science inquiry, and found that to be true of first-grade students at a private school in Phoenix, Arizona. Sixteen students conducted open-ended inquiry on their school grounds for a full academic year. They were able to pose and answer their own questions about the ecology of their schoolyard, and developed process skills at the third-grade level as stated in the Arizona State Science Standards. This work indicates that very young students can master significant science process skills when allowed to conduct genuine, open-ended inquiry into their own questions related to phenomena with which they have had experience–in this case, those occurring outdoors on their school grounds.

Observing

We began work with science inquiry by practicing observation skills with some fun games. Then we made collections of interesting natural things found in the school yard, and recorded what we noticed and wondered about each thing. Soon we were ready for our first open-ended inquiry.

Insect Study

Using plastic cups and spoons, we collected insects from the school yard. We observed them and asked questions about them:

- Why are the insects trying to get out of the box?
- Are the bones in an insect delicate? Are they small?
- How often does the insect go to the bathroom?
- Why do insects have antennae?
- Do the antennae bend?
- Do these insects have wings?
- Why do the insects crawl around so much? What are they looking for?
- Why do the insects move fast?
- Why are the insects moving dirt?
- Why do the insects have sharp points on their legs? (Hypothesis: for protection)

We discussed ways of finding answers to the questions:

- looking them up in books or on the Internet
- asking people who might know, especially scientists
- observing
- experimenting

We considered each of our questions about insects and decided which would be the best way to find the answers. We assigned research projects to the children whose questions could be answered by doing research.

We learned what a hypothesis is–a statement of what we think the answer to a question might be and why, based on our knowledge and observations–and we hypothesized about why insects move fast:

- to run away from predators
- to chase their prey
- to escape from captivity
- because they are blind and don't know where they're going

We discussed what equipment we would need to do experiments around our questions about insect movement. We decided we needed:

- insects
- see-through containers in which to watch them move
- sets of two different things or conditions between which the insects could choose

We discussed why it is important to run our experiments with more than one insect. Just as one child's favorite food may not be the favorite food of all children, the behavior of one insect may not be the same as the behavior of all others of its species. We need information about many insects of the same species before we can make a general statement about that kind of insect.

Now we were ready to do the experiment. We set up two experiments with the beetles we found to answer the questions:

- Do they prefer light or dark?
- Do they prefer a dry or a damp environment?

As scientists often do, we hit a glitch. The weather had become cooler as we entered late autumn. On the day we ran this experiment we only found two beetles. So we knew that we would not have enough examples of insect behavior to convincingly answer our questions. But we ran the experiment anyway, and this is what we found:

Condition	Damp	Dry	Light	Dark
#/Insects Choosing	0	2	1	1

We hypothesized that we would not find very many insects during the winter because the cold weather made them hibernate, or made them too cold to move around much. We decided to postpone further work with insects until the weather warmed up.

Algae Adventures

Since the fourth and fifth graders were studying algae, we decided to take advantage of their microscopes and slides to look at algae ourselves. Wow, it really looked neat under the microscopes! We came up with lots of questions.

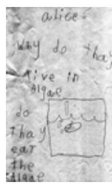
- How does algae live in so many different places?
- How does algae come in different colors?
- Why does algae look like it isn't alive?
- What else did you find in the pond?
- Is algae alive?
- Does algae breathe?
- How does algae help the water?
- Why is algae so green?
- How can algae live in/on ice?
- Why does algae make oxygen?
- What kind of oxygen does it make?
- Why does algae look like an aquarium?
- What kind of algae did we see?
- How does algae grow?
- Why did the algae look gooey?
- Why does the algae look like dust and bugs with hairs?

We looked at a few other things we were interested in under the scopes, and then decided to take a look at things in our pond, since that's where the algae came from. When we started investigating our question, "What else lives in the pond?" we discovered that we were more interested in learning about the critters there than the algae.

Pond Investigation

We started our investigation by observing what was living in and around our pond. We drew and labeled the things we saw there.

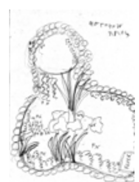
Then we divided into groups for more detailed investigations of the animals we had seen in the water: fish, insects, worms, snails and tadpoles. We captured examples of each and placed them in clear tanks. We observed them carefully and recorded our observations and questions.



Many of us were interested in what the fish ate. We decided to do an experiment to test their food preferences. We selected two vegetable and two meat choices: algae and lettuce, fish food and blood worms (mosquito larvae). Before running our experiment, we predicted which food the fish would like best. We did not all make the same prediction. One student hypothesized that because most fish are carnivores that catch their prey, they would like the blood worms best. It turned out that his hypothesis was correct.

Here is how we set up the experiment. We put three fish into each of two clear tubs. In each tub, we placed two kinds of food. We watched the fish carefully and recorded each nibble taken on each kind of food. The most nibbles were taken of blood worms, the second most of fish food. The lettuce and algae were not popular. After we had done our experiment, we returned the fish to their habitat. We concluded that the fish in our pond are carnivores.

We decided to map where creatures were found in the pond. Before making our maps, we predicted where we would find the greatest number of fish and snails. We were surprised to find that the snails liked living in the shallow water running from the top pool down to the waterfall.



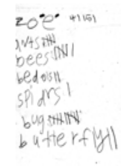
Hummingbird Experiment

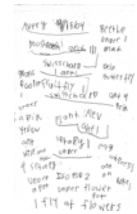
We discussed what we knew about hummingbirds. Many of us had hummingbird feeders in our yards at home, and we had several in our Roxaboxen (our classroom's outdoor area). We decided to test how much sugar hummingbirds prefer in feeders. We discussed the importance of testing only one variable at a time when doing experiments. That meant that we had to keep everything the same except the amount of sugar in the nectar. All the feeders had to be the same shape, size and color, and they had to be set up in the same place. We set up four feeders, two with "regular" nectar (1/4 cup sugar to 1 cup water), and two with "super sweet" nectar (½ cup sugar to 1 cup water). We predicted which solution most hummingbirds would prefer before we set the feeders outside. Most of us thought the hummingbirds would prefer the sweeter solution. After two weeks we took our feeders down and measured the amount of nectar left in each feeder. Sure enough, there was less left in the feeders with the super sweet nectar.

The results of our experiment led to a further question. Was there a level of sweetness that would be too sweet for hummingbirds? We decided to set up our test again, this time doubling the amount of sugar in the two sets of nectar. This time our "regular" nectar was ½ cup of sugar to 1 of cup water, and our "super sweet" nectar was 1 cup of sugar to 1 cup of water. We hung our feeders in the same spot and waited. There was a surprising result: the super sweet nectar attracted bees. We had to dismantle the experiment, but not before making a further hypothesis: that hummingbirds would avoid the feeders with extra super sweet nectar because bees would keep them away. We concluded that the best nectar solution for attracting hummingbirds is ½ cup of sugar to 1 cup of water.

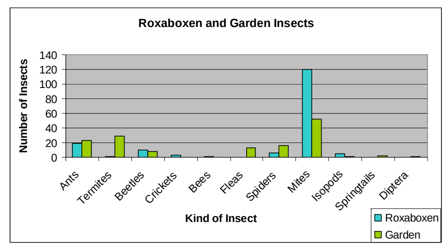
Back to Bugs

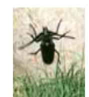
The weather had warmed up again, and we were ready to get back to bugs. We wanted to see what kinds of bugs we could find on our school grounds. We chose five areas we wanted to survey–the pond area, the big garden, our Roxaboxen, the soccer field, and the north-side Roxaboxen fence line. We divided into groups and recorded the kind and number of insects we found in each of the five areas. Before doing our observations we predicted which area would have the greatest variety of insects. Our observations indicated that the garden area had the greatest variety of insects and the pond area had the least.

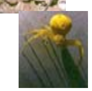




Next, we decided to use trap lines as a more systematic way to collect ground arthropods. We chose our own Roxaboxen and the garden area to set trap lines. First we measured the perimeter of each area with meter tapes, and recorded the temperature of the air and soil in sunny and shady parts of each area. Then we buried ten Solo cups in the ground, five meters apart, in each area. The lip of each cup was just below the level of the ground so that arthropods would fall in. It was hard work digging the holes! After 72 hours, we collected the traps and recorded the kind and number of insects in each trap. Here is what we found:







Questions for Further Investigation

The process of science is a cycle. What we discover in the course of answering one question almost always leads to other interesting questions that we would like to investigate. Here are some of the questions we want to investigate next. We are looking forward to continuing our investigations with these and other questions in second grade.

- What is inside bugs?
- Find out the names of bugs
- Are bugs meat? What are they made of?
- How do bugs reproduce?
- Do dung beetles really eat dung? Are there other animals that eat dung?
- Do dung beetles lay their eggs in dung? What do the eggs look like?
- What do bugs eat and drink?
- Why do termites eat wood?