Doing “Good Science”: On the Virtues of Simply Messing About

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Who made the grasshopper?
This grasshopper, I mean--
the one who has flung herself out of the grass,
the one who is eating sugar out of my hand,
who is moving her jaws back and forth instead of up and down--
who is gazing around with her enormous and complicated eyes.
Now she lifts her pale forearms and thoroughly washes her face.
Now she snaps her wings open, and floats away.

From “The Summer Day” by Mary Oliver

In July and August in Oklahoma, countless millions of locusts and grasshoppers leap through gardens and fields, chomping their way through the green leaves or stalks growing in their path. Lazy summer days are accompanied by the ubiquitous background hum of these creatures rubbing their ridged hind legs against their wings, an erotic song aimed at the properly attuned antenna of the opposite sex. To humans, especially those of the gardening variety, this insistent buzz resonates with ancient, archetypal fears. I have never actually seen a swarm of locusts, like you read about in the Bible, or which still occur regularly in parts of India, but given the damage that the southwest variety can perpetrate, I can only imagine the mythic terror when the sky darkens and the unceasing drone amplifies like in a scene out of a Hitchcock movie.

Given the pervasive presence of these creatures on our homestead, it was not surprising that our “unschooled” boys would take an interest in their habits. One day in mid-August, I was struggling against the elements (late summer drought, scorching heat, potato beetles, and the invading grasshoppers) to salvage something of our garden. As I weeded and mulched and relocated potato beetles from the potato plants to a can of kerosene, I noticed Shaman, who was seven years old at the time, sitting on our front stoop, gazing intently at something that he held in his fingers. From the garden I couldn't tell what it was. Forty-five minutes or so later, my curiosity piqued, I found an excuse to go into the house and stopped to visit with him. He was still sitting in the same position holding a grasshopper by its hind legs and examining its face.

"What are you doing?" (one of my top ten open-ended questions).

"I'm trying to figure out how its jaws work," he replied, staring intently at the creature.

"Well, what have you found out?" (another of the top ten).

"It has lips and teeth and it spit out a brown juice when I picked it up."

"Eeooh, gross," I said (my guaranteed way of ensuring the boys' intense interest in the natural world.)

"But I still can't figure out how its jaws work.."

"How 'bout you look it up in the World Book?" (my fall back position).

And so, he headed indoors to find a jar for the captured critter and carry on his investigations.

A couple of hours later I went into the house to see what was up. Shaman had created a ten-page grasshopper book with detailed pencil-drawn illustrations and relevant text, complete with a green colored paper cover. I learned from reading this delightful little book that grasshoppers' mouths have two large, horny lips. I learned that between their lips is a pair of sharp jaws called mandibles and that behind the mandibles is another pair of jaws with feelers that taste and eat grass. I learned that they have five eyes. Five eyes! Wow! And what an amazing abdomen – eleven segments that work sort of like a telescope, expanding out so that the female can deposit her eggs deep in our Oklahoma soil. And those ovipositors – sharp things at her rear end powerful enough to dig holes in the ground! (Now, this is truly amazing, given that I never found a shovel sharp enough to dig holes in the sun-baked red clay that passes for soil in central Oklahoma. Talk about adaptation!)

I confess, prior to this day, I had mainly thought about grasshoppers, when I thought about them at all, as virulent enemies. Now, thanks to my son's diligent research and careful documentation, I had a new appreciation for the marvelous engineering that went into the invention of these hungry orthopterans. If the learning experience had ended here, it would be a valuable one. Shaman had responded to something in his environment with interest and curiosity. He had utilized his powers of observation to develop further questions. When observations alone could not satisfy his curiosity, he went to printed source materials to find out what the experts had to say about his topic. And finally, he represented what he learned in a creative way that was both visually interesting and factually accurate. But this was only the beginning.

The next day I was again out in the garden fighting the good fight for my tomatoes, corn, and potatoes against everything that would burn, shrivel and devour them before they reached our table. I noticed Shaman walking in ever-widening circles around the house. Periodically he would reach down into the tall grass that was forever encroaching and then walk back over to the stoop. Again, my curiosity got the best of me. I walked over to where he sat and noticed that he had a black laundry marker with which he was marking a grasshopper.

"Did you know that grasshoppers can jump twenty times the length of their own body?" he asked as he leaped down from the stoop and let the creature loose.

"No I didn't," I responded. "How far could you jump if you could do that?"

He didn't take me up on that one, although I could see the wheels turn. Sometimes the best pedagogical questions simply do not resonate with what the learner has in mind. In this case, what he had in mind was collecting grasshoppers and marking them with the indelible pen. Hour after hour. As an art project, it wasn't up to his usual standards. I figured he must have some other, non-artistic motive. And indeed he did.

"What are you doing?"

"Marking the grasshoppers."

"I can see that."

Rolling his eyes back as if to say that anyone with any sense ought to know what he was up to, he patiently explained that he was marking the grasshoppers, releasing them, and then investigating in ever-widening concentric circles to see how far they were traveling from the house. He was interested in range, you see – an ecological concept that is not usually taught in primary school. As far as I know, we had not talked about the concept. I would not have thought to build it into a "lesson plan." But here it was, emerging as an interest strong enough to justify devising a meaningful and systematic experiment. And systematic it was. For the next few days, Shaman continued to mark grasshoppers, to walk in circles around the house, and to search intently in the grass for the marked insects. The results, as they say in the scientific world, were inconclusive. Given that we probably had a trillion or more of the creatures within a twenty-foot radius of the house, the chances of recapturing marked grasshoppers were slim at best.

Surprisingly, he did find a couple. And the interest stayed with him long enough for us to have absorbing conversations about habitat, food chain, migration, range, and the procedures of investigative biological and ecological science.

In my curriculum classes, I like to use this story as an example of doing "good science," as opposed to "textbook science." Good science is messy and exploratory. Scientists operate on hunches (often resulting from intensive study of a topic or problem). The outcomes of experiments are unpredictable. There are many dead ends. Textbook science, on the other hand, is tidy and predictable. All the facts are laid out in an orderly manner, as though one discovery had followed inevitably upon another. The scientific method is presented as a sort of unwavering sequence of hypothesis-experiment-evidence-results-conclusion. All of the chaos and confusion, wrong turns, and bitter battles are absent from the textbook version of discoveries.

Many teachers do make heroic efforts to do "hands-on" or "discovery" science. Although there may be some manipulation of physical materials, there is seldom much actual discovery outside of what the teacher or textbook has in mind. Hands-on classroom activities are most often carefully structured, and designed to teach students how to follow directions and promote a number of process skills: observation, hypothesis formation, prediction, and the recording of data. For example, a primary school teacher might gather twenty-five Styrofoam cups, purchase potting soil, and obtain bean seeds. All of the youngsters might copy down the following instructions from a chart:

1) Put your name on the cup
2) Fill the cup almost to the top with soil
3) Put three bean seeds on the soil

4) Cover seeds with an inch of soil
5) Put just enough water in your cup to wet the soil
6) Place the cup on the windowsill
7) Wash your hands

Daily, they will observe their cups for signs of sprouting, and given the fact that many contemporary first graders have never set foot in a garden, there is likely to be some excitement over this. They may be expected to measure the sprouts and record the growth on a graph, thus introducing an important math skill. But what are the chances on any given day that twenty-five first-graders are all going to develop a passionate interest in the rate of growth of bean seeds? The excitement is likely to wane as each student, daily, is compelled to find time in between the spelling test and the reading journals to dutifully record the minute growth of their bean plant.

In contemporary classrooms, there is little opportunity to engage in the exploratory processes that involve conceptualizing problems and planning experiments. And planning investigations, according to science education writer Wynne Harlen (2001), is one of the most important, and most neglected aspects of science learning. Planning is an imaginative activity that encourages children to think through the potential consequences of their actions. But it is time-consuming. To be more *efficient* (a major goal of modern education— as though learning were an industrial process), instructions for science activities are usually carefully delineated, either on instruction sheets, or on work cards in learning centers. Providing a set of instructions to follow effectively prevents children from engaging in planning. This approach to science, although better than no science at all, holds little promise of nurturing the “scientist within,” for there is little scope for personal interest, extended observation, musing, the twists and turns of genuine exploration, or following a quest until the passion has been exhausted. The "structure" of the learning is external to the learner, the discovery process already laid out by adults who have predetermined the cognitive outcomes.

Shaman's grasshopper curriculum, on the other hand, while not structured by a lesson plan, was definitely not *unstructured*. In fact, there was a *deep structure* to the activity. First, there was an extended period of observation, in which he systematically noticed the intricate design details of the grasshopper. While doing this, a baffling question arose: *how do its jaws work?* Out of all the possible wonderings one might come up with, this was the one that intrigued him. This question structured both the observations and the subsequent investigations in the World Book. What he learned in the encyclopedia answered his initial question, but he had a need to reinforce his knowledge by generating a series of detailed drawings—of the mandibles, the digestive system, the limbs, and the reproductive system of this meticulously studied creature. He was not given an *assignment* to draw the various components of the grasshopper, he *needed* to draw them in order to *internalize* what he had learned, to make sense of things. And in this *making sense of*, this process of ordering his new knowledge conceptually, a new question arose: *if these creatures can hop twenty times the length of their bodies, how far from the house might they venture?* This new question then *structured* the next phase of the investigations—a planned experiment to discover the range of the grasshopper's habitat. The structure of the activity was internal, it was *inherent* in the activity itself. The outcomes of this learning were not predetermined, nor was the direction of the study preplanned. It unfolded, if you will, each step of the way. I call this *emergent curriculum*, because the questions, the activities, and the end products emerge spontaneously from, as John Dewey (1938) would say, the transactions between the child and the environment, the child and the adult, the child and organized knowledge. Further, these transactions have a kind of continuity that can lead to the construction of new knowledge. I say *can lead to*, because clearly there is a role for guidance in this process by adults who have more informed ideas about the world. All experience is not necessarily educational in itself, but can become so through dialogue and reflection upon its meaning.

My guidance in this case was minimal, mostly consisting of casual questions, a suggestion to turn to a book for further knowledge, and then genuine interest in his creative product, from which I learned things that I did not know or had forgotten. But as his investigations reached a natural conclusion, I took a more active role, and introduced new concepts—habitat, range, food chain and migration— which built upon other experiences we had shared and which had the potential to lead to other, related areas of study. The concepts also named what he had learned, or provided theories for his experience. He had intuited the notion of "range" as he walked his concentric circles to see how far the grasshoppers roamed, but the theory that animals in an ecosystem have a normal range of movement is "organized knowledge"—knowledge that other scientific investigators have discovered through collective study. Not all knowledge can be, or needs to be discovered by the learner. But if knowledge is to be meaningful, if it is to result in significant cognitive change in a learner, it must connect with deeply felt interests, or needs, or questions. And these questions should, ideally, result from the interactions of a child with his or her material environment.

I confess that the kind of role I assumed in this instance was not an unintentional one. I was, at that time, strongly influenced by what I still think, many years after first encountering it, is one of the most useful books in education, Charles Silberman's *The Open Classroom Reader* (1973). In his chapters on science learning, he makes a case for what David Hawkins calls "messing about," "free and unguided exploratory work in which children are given concrete materials and are allowed 'to construct, test, probe, and experiment without imposed questions or instructions'" (703). I am intrigued by this idea of messing about, this unrestricted encounter with *stuff*, in which a child has the opportunity to touch, taste, feel, see, smell, manipulate, and experiment with the substances and elements, the objects and creatures of the world. It is an opportunity that is all too circumscribed in formal school, a place in which now, more than ever, every moment is planned, premeditated, even scripted. Messing about is crucial, as Silberman says, to the beginnings of things, for it can foster curiosity, guesses, estimations, and speculations. Messing about raises questions that require further investigations. Messing about can necessitate the acquisition of new skills (measuring, using tools, doing calculations, handling substances). Important as it is, of course, learning does not end with messing about. There is an important place for guidance, and there is certainly a need for knowledge that has been discovered, organized, and synthesized by knowledgeable others. But to neglect the initial phase of discovery, the all-important phase of observation, free play, creative thinking and wondering, is to miss the chance to spark the thirst for inquiry that characterizes genuinely "good science."

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Harlen, W. (2001). Primary science: Taking the plunge. Portsmouth, New Hampshire: Heinemann Books.

Silberman, C. (1973). The open classroom reader. New York: Vintage Books.

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