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ABSTRACT

This paper describes a longitudinal case study that examined the various products that a primary grade student created as he co-researched with his teacher how to implement self-selected science inquiry in a suburban first grade classroom in New Jersey. Transcriptions of science presentations and interviews, parent and student reflection, and the student's year-long science notebook are used to retrace and examine what doing science meant to a first grade student who participated in multiple shared, guided, and self-selected science inquiries. The importance of including family in the school learning environment and the need to cross the border into home with science investigations initiated in school are documented. This case study not only describes how a young student developed his science literacy, but also how he became a science education researcher. (Contains 17 references.) (Author/WRM)

A Young Scientist's Trail of Evidence of Learning to Engage in Science Inquiry as a Student, Teacher, and Researcher

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Abstract

This is a longitudinal case study that examines the various products that a primary grade student created as he co-researched with his teacher how to implement self-selected science inquiry in a suburban first grade classroom in New Jersey. Transcriptions of science presentations and interviews, parent and student reflections, and the student's yearlong science notebook are used to retrace and examine what doing science meant to a first grade student who participated in multiple shared, guided, and self-selected science inquires. The importance of including the family in the school learning environment and the need to cross the border into the home with science investigations initiated in school are documented. This case study not only describes how a young student developed his science literacy, but also how he became a science education researcher.

A Young Scientist's Trail of Evidence of Engaging in Science Inquiry as a Student, Teacher, and Researcher

This is a longitudinal case study of Jeffrey, one of 19 students in a suburban first grade, where I, the classroom teacher, had solicited the help of parents and students to discover a way to implement self-selected science inquiries in elementary school. The story is told through the multiple artifacts that Jeffrey produced. The meaning of each artifact is enhanced by the written and oral reflections both Jeffrey and his parents shared with me during the two-year period of time that was required to complete both the classroom implementation and the hermeneutic dialectic process (Guba & Lincoln, 1989) of constructing a shared meaning of what transpired.

Jeffrey's story records the impact of expanding the expectations of science education in a primary classroom. In addition, Jeffrey and his family model and articulate the outcome of including parents and students as co-researchers when educators seek to study and understand the impact on learners of classroom practices.

Methodology

This longitudinal case study follows in the tradition of many researchers who have uncovered new frameworks in education by limiting the focus of their investigation to one student. Gardner (1980) spent several years collecting and studying the drawings of his own three children, Kerith, Jay, and Andrew, to uncover the developmental stages of children's drawings. Calkins (1993) spent two years documenting the changes in the writing of one child, Susie, during her third and fourth grade year to demonstrate how each child's writing development involves the special combination of a youngster's personal style, cognitive development, and writing instruction. Taylor (1991) spent four years chronicling a school district's pursuit of a young child's suspected disability to reveal the popular misconception "that the cause of school failure lies within the child." (p. xii).

This study documents how Jeffrey, a six-year-older in a suburban first grade, negotiated the multiple tasks that introduced science inquiry into his first grade curriculum. The study also shows how Jeffrey used the knowledge that he constructed in science in first grade as a framework for his continued search for meaning of natural phenomena.

As a first grade student, Jeffrey participated in several guided inquiries, which were reported in his science notebook and were documented in my teacher journals and lesson plans. He also completed a self-selected science inquiry at home, for which a data source of entries in a science notebook, photographs, and transcriptions of audio-taped presentations was collected. In addition, Jeffrey engaged in a 12-month dialogue captured on audio-tapes, video-tapes, and email responses about the science curriculum he experienced in first grade. To expand understanding of family involvement and support that surrounded Jeffrey's engagements in science inquiry, audio-taped interviews, written reflections, and email responses from his parents also were used to help provide an additional interpretative lens. Jeffrey, as a second-grader, completed at home a second science inquiry, which was documented by an undergraduate student, majoring in elementary education. Finally, as this article was being drafted, both Jeffrey and his parents were invited to participate in multiple member checks, which resulted in Jeffrey joining me as co-author of this text so that his evolving perspective of science could be clearly presented. His voice, as a third grader, reflecting on the content of this paper is captured in italic print, which was generated as Jeffrey sat a computer screen reading drafts of this paper and dictating to his mother or me how he wanted the meaning of this text enhanced.

Initial Meeting – Home Visit

I met Jeffrey at 7:00 P.M. on August 21, 1997, when I went to his home to introduce myself as his first grade teacher and to complete a family interview that was supposed to be a means of initiating open and frequent communications between the family and the school. The first statement that I recorded on my interview sheet the evening that I met Jeffrey was that he was just about "ready to lose his third baby tooth" (First Grade Family Conference Response Sheet, August 21, 1997, p.1).

In addition, Jeffrey and his parents told me that his interests were computer games and sports, especially swimming, soccer, and t-ball. His parents described him as kind, considerate, and very focused. His dad, who is a public interest lawyer, reported that his favorite moments were playing soccer with Jeffrey. His mom, an archive consultant for local historical museums, was most proud of how he was able to be a good friend to people. His parents' goals for Jeffrey in first grade were that he would learn to read fluently and understand what he read and that he would like to go to school. Jeffrey's goal for himself for first grade was that he "would have lots of friends" (p.2). At our first meeting, no mention of Jeffrey's engagement in science activities was communicated to me by either the child or the parents.

Leaving Science Resource in the Home

To invite Jeffrey into the world of doing science, as I left the home, I gave him a picture book about insects to read with his parents and a magnifying glass to examine and learn what he could do with it.

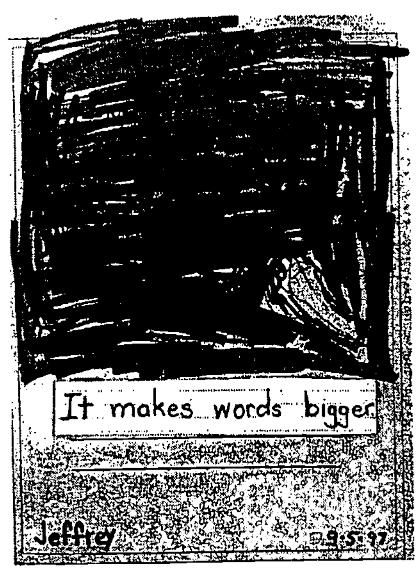
Jeffrey: Now I realized the size of the letter you see through the magnifying glass is bigger than the normal print in the book; however, the letters aren't all made the same size. The size of the letter you see looking through the magnifying glass depends on the size of the print in the book. I didn't notice that when I was first using the magnifying glass. I thought I was seeing it clearer, not larger. I thought every size letter was the same size when you looked at it through a magnifying glass.

Introducing the Use of a Science Notebook

During the first week of school, the magnifying glass was used to introduce students to the importance of recording observations in a science notebook and sharing the information in science talk with a community of learners.

Skill One: Recording Through Drawings

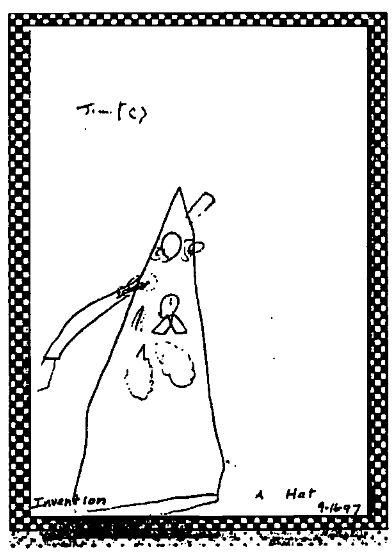
In class on September 5, 1997, Jeffrey drew a picture of a magnifying glass with a



Jeffrey's Science Notebook Entry of a Magnifying Glass – September 5, 1997 large capital A in the center of the lens. Underneath are recorded his dictated words, "It makes words bigger" (Jeffrey's Science, Notebook, September 5, 1997).

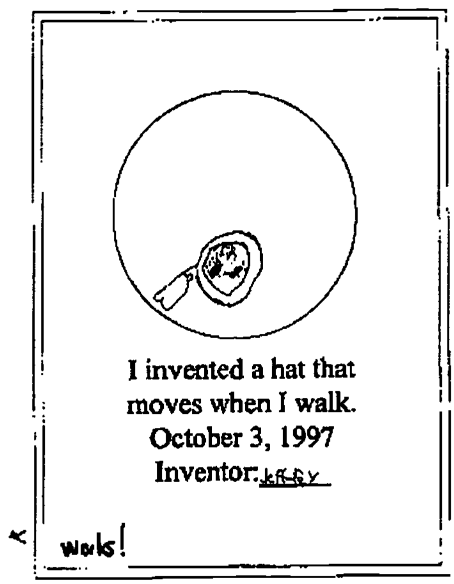
This notebook recording Jeffrey brought to a rug, where he and his classmates gathered to talk science (Gallas, 1995) with each other and to share their findings, which were recorded on a large class chart.

On September 16, 1997, Jeffrey drew in his science notebook a picture of his first technology invention, a hat with a movable part. His developing fine motor skills limited how accurately he was able to capture in drawings what he observed. However, he did record the shape of the hat, symbols for the stickers he used to decorate the hat, and a large rectangle that represented an object that protruded from the hat and moved.



Jeffrey's Science Notebook Entry of an Invention – September 16, 1997

Again on October 3, 1997, Jeffrey recorded a drawing of a second hat that he invented with a movable part that made noise whenever he walked. At this point Jeffrey was not using any labels to enhance the meaning of his drawings. In order to model for Jeffrey that words could also be used to record events in a science notebook, I had written "works!" to document that he had demonstrated to his classmates' satisfaction that the hat indeed did make noise whenever he wore it and walked.



Jeffrey's Science Notebook Entry of an Invention – October 3, 1997

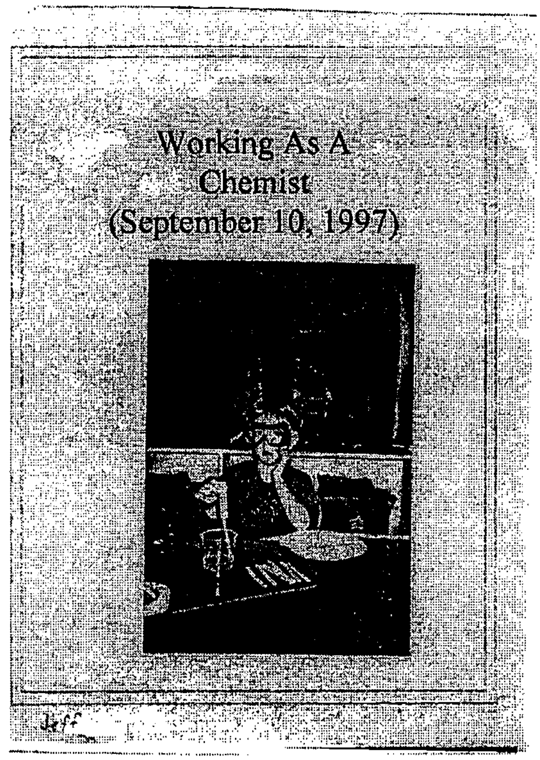
Skill Two: Recording Date of Observation

Jeffrey's interest in science piqued on September 10, 1997, when he brought to class large green maple leaves he had found on the ground by the school. In school, he was introduced to chromatography as a technique to discover the colors hidden in these leaves. Using a penny, Jeffrey crushed the tissue from one of his maple leaves onto a coffee filter, whose end he dipped into a small plastic cup containing alcohol. When the colors from the leaf had separated, he glued the coffee filter with the evidence to a science notebook page and wrote the date, "9-10-97", as directed by me.

Jeffrey later selected leaves to study for his individual science inquiry in first grade. He reports that it was this chromatography guided inquiry in which all the students participated, that later gave him the idea to investigate leaves as his self-selected investigation.

Fourteen months later when Jeffrey was interviewed about his favorite memory of first grade he responded:

My favorite memory was when we were chemists in table groups

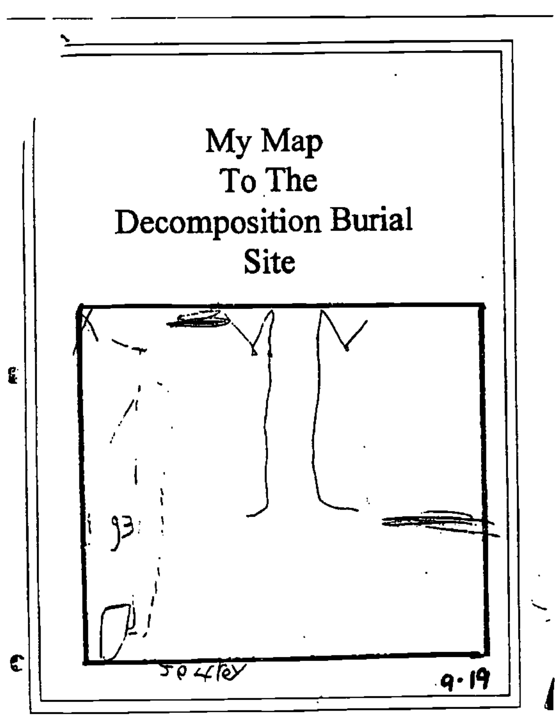


Jeffrey using chromatography to investigate leaves – September 10, 1997

and we had a piece of paper with a leaf on top of it. We scratched it with a penny and we saw all the colors in the leaf. I took the first layer off. Some of the colors were on the paper and some were on the leaf. We had to wet it before we saw the colors. It was interesting. I never knew that leaves had all different colors inside. What I think now because I have thought about it is that around now, late fall, the colors I saw hidden in the leaves are the colors that I see now when the leaves are not green and fall from the trees. The colors I saw in school last year are the colors I see this autumn falling from the maple tree. (Transcript of Interview, November, 11, 1998)

Skill Three: Adding Details to Drawings Including Numerical Symbols

On September 19, 1997, Jeffrey brought a green balloon and a plastic electric outlet cover to school to bury in the ground inside a nylon stocking to study decomposition. This time he traced the items he buried and carefully added details to his drawings. On the same day he made a map showing where he had buried his items. On his map appears the numeral, 93, which is the first time he had used a numerical symbol, other than a date, to enhance the meaning of his science notebook drawings. The "93" represented the number of walking steps he had taken away from the school building before burying his balloon and outlet cover.



Jeffrey's Notebook Entry of Map of Burial Site – September 19, 1997

Jeffrey: When we tried to unbury our objects in the spring, we learned a big lesson: never go near a big pile of leaves in June. When we went to the spot where we thought the *objects were buried, the place had been used to build a nest for yellow jackets. We found this out when we started to move the leaves with our hands. I stepped on the hive and got stung three times. Eleven other children also got stung on the arms, legs, and face. We all went to the nurse's office to put ice on our stings. There was barely enough room for everyone. When we went back to the classroom, some of my friends wanted to invent a way to go back outside and unbury our objects without being stung. We didn't because it was the last full day of first grade.*

Introducing Rubrics to Assess Science Products

On October 21, 1997, Jeffrey was introduced to the use of rubrics for assessment (Marzano, Pickering, & McTighe, 1993; Burz & Marshall, 1997; Doran, Chan, &Tamir, 1998). He was asked to evaluate the games he and his classmates had invented and presented to the class. Students demonstrated and explained their games and the storage container they had created in a three-minute presentation. Students were required to evaluate each other's game, storage unit, and presentation using the following criteria:

0 means inadequate

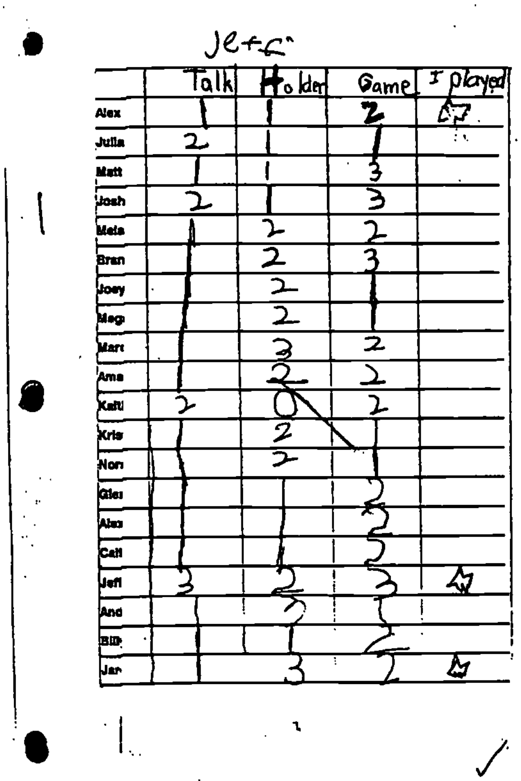
1 means adequate

2 means good

3 means excellent

Jeffrey: I didn't understand what "adequate" meant. I figured that zero probably meant nothing, and one meant poor and two meant good and three meant excellent. That's how I used the number code.

Jeffrey carefully recorded three evaluations for each of his peers and himself. Jeffrey's assessment documents for us that each of his classmates had participated in the game invention activity and had orally presented to the class. It also shows us how Jeffrey was able to record multiple data into a pre-designed grid. Jeffrey gave only himself an excellent rating for presentation. Did he accurately assess his own skill at orally presenting, or was his self-image of being successful responsible for developing his oral presentation skills? One year later, Jeffrey was traveling to local universities to speak to groups of educators, to whom he reported how he had learned to do science inquiry in first grade.



Jeffrey's Notebook Entry Assessing Games – October 21, 1999

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Documenting an On-going Guided Science Inquiry

By the first week in November our two grow-labs in the hallway were overflowing with plants that had germinated from peanuts that we had planted as a class in September. Since it was time to transplant the plants into larger pots, each student was asked to select a plant to adopt and maintain for two months. Students were encouraged daily to check their peanut plants and to move, water, or transplant the plants whenever it was necessary. Once a week each young botanist was required to record information in a science notebook about the plant.

Posing and Recording Questions

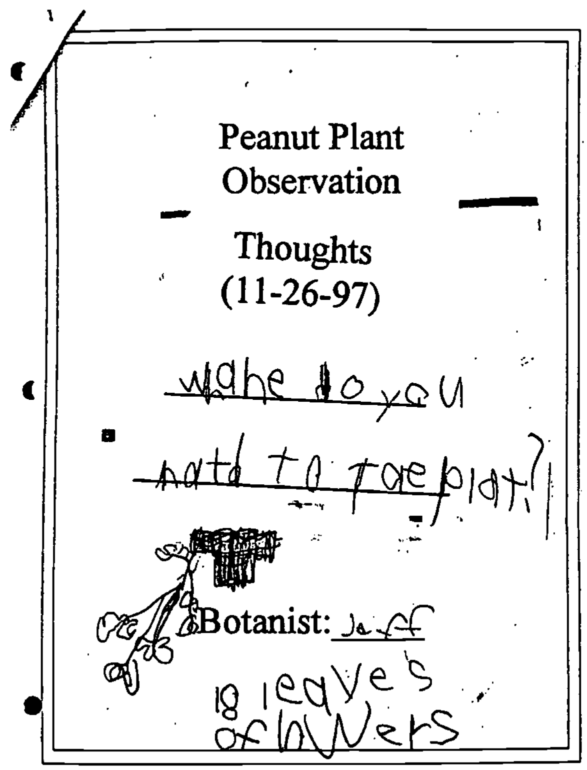
On November 3, November 12, and November 20, 1997, students were asked to draw a picture of their adopted peanut plant and to keep looking at it until a question came to their minds. Each child was to record a self-generated question in the science notebook with the drawing of the plant. This guided inquiry task was to help children listen for their internal voices and to identify and record the questions that their curiosity naturally generated. Jeffrey recorded the following questions:

11/3/97	What is it? Will it grow peanuts? Is it a good plant?
11/12/97	Why is it tilting?
11/20/97	Why does the pot have a hole in it?

Reporting Quantity and Length

In their drawings, Jeffrey and his first grade classmates were not documenting the number of leaves and flowers on the plant in their science notebook. Rather they were focusing on the position of the stem. This may have been the result of how a straw construction investigation that was going on simultaneously in the classroom focused the plant observations. In order to have the students look more carefully at the leaves, for the next three science notebook responses, I required each student to add to their report how many leaves and how many flowers they observed on the peanut plant that they were tending. Jeffrey's notebook contained the following reports:

11/26/97 18 leaves, 0 flowers Why do you need to transplant?



Jeffrey's Science Notebook Entry about a Peanut Plant – November 26, 1997

12/4/97 39 leaves, 0 flowers What is the orange stuff in the soil?

12/12/97 26 leaves, 0 flowers When will it grow flowers?

I also had the students on the last two written responses measure and record the length of the longest leaf. Jeffrey used centimeter cubes to measure the length. He recorded the following findings:

12/4/97 The largest leaf is 5 centimeters long.

12/12/97 The largest leaf is 4 centimeters long.

Sharing Knowledge with a Community of Learners

When Jeffrey was asked at the conclusion of the peanut plant study to record the most interesting thing he had learned about the peanut plant, he wrote:

12/12/97 The stem tilts.

Jeffrey: The stem tilts because it grows towards the sun. Because the peanut plant stem is not sturdy, as the plant tilts it falls down on the side of the pot.

Jeffrey's comment was published in a class list of findings that was given to students to put in their science notebooks. This list shows how a community of scientists socially constructed knowledge and how individual students constructed their own personal meaning (Tobin & Tippins, 1993) about the growth of a peanut plant. /Insert Figure 1/

On November 11, 1997, the students went to a farm and picked peanuts. When students returned to the classroom they discussed and recorded in their science notebooks what was the most interesting thing they had learned on the field trip. Jeffrey drew a picture of a peanut plant with many peanuts growing from nodules in the soil. He dictated the following statement, which below his picture I recorded:

I didn't think there would be so many peanuts on a plant.

Reflecting on a Guided Science Inquiry

In May 1998, Jeffrey was asked to identify the things he was most proud of having accomplished in first grade. One of his five selections was the peanut investigation. He wrote:

> I grew a peanut plant all on my own. I learned that you don't have to water it as much as other plants. (Post-it Note on Science Notebook. May 1998)

Jeffrey: Now I know how I might prove this. I could find out by asking the farmer, going to a web site, visiting the library, or I could go outside and find out on my own. I would plant two peanut plants, and I would water one a little and water the other a lot. At the end of a week I would see which one had grown more. Then I would continue watering one a little and one a lot and measuring them each week. I would also do it with other kinds of seeds. Whatever happens, I would have to try it another time, to duplicate my results. Then I would put all the plants in a pot and show people who are interested. If what I discovered didn't agree with the books and the web site, I would believe what I had observed. However, I would wonder if the facts in the books or on the web might have been reporting experiments done in a different state or in a different part of the world. I would want to find out where they did the planting. Maybe I would also believe the book, if I found out that the experiments reported took place in a different part of the world where they got more sun, water, or had a different kind of soil or better vitamins in the soil.

Connecting Science with Problem Solving

At the end of October 1997, we started to build structures, first using masking tape, straws, and paper clips. With these materials the students created a variety of structures and measured their height with meter sticks. At the conclusion of each day's classroom science work time, we gathered together around a rug to examine and discuss the structures and to record the heights on a large group chart.

Looking for Patterns

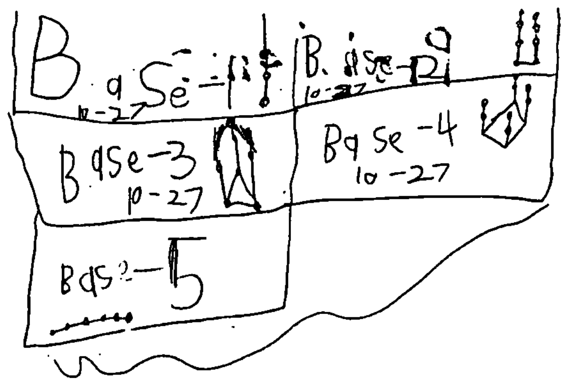
We discussed how we might use each other's results to discover a pattern (Stevens, 1974; Osbourne, 1999). Daniel, Jeffrey's classmate, noticed that the more places a structure was touching the floor, the greater was its height.

Valuing Problems in Science Investigations

We continued building with straws and masking tape. Students became upset when their structures started to wobble, bend, and fall. They were encouraged to try to find the point of weakness or problem with the structure and to refine the design. As students learned to look for the underlying cause of the problem, they identified two material constraints: the straws were flex-straws that bent when they were used for building and the masking tape seemed too heavy to use for joints.

Wanting the young scientists to learn to see problems as a starting place for learning, I acknowledged the problem with the materials and had them begin building structures using new materials that they had suggested - clay and toothpicks. I asked the students not only to record data on the group chart, but also in their science notebook to draw a picture of what they had built and to record problems that they were experiencing. I remember walking around the classroom as they recorded in their notebook and reminding them that although this would be an ongoing investigation, I did not have room to store their constructions. I told them it was very important they record exactly what they had built.

Jeffrey took my advice and his notebook pictures were detailed renditions of his buildings. He created his own symbols He used straight lines to represent the toothpicks and solid circles to represent the clay balls. He designed his own grid in which he recorded the structure he built for a base of one, two, three, or four. In his grid he also included the date he completed his structure. The problem he recorded in this notebook was that "it breaks."



Jeffrey's Science Notebook Entry about Structures – October27, 1997

Changing the Parameter of the Guided Investigation

For the next construction task, the children negotiated the right to build with all the materials: clay, toothpicks, straws, tape, and paper clips. When we gathered together to observe these structures we noticed that many students were building bases with multiple points of contact, usually of clay. The students requested that they now be able to build even larger bases. They theorized that the larger their base the higher could be their structure.

I asked the class to think about how real buildings handled the need for a large base. The following conversation transpired:

Jeffrey: They build a deep hole in the ground.

Teacher: Does it make sense to dig down to be able to build up?

Jeffrey: Yes, I've seen it in many buildings.

Denise: I agree. I saw builders dig deep holes to hold the building up.

Teacher: Is there any way we could duplicate that with our materials.

Jeffrey: I could if you gave me a big piece of clay.

Teacher: How about if I give you a large block of Italian plasticine to take home to explore this idea?

Jeffrey: Yes, I will be try using it as a base.

(Email from classroom teacher to science education mentor, November 9, 1997)

Jeffrey: I started by making a square base. I took the center out of the base. I wanted to put the straws inside the square and have the clay on the outside. I put straws in the center and some of the straws fell, the ones on the corner inside the hollow square remained standing. That is when I stopped. I was working on the back porch. My sister, who is two years younger than me, kept running in and out for sports equipment and toys that were stored there. This annoyed me, so I asked for a science lab in the basement, but I couldn't get my mom to change her plans for turning the basement space into her office. I stopped exploring structures when I began my investigation of leaves. After Denise taught the class about her science inquiry about structures, I wanted to return working with the clay foundation at home, but I couldn't find the clay.

Having read more about building structures (Roth, 1998; Kluger-Bell, 1995), I have been introduced and am beginning to understand and use the canonical terms involved in engineering and building: beam, column, foundation, material strength, torque, joint, brace, compression, tension and forces. However, it is important to see how these first grade students and I co-constructed knowledge of these concepts without first having the canonical science labels. Together we handled materials, collected data, identified problems, tested solutions, and created our own shared vocabulary to represent what we were learning.

Doing a Self-selected Science Inquiry

Having provided students with many of the tools and strategies they needed to do their own science inquiry, in December 1997, I asked each child to begin a science inquiry at home with parental support. Jeffrey decided to study leaves, which he investigated for two months.

Reporting Progress and Responding to Problems

During January 1998, students communicated to me the progress of their home science inquiry by completing. with parental help, a science notebook page. Jeffrey and his mom submitted the following reports to questions posed on the science notebook response sheets. His mom wrote these answers:

My First Grade Science Inquiry - January 9, 1998

Scientist: Jeffrey Reporter: Mom

What material or topic are you observing and investigating?

Leaves - Types and what happens to leaves.

What have you done so far as part of your investigation?

Collected leaves. Traced them. Recorded observations.

Though about the life cycle of leaves.

Talked to the leaf collectors and found out where leaves go.

Talked to people about what happens to Christmas trees in different places.

What have you learned?

What the life cycle of a leaf is.

Leaves have uses even after they die.

There are two major types of leaves.

Jeffrey: I still have questions. Do the leaves really die, if they are cycled back as mulch and are used as food for new leaves? How does the tree use the leaves in the mulch to make buds and new leaves?

What problems are you facing?

Finding leaves that aren't evergreens in the middle of winter.

After reading this report, I sent home with Jeffrey the leaves the children had brought to school in the fall to use for chromatography. The children had pressed, and I had laminated, the extra leaves that were not scratched. This gave Jeffrey a good collection of neighborhood leaves to study in the winter.

My Science Notebook – January 16, 1998

Scientist: Jeffrey Reporter: Mom

What did I do for my investigation this week?

We made appointments to visit the Ecological Center and to visit a neighbor's compost site. We visited friends who compost leaves. We looked at the leaves the children collected and noticed the differences. We cut branches to bring inside to see if the flowers and leaves would think it was spring and bloom.

What new questions have come to my mind as I work on my investigation?

What is a leaf made out of?

How big can leaves get?

What problems am I having?

Understanding how leaves decompose, but I hope to learn this weekend.

I would like to look at a leaf under a microscope, but I don't have one.

What investigation problems have I been able to resolve this week?

Finding leaves.

What did I learn this week while working on my investigation?

I learned leaves turn into mulch and rich soil when you compost. I learned leaves have different shapes, colors, veins, and sizes. The edges are also different sometimes.

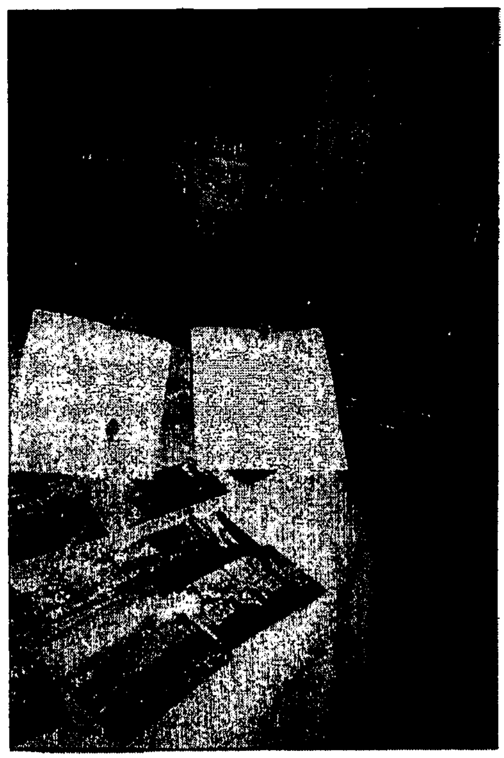
Jeffrey: At the ecological center I learned that leaves turn into rich soil with time, insects, and increased temperature.

After reading this report, on January 21, 1998, I took a microscope to Jeffrey's house, where he talked to me about his science investigation.

Visiting the Home to Partake in Science Discourse

His mother, who had been a co-learner and co-researcher, was present in the dining room, where on a table Jeffrey had spread the evidence of his investigation. I carried a clipboard with a list of questions to guide our science dialogue. /Insert Figure 2/

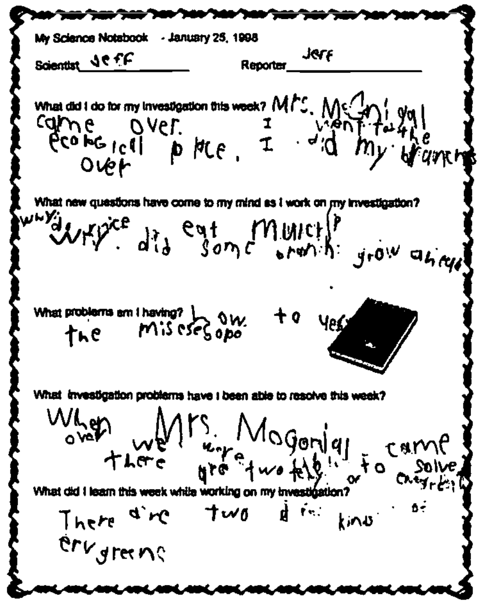
As I listened to Jeffrey, and then invited his mom to add anything that she wanted to tell me about the investigation, I took three pages of notes on a legal yellow pad. The act of writing helped me to remember and to think about what I was hearing. The home interview was a way for Jeffrey to prepare for his oral presentation to the class. It gave me a preview of what he had learned so that I could support him with questions during his presentation, if speaking in front of his classmates became a difficult task. I also listened carefully to find a way to extend his investigation one more time before Jeffrey shared his knowledge with his peers.



Home Visit with Jeffrey – January 1998

Jeffrey had learned about evergreen and deciduous leaves, composting, the food chain at the ecological center that included compost, mice, and foxes. He also had investigated how different branches of flowering bushes could be brought into the house and forced to bloom. I introduced him to the importance of multiple trials to confirm his results, and I asked that he try forcing branches from the same bushes again.

On January 25, 1997, Jeffrey submitted his last report for his science notebook about his self-selected investigation. This time he wrote all the responses himself.


My Science Notebook - January 25, 1998

Scientist Jeff Reporter Jerf

What did I do for my investigation this week? Mrs. McGnigal came over. I went to the ecologicall place. I did my branches over

What new questions have come to my mind as I work on my investigation?

What problems am I having? how to yes the misesesopo

What investigation problems have I been able to resolve this week?

When Mrs. Mogonigal came over we were

What did I learn this week while working on my investigation?

There are two kinds of ervgreens

Jeffrey's Notebook Entry about his Self-selected Science Inquiry – January 25, 1998

My Science Notebook - January 25, 1998

Scientist: Jeffrey Reporter: Jeffrey

What did I do for my investigation this week?

I went to the ecological place. My teacher came over. I did my branches over.

What new questions come to my mind as I work on my investigation?

Why do mice eat mulch?

Why did some branches bloom in the house before others?

Jeffrey: This is still questionable because the two tests had different results. I did one test in the middle of January and one at the end of January. I now know that I should have forced two branches from each plant at the same time.

What problems am I having?

How to use the microscope.

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What investigation problems have I been able to resolve this week?

When my teacher came over we were able to solve that there are two types of evergreens … broad leaf and coniferous.

What did I learn this week while working on my investigation?

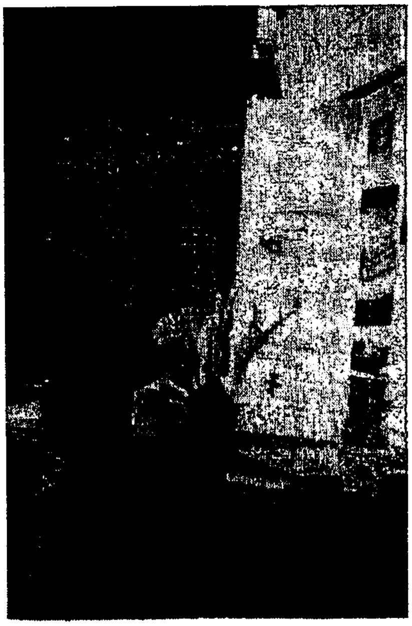
There are two different kinds of evergreens.

Jeffrey: I also wanted to learn how many individual leaves there are in the world. I think I would figure it out if I knew how many trees there were in the world, and how many leaves would be on each tree. I would count the leaves on a young tree and an old tree and get an average. I would do this for each kind of tree. There is an end to almost everything, so there should be end to the investigation about how many leaves are there. I would do this in the summer before the deciduous leaves fall from the trees. I would ask for people to give me samples of the count on leaves in other places. They could email me the information,

When I went to Jeffrey's house, I did not understand how leaves were composted for mulch at the ecological center. I also did not remember learning about deciduous and evergreen leaves. I certainly didn't know that there were two types of evergreens. Together we were co-learners and co-teachers. As Jeffrey showed me his evidence, I was curious to learn as much as I could. When I didn't understand something, I asked for clarification. When Jeffrey, his mom, and I talked and wondered about evergreen leaves in his dining room, his mother reached for a gardening book, and together we discovered simultaneously about broad leaf and coniferous evergreens. Jeffrey was a co-learner with his parent and his teacher.

Presenting Findings to Students and Educators

On Friday morning, January 30, 1998, Jeffrey brought his materials to school to teach his classmates what he had learned about leaves. Jeffrey was the first student to share his science inquiry with the class, after our model of doing a self-selected science inquiry at home had been designed with the co-participation of parents and students who helped me discover the framework in the fall. With Jeffrey's permission, I invited my principal to attend his science inquiry presentation.



Jeffrey presenting his science inquiry to his classmates – January 1998

Each member of the audience was required to fill out a response sheet by answering the following three questions:

What did Jeffrey do?

What did I discover from Jeffrey's presentation?

What new question now needs to be investigated about leaves?

I compiled a list of the responses to give to Jeffrey to take home. Each original response sheet was stored in the reporter's science notebook.

In addition I planned to tape record each presentation so that it could be transcribed and placed with the tape in the student's science notebook. Unfortunately, for the first presentation, in which Jeffrey used a microphone and stood by a table that displayed his evidence on a whiteboard, I forgot to turn on the tape recorder. Jeffrey agreed to repeat his presentation in the afternoon to our fourth grade mentors who daily helped us develop reading and writing skills. This problem and solution led to an interesting outcome; the first grade scientist experts often requested to follow Jeffrey's lead and present their knowledge and evidence multiple times to different audiences. *Jeffrey: The two presentations were different. There were always different questions that people in the audience asked. The second time a fourth grader gave me the idea to figure out how many leaves there are in the world. I thought that was an interesting question because it would be challenging to find out and I would find lots of other information along the way.*

In the transcript of Jeffrey's second presentation to 15 fourth graders, I had an authentic documentation of the wide range of canonical science knowledge Jeffrey was constructing. He pointed to each photograph on his whiteboard and talked about how leaves are composted by individual homeowners and ecological centers. He described a life cycle for leaves that included budding, growing, changing color, falling, collecting, composting, and recycling in gardens as mulch. He correctly identified deciduous leaves and broad leaf and coniferous evergreens. He described the mulch-mice-fox food chain, which he had uncovered at the ecological center. He referred to a map as a tool he used in his inquiry to get to the ecological center. He reported how he had repeated his experiment of forcing plants to bloom, having run two trials, one on January 15th and one on January 22nd. He mentioned using a magnifying glass and a microscope to look at the leaves. He presented his theory that broad leaf evergreen leaves are thicker than deciduous leaves because they stay on the tree longer and must hold more water. Jeffrey had two questions that still puzzled him. He did not understand from what a leaf was made. He proposed that maybe leaves were made from paper because dried leaves felt like paper when they were being raked. Jeffrey also wanted to find out when a branch was considered dead. He questioned whether the branches he had cut from trees and forced to bloom should be considered alive since they no longer were attached to the tree.

Jeffrey: Now I know that leaves can't be made from paper because paper is made from trees and leaves grow on trees. They add stuff to make the paper from the trees. The leaves do feel like paper when they are dried and have no water in them.

<u>Listening for Themes for New Guided Inquiries</u>

Near the end of the school year, I used Jeffrey's first question from his presentation to frame the last guided science investigation for the first graders. We used microscopes to examine cells of different plant parts. His second question I carried with me and used as a talking point with my husband and my father. I found that many adults wonder and try to construct a meaningful answer for Jeffrey's question. My husband talked about cut branches as dying, but not dead. My father related Jeffrey's question to his own queries about when to consider a human fetus alive? Just as I had crossed the boundaries from school to Jeffrey's home to learn about leaves, so Jeffrey's science inquiry had crossed the boundaries from school to my home.

<u>Receiving Feedback</u>

From his first science inquiry presentation, Jeffrey received a memorandum from the school principal. In the letter the principal answered the response questions which had been given to Jeffrey's classmates:

What did Jeffrey do?

He presented the life cycle of leaves.

He went to a leaf recycling plant and learned about the recycling process.

He did an experiment to see which plant would bloom the faster when forced.

What did I discover from Jeffrey's presentation?

I did not realize that there were broad leaf evergreen trees.

What new question now needs to be investigated?

Your initial investigation was focused on types of leaves. You seem to have moved from this investigation to exploring the factors that affect the rate trees or flowers come to bud. It would be interesting to discover more about the factors that affect the rate which trees and flowers bud.

(Memorandum from principal, January 30, 1998)

The first graders provided Jeffrey with pages of responses that included some of the following statements:

What did Jeffrey do?

He sorted leaves.

He showed soil that came from leaves.

He found a food chain.

He forced flowers to bud.

He traced leaves.

He taught us that leaves can turn into mulch.

He saw a big machine at the Ecological Center.

Jeffrey: The big machine was a big automatic rake to turn the leaves over to make the compost.

He took photographs of trees, compost piles, and leaf trucks.

He identified and wrote the names of leaves on papers.

He told us about the life cycle of leaves.

What did I discover from Jeffrey's presentation?

That there are two different kinds of evergreen leaves.

That leaves compost.

Leaves change color.

Mice eat mulch.

There are lots of different kinds of deciduous leaves.

The evergreen leaves can be that shape – broad – they look like the ones that change color.

Leaves die.

Jeffrey: Leaves change from one stage to another stage. First they are a bud, then a leaf, then they decompose and become mulch, which goes in a garden and grows new trees that have buds, and the cycle keeps going and going.

What new questions now need to be investigated?

How do leaves grow?

What are leaves made out of?

How long can an evergreen leaf stay alive?

Why do leaves feel like paper when they die.

(From composite list in Jeffrey's Science Notebook)

Participating in a Community of Scientists

The first graders each presented what they had done and what they had learned while doing their own self-selected science inquiry at home. Jeffrey listened, questioned, and responded in writing to presentations about frogs, mealworms, structures, symmetry, fungus, hair, hissing roaches, fish, crystals, crayons, pencils, tobacco hornworms, cats, clocks, cacti, rocks, feathers, balls, and flowers. He was a part of a community of first graders who viewed themselves as scientists and engaged daily in class in the discourse of science with each other.

Jeffrey: I listened to Thomas's presentation about the logs and fungus. He told us about how the fungus used the tree to get food. I wondered how the tree made food. So later, near the end of first grade, I was looking through a Magic School Bus book and it was about nature, and then I found something about how trees made food. The leaves make the food by using the soil, sun, and water.

Composing an Organized Account

After every presentation was completed the students prepared for a science inquiry conference (Bourne, 1996) where other classes would tour the classroom filled with their presentation boards, evidence, and science talk. For this science conference I asked students to write an organized account that would be published with student-drawn illustration in a spiral bound book. After we read several non-fiction science books to discover the conventions of writing that genre, together we created an outline of headings for the individually authored books. /Insert Figure 3/

Writing to Learn

Jeffrey spent one week at home in the evenings writing his rough draft, which I published in a blank book and returned to him to illustrate. My purpose for this activity was threefold:

1. To integrate non-fiction writing (Graves, 1989, Freedman, 1990) in the science inquiry model,
2. To provide families additional reasons to use the science discourse that they had co-developed,
3. To create written records of the science inquiries that could be placed in our classroom library.

Jeffrey and his family, however, used this assignment for another purpose; they extended their science inquiry about leaves. Rather than just reporting what they had learned, they used print resources to confirm and expand their knowledge about leaves. In the glossary new terms appeared. Jeffrey wrote about the conifer and broad leaf evergreen leaves as he had reported to me at his home visit and to his class during his presentation. However, in his book he also described with words and his own drawings lobes of leaves, compound leaves, and how water moved through veins.

Writing to Reflect

In the section of his book where parents were invited to respond to the science inquiry his mom wrote:

> Jeffrey learned a great deal about investigative techniques. He used a number of tools: a camera, magnifying glass, microscope, pencil and paper to record his observations. He also realized it was important not to rely on just one instance or experience, but to repeat a test to confirm results. The science inquiry was truly a family affair, particularly with the site visits, which probably were the most effective learning experiences. (Written correspondence from mother, February 3, 1998)

Talking about Science Inquiry

The following year, in November 1998, I visited with Jeffrey at his home to see what he remembered about leaves and science inquiry. When I asked him to define inquiry he responded:

> An inquiry is something you really want to learn a lot about. You figure out what topic you want to study and you get one of the things you want to study. First you observe it, and then you start to do other stuff with it. You might split it in half and see what is inside it, or you could get another one of what you are studying

and compare them. You can make tests to compare them.

(Transcription of interview, November 1, 1998)

Jeffrey: While doing an inquiry, you could go places to find out more. You could do experiments, which need to be done at least twice and you must remember to keep everything the same when you repeat your experiment.

As we continued talking about science inquiry, Jeffrey remembered so much about composting, forcing buds indoors to bloom, and the different evergreen and deciduous leaves. Jeffrey also insisted that I listen to what he had learned from his classmates' inquiries. He talked about how Thomas had counted the rings of tree trunks that had fungus growing on the bark. He reminded me about that Allen had dissected a fish for the class and showed us the gills. He was fascinated with the ways different balls bounced and rolled because of their surface and what was inside of each one. He talked about how Walter had run food preference tests for mealworms and had discovered that mealworms change into beetles. Jeffrey expressed disappointment that he had never observed the metamorphosis of the mealworm that Walter had given him. The insect had died at Jeffrey's house before it had changed into its pupa stage.

I asked Jeffrey if he would be interested in doing another science inquiry. At first he responded that he already was because he was watching for a pattern in how the trees were losing their leaves. He also said that he wanted to cut open a stem of a leaf and see what was inside of it, because he still wondered how water traveled through stems and veins. He said that it would be better, if he knew he had an audience to present his findings. Without an audience, Jeffrey believed that he would just think about his questions, rather than investigate and record findings.

Talking about Science Inquiry as a Co-Researcher

In July and December 1998 and in January and February 1999, Jeffrey and his classmates, now second graders, were invited to share their first grade presentation boards, science notebooks, and published organized accounts to educators at local universities. At one of these presentation, after Jeffrey told the pre-service teachers and science education researchers how he and his teacher and his classmates had discovered together a way to do science inquiry, one of the members of his audience asked to mentor him through another science inquiry. Jeffrey was delighted with the prospect.

Jeffrey at an Elementary Science Methods Undergraduate Course – January 1998

Choosing a New Science Inquiry to Confirm and Extend the Findings of a Peer

When allowed to self-select a second topic to investigate, Jeffrey reported that he really wanted to learn about mealworms and how they changed to beetles.

During March and April 1998, Jeffrey completed his second science inquiry. His mentor, Shirley, was an undergraduate student majoring in elementary education. She obtained some small and large mealworms at a pet store for Jeffrey to observe. She and Jeffrey kept a science notebook for their inquiry, which was photocopied and given to me.

Jeffrey: Shirley first brought a composition book to use for the science notebook. I told her about portfolio notebooks. A portfolio is a place where you store your work. You take a three-ring binder and take pages and put the pages in and you can label the pages. You use tabs to make sections for your portfolio. You can just keep adding pages and pages and pages. You are able to add pages wherever you want and you won't miss anything. You will be able to record everything. That is important because you never know when what you are doing might turn out to be the most important observation or experiment of your inquiry.

From that science notebook, I am able to track many of the steps that Jeffrey took to learn about mealworms. This time, as his language skills were developing, he used email to access a science educator in North Dakota and an entomologist who researched ways to package insect-free food for the United States Army.

Narrowing the Focus of a Self-selected Inquiry

The question that drove Jeffrey's investigation was how to get his super large mealworms to change to pupae, for Jeffrey only was able to observe his small mealworms go through a metamorphosis.

Email to Science Educator:

> Dear Dr. G.
>
> I met you at a conference and you told me about your mealworms. Are there any different species? We have big mealworms and little mealworms. Does that mean they are different species? My big worms are not changing to pupae like the little ones did. Do you

> know if the big guys change into pupae? What kind of beetles do mealworms become? (Email sent on March 14, 1999)

Jeffrey: I know now that there are different species of mealworms. There are white ones and red ones. There are different types of beetles. I didn't know that when I started investigating mealworms. I heard this on the news on the radio, during my investigation.

Jeffrey received the following response from the science educator that encouraged him to continue his investigation. He realized that there was much to learn and that he possibly might find answers to share not only with his peers, but even with science educators.

> I am not a mealworm expert, but I have some experience that I'll share with you. I'm not sure how many species of mealworms there are. There must be several because I have also had some of the big mealworms that I bought at a bait shop. I noticed that these, like yours, did not turn into pupae and then into adults, but all just eventually died in the container of oatmeal. (Email received on March 15, 1999)

Connecting a Science Inquiry with a Field Trip

Jeffrey continued observing his mealworms. He experimented to see whether the small or big mealworms moved faster. He watched to see which colored paper they liked better which he determined by how long they stayed on it. He experimented to see what foods they preferred.

Jeffrey: The super mealworms moved faster. All the mealworms liked red and orange paper, not green and blue. They liked sugar more than apples. The experiment initially *was supposed to be comparing the speed of little and super mealworms, but it became speed and food, because we were trying to get them to get to the other side of the pan to see who moved the fastest. So we used food to get them to move. The little mealworms just moved around in circles until we moved the food.*

He encouraged his undergraduate mentor to take him on a field trip, which he had learned was a great way to investigate his science inquiry about leaves. They went to the Delaware Museum of Natural History, where they learned:

> The big mealworms are called super or king or tropical mealworms
>
> and that if you isolate them they should change.
>
> (posted on March 22, 1999 on a university web site,
>
> http://www.learning.gse.upenn.edu, by Jeffrey]

Jeffrey returned home from the Museum of Natural History and isolated two of his large mealworms.

Jeffrey: When I started this investigation, by younger sister, Colleen, was interested in the bugs. Since she was the only one who was willing to handle the mealworms, I allowed her to join my investigation.

Shirley, Jeff, and Colleen investigating mealworms – March 1998

We studied mealworms and caterpillars together. This time Colleen was working so softly that I didn't even realize that she was working with me. Together we became scientists learning about insects.

Communicating with Research Scientists

In April, Jeffrey saw one of his big mealworms change into a pupa. Now he began wondering what would emerge from the large pupa. He emailed an entomologist.

> Dear Mr. K.
>
> We've been trying to change mealworms into pupae and pupae into beetles. This worked for the little mealworms, but I found out I had super mealworms and I had to isolate them to make them change. I isolated two of them. We put food and water in one and that one died. We put nothing in the other one and that one's a pupa now. I had them more than 59 days before one changed. It was 21 days since we isolated them before one changed. Do you know what kind of beetle will come out of this pupa? Do you have any idea why the one with food and water died and not the other one? We did an experiment and found out that little pupae don't need food or water, but the super mealworm was still a pupa.
>
> (Email sent on April 14, 1999)

The entomologist responded that there were more than 86,000 species of beetles. He suggested that Jeffrey keep the beetle when it emerged so that together they could try to identify it when Jeffrey visited his office in the future.

Jeffrey: Using the computer to talk with scientists made me feel comfortable because the scientist didn't know I was a little kid.

Voicing His Research with Science Educators and Science Education Researchers

In April 1999, Jeffrey and his first grade classmates and their parents presented all the evidence that they had collected about their implementation of science inquiry in first grade to education researchers at the 20th Annual Ethnography in Education Research Forum at the University of Pennsylvania. Together the parents, students, and researchers discussed how children, a classroom teacher, and families co-created their own way to do science and expand their science knowledge. Jeffrey's mom spoke about how parents had learned to work actively to provide a learning environment at home that connected with the school science curriculum. She also spoke about the importance of raising a parent's expectation levels for their children because "based on last year's experience we discovered that our children are capable of so much more than we ever dreamed" (Notes prepared by Jeff's mom to present at Ethnography Forum, March 4, 1999).

Jeffrey concluded our presentation at the ethnography forum with statistics that he had generated from a questionnaire that he had co-developed with me for his classmates about the learning environment of first grade. He reported that "all nineteen students who answered the questionnaire responded that they had enjoyed science, tried their best, were interested in science lessons, and believed that what they were doing in science in first grade was important" (Notes Jeff prepared for Ethnography Forum presentation, March 4, 1999).

At the closing ceremonies of this education forum, Erickson (1986), a noted leader in qualitative educational research , recalled that at the first ethnography forum in

1979 Margaret Mead had challenged educators to use the tools of the anthropologist in their educational research. Erickson mentioned the names of many of the great educational ethnographers and teacher-as-researchers who had shared their research findings at the annual ethnography forums in the years after Margaret Mead's challenge. Included in his listing were Jeffrey and his classmates, who were recognized as elementary students-as-researchers who had documented how to include science inquiry in an elementary school curriculum.

Conclusions

In 20 months Jeffrey evolved from a child who engaged in little science talk to a co-learner who felt comfortable communicating with his peers, his teacher, science educators, and scientists about his own investigations of the phenomena of our natural world. We may never know why Jeffrey experienced this personal metamorphosis, but we can use his story to identify some of the scaffolds that were put in place for him to successfully enter the world of science and science education.

Expectations were always shared with Jeffrey that science was an inviting place where his observations and questions were valued. No limits were placed on what were the possibilities or developmentally appropriate activities for this child to try. The significant people in his life, his family, his peers, and his teacher were partaking in his investigations and discoveries and co-creating a shared science discourse.

Jeffrey's interests and concerns were valued and were used to frame his school science curriculum. In addition, he was provided a way to voice the problems and challenges that he faced and was shown how to use them as starting points for learning.

The boundaries between his home and school were crossed in many ways, as well as the boundaries between his explorations and the resources at colleges, museums, and science workplaces.

Jeffrey was given many opportunities to use his new science discourse in multiple written, oral, and action formats. Over a period of 20 months, with lots of opportunity to authentically engage in talking, reading, and writing science, Jeffrey had become comfortable and fluent in his new science language acquisition.

Jeffrey's story causes us to pause and to think of the possibilities that could unfold in elementary classrooms where students are invited to participate in self-selected inquiries and are mentored by teachers and science educators who are willing to take the risk of learning at the side of young students.

Ben Franklin Symposium – University of Pennsylvania – December 1998

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Figure 1: Class Data Chart about Peanut Plants

Student	The most interesting thing I have learned about peanut plants is:
Raymond	From the flowers come peanuts
Ruth	Not every plant grew flowers
Thomas	They have flowers.
Philip	Growing them takes a long time.
Melanie	Flowers can make peanuts.
Walter	It takes a long time to grow flowers
Robert	My plant had more leaves than flowers.
Dorothy	The bugs come to the plants.
Neal	They are real nice.
Molly	It has orange flowers.
Marguerite	Don't' pick your flowers.
Danielle	The plant stands up.
Carolyn	Some peanut plants have flowers.
Paul	It dies.
Steven	It has to be moved to a larger pot when it grows big..
Denise	It has flowers.
Jeffrey	The stem tilts to the light.
Marvin	They grow more flowers than leaves.
Allen	You can plant a peanut and a plant will grow.
Daniel	The leaves close at night and open at day.

Figure 2: Home Visit Pre-Presentation Interview

Name:

Date:

What material did you investigate?

What did you learn from the material?

What evidence do you have?

What changes did you observe?

What boundaries did you set?

What fair test did you do?

What tools did you use?

What did you measure?

How did you measure it?

What evidence of multiple trials do you have?

Where did you take your new knowledge to another situation to confirm?

Where did you take your new knowledge to another situation to extend it?

What corroborative evidence did you get from other resources?

Figure 3: Headings for Science Inquiry Organized Account

My Science Inquiry

Written and Illustrated by _________

Copyright March 1998

Dedicated to:

Section One – Why I Selected This Topic

Section Two – Where I Got My Materials

Section Three – Tools I Used

Section Four – Things I Observed

Section Five – Experiments I Did

Section Six – Data I Collected

Section Seven – Facts I Learned

Section Eight – All About My Presentation

Section Nine – Questions I Still Have

Section Ten – People I Need to Thank

Section Eleven – Parent Response (written my a parent)

Section Twelve – My Response

Section Thirteen – Glossary

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