Three Workshop Sequences

The backgrounds and details of the main activities of three workshop sequences are provided in this chapter. The topic of the first sequence is the basic addition facts. The second sequence described is on the science topics of the life cycle and environments of plants. The third is on student-directed workshops. Later chapters describe how to teach effective minilessons to begin these workshops, what to do during the activity period, concluding each workshop with reflection, and assessing what students learned.

Math Game: Basic Addition Facts

Children need to know the number facts. Automatic recall of these basic number combinations allows children to fluently compute, and these facts come in handy both in school and at home. Aside from its mathematical value, knowledge of the math facts also is valuable on the public relations front. Children’s mastery of the facts is often the preeminent criteria for the community to use in judging the success of its school’s math program. In other words, if you can get the kids to learn the math facts, you are well on your way to having the parents on your side. The following workshop sequence shows one way to help your students develop automatic recall and understanding of the addition facts.

Background

The theories and activities of this sample math workshop are not mine alone. The work of Constance Kamii (1989, 2000) and of Thomas Carpenter and his colleagues (1989, 1999) has formed much of the theoretical and practical framework for the teaching and learning of addition.

Memorize or Think? Children can learn math facts through two very different processes: memorization and thinking. Of course this is some-
what of a false dichotomy. Memorization requires thought, but considering memorization and thinking to be opposites helps to illustrate their differences.

Rote memorization has traditionally been the method used by teachers to teach addition facts. For example, $9 + 6 = 15$ is learned by memorizing the sentence Nine plus six equals fifteen. These words are divorced from what 9, 6, and 15 actually mean. Typically, when teachers teach through memorization, students are drilled using flashcards and worksheets and were assessed through frequent timed tests.

In contrast to memorization, children can learn the facts by thinking about the numbers. For example, $9 + 6$ can be solved by decomposing the 9 into $6 + 3$ and then, using a child’s doubles knowledge, solving $(6 + 6) + 3$. Or 1 can be taken from the 6 and added to the 9, turning $9 + 6$ into the easier-to-solve $10 + 5$. As children manipulate and reflect on number combinations over time, many (but not necessarily all) addition facts are committed to memory, to be retrieved without thinking. Many children, however, never commit every fact to memory but can automatically solve fact problems because they become so efficient with these strategies (Carpenter et al. 1999). To illustrate this, calculate $14 + 7$. You probably knew the answer immediately, but I doubt that you ever sat down in school to memorize fourteen plus seven equals twenty-one. Instead, these thinking strategies have become so familiar to you that solving similar problems becomes second nature.

To build these computation strategies, it is necessary to embrace the informal problem-solving strategies that children learn in their years prior to school (Issacs and Carroll 1999). My four-year-old daughter, for example, can accurately solve a variety of computation problems, such as how many cookies she and her friend would have if she had 3 and her friend had 6. She often solves this type of problem by using her fingers, first holding up 3 and then putting up 6 more. This strategy is known as direct modeling. Finally, she counts all her fingers from 1 to 9. This strategy is called counting all (Carpenter et al. 1999).

Children learn other, more sophisticated strategies in several ways. First, when students are encouraged to describe and debate ways of solving problems, they often end up trying new methods. Second, problems can be designed that promote the use of newer, better thinking strategies. For example, when one addend is large and the other is small (such as $16 + 2$), it invites the use of the more efficient counting on strategy—starting at 16 and counting on 2. Later, by discussing facts that are closely related to ones that children have already committed to memory, children begin to draw from what they know to solve unknown problems. Doubles such as $4 + 4$, for example, are learned early on by children, and can be used to derive the answer to $4 + 5$ (Carpenter et al. 1999).
Advantages of Thinking over Memorization  Should children learn the addition facts through rote memorization or thinking? There are several problems with rote memorization. First, children who memorize $9 + 6 = 15$ don’t necessarily understand what this means. We’ve all seen children have trouble with word problems that can be solved using simple addition facts that they can recite. Second, memorizing the facts robs children of one of the best ways to develop other mathematical concepts. As illustrated next, when children think about addition they develop a greater understanding of number than those children who just memorize. This is not surprising because these children spend their time thinking about numbers, whereas the other group is not thinking about numbers. Results of research illustrate the advantages of having children think about the addition facts.

Early Research  Three early studies have especially influenced thinking on how children learn facts with understanding. Brownell and Chazal (1935) found that frequent drill hindered children from advancing to more sophisticated strategies. For example, if a child counts 4 fingers on one hand and 5 fingers on the other to solve $4 + 5$ and then counts all of them one by one, frequent drill reinforced this strategy but did not help that child develop better strategies. In a later study, Brownell (1944) found that children who used strategies to solve facts had far better immediate recall at the end of the school year than students who simply memorized the facts. The third study showed that children who could explain how they solved basic facts at the end of the school year forgot far fewer facts over summer break than did students who could not describe how they solved facts (Rathmell 1978).

Kamii’s Data  More recent data collected by Kamii (2000) further demonstrate some of the advantages of promoting thinking strategies. Her study compared children in a strategy-based first-grade classroom, with those in classrooms that taught the facts using a textbook and workbooks. In timed interviews at the end of the year, children who learned the facts by playing math strategy games, solving word problems, presenting and debating strategies, and using situations outside of math class (such as taking lunch count), outperformed those children encouraged to memorize in 26 of 29 addition facts. There was no difference between the groups on the other three facts. Usually the differences between the two groups were quite dramatic. For example, 52% of the strategies group could say that the answer to $5 + 8$ was 13 within 3 seconds, compared to only 14% of those children who memorized.

More than just a better ability to solve addition facts, the children in the thinking group in this study were able to apply their knowledge to solve word problems that required application of math facts. The text-
book and worksheet group was much less able to use their facts to solve problems. This study supports much of the research found in Chapter 2: memorize-and-repeat teaching methods often sacrifice understanding for simple recall. And in this case, parrot math did not even yield better recall.

Math Workshop Project Data

Another study shows further advantages of thought-based instruction. Beginning in the 1997–1998 school year, I directed the Mathematics Workshop Project, a 4-year study of first- and second-grade students in two schools in my suburban Chicago public school district. One hundred eighty students were given a battery of interviews testing logical development and mathematical understanding during the study. By comparing students taught through a math workshop approach with those taught in other ways, I hoped to learn more about how the math workshop worked as a teaching technique. The study yielded a wealth of information, some of which has been summarized previously (Foster 1999b; Heuser 1999, 2000b; Heuser and Foster, in preparation). I will provide additional portions of the project data to illustrate certain points, starting with this chapter.

One of the interviews assessed children’s knowledge of number families. A number family consists of all of the whole number pairs that, combined, equal a particular number. The 9 number family, for example, includes the pairs 9 and 0, 8 and 1, 7 and 2, 6 and 3, 5 and 4, 4 and 5, 3 and 6, 2 and 7, 1 and 8, and finally 0 and 9. Children gain this knowledge of 9 over time, as they physically construct and divide sets of objects and mentally manipulate numbers. Because it makes sense that a child with such intimate knowledge of 9 could fairly easily solve problems such as $6 + 3 = ?, 6 + ? = 9$ (as well as $9 – 6 = ?$ and $9 – ? = 3$), we assessed children’s automatic recall of the 4, 9, and 13 number families.

The number families interview was adapted from the hand assessment developed by Dale Rubley Phillips (1991). In each interview, the interviewer held out an open hand in which there was a given number of chips and a closed hand hiding an unknown amount. Having been told the total number of chips, the student had to figure out how many chips were in the closed hand. The interviewer then redistributed the chips and asked the same question. If a child correctly named, within 5 seconds, the hidden quantities in three of four trials, he or she was awarded one point and moved up to the next higher number family. Thus, a child who failed the 4 number family assessment was awarded 0 points, and so on, up to a maximum of 3 points by knowing the 4, 9, and 13 number families.

Second-grade students in classes using the math workshop and those in a text-based program were given the assessment as a pretest in September. Those awarded three points were disqualified from this portion of the study. In May the posttest was given. Posttest results are shown in Figure 5–1.
The workshop group, despite starting the year with essentially the same average as the nonworkshop group, ended with a significantly greater knowledge of these number families. What is especially telling is that the control group was taught by teachers who used a program—Everyday Math (Everyday Learning Corporation 1989)—that many consider quite progressive.

Why the math workshop group did better is open to speculation. One likely possibility is that teachers following the text to the letter would be missing many opportunities for using the four elements that research shows helps children learn—hands-on activities, choice, reflection, and inquiry and problem solving. I have found this to be a common problem with many texts; the bones of worthwhile activities are there; they are just not fleshed out enough to reach their full potential. The next section will describe an addition facts game that is the main activity for the addition facts workshop sequence.

Addition Facts Game

The game is called Double Roll and Grab. I have found it worthwhile for first- and second-grade students of all abilities; kindergarteners that can count will also benefit. Students have the opportunity to develop their counting abilities (by ones, twos, fives, tens, twenty-fives, one-hundreds, etc.), and place value as well as the addition facts.

Game Rules

Four standard dice and between 25 and 100 counters are needed for each pair of students. Each player rolls two dice at the same time. The player with the higher total takes that number of counters from the bank and puts it in his or her winner pile. The other player takes no counters. If both players roll the same total, they both take that number of chips. Play continues until all of the counters in the bank are gone. The player with the most number in his or her winner pile wins the game.
Variations Variations of this game can be played in order to meet the needs of your students and to encourage new, more efficient strategies. Most variations rely on different dice. Standard dice are used in Double Roll and Grab. These are the easiest because of the low numbers and because students can count the dots if needed.

Single Roll and Grab Only one standard die is used. This variation is good for many kindergartners or students just beginning to count.

Special Double Roll and Grab Students are given the choice (or guided by the teacher) of different nonstandard dice. These dice offer many opportunities for children to develop more advanced thinking strategies. Numeral dice, including those with numbers greater than six, can be used for more advanced students. Combining one numeral die with one standard die encourages children to use the counting up strategy, because they can start with the numeral (5) and then count up using the dots (6, 7, 8). This is especially true if the numeral die has higher numbers. Using two numeral dice requires children to add the numbers mentally and should be reserved for those students who are ready for them. If they are allowed to pick these dice before they are ready, most collect the chips separately (i.e., collect 5 and then 6), which has limited benefit.

Triple, Quadruple, etc., Roll and Grab Increasing the number of dice encourages children to look for number combinations that are easier to add. For example, if a 6, 3, and a 4 are rolled, students often combine the 6 and 4 to make 10, and then add the 3. There are also times when children can decompose larger numbers. For example, if an 8, 9, and 14 are rolled, a child could solve it this way: $14 - 1 \Rightarrow 1 + 9 = 10$, $(14 - 1) - 2 \Rightarrow 2 + 8 = 10$, so $10 + 10 + 11 = 31$.

Science Inquiry: Plant Life Cycles and Environment

Background

Cycles can be found throughout math and science. Constancy and change, geometric and number patterns, cycles of rocks and water, time and seasons, the flow of energy, behaviors of living organisms, including people; knowing each of these is dependent on understanding cycles. The life cycle—birth, maturity, reproduction, and death—is at the same time abstract and immediate. Young children often are intimately familiar with events such as the birth of a sibling, the death of a pet, and the age-related differences between their grandparents, parents, and themselves.
At the same time, children have a hard time gaining the big picture of life cycles, in part because it can take many years for humans and animals to cycle through their lives.

**Teaching Using Animals and Plants**

One way to gain this understanding is for children to observe animals and plants that have a relatively short life cycle. In schools frogs and butterflies are often observed, partly because, as organisms that metamorphose, their life cycles are particularly striking. Plants such as green beans and peas are easy to care for and relatively quickly sprout, flower, develop seeds, and die.

Even with these specimens, understanding a life cycle is difficult for young children because the cycle is still progressing at a timetable that is usually longer than children’s attention. Teachers need to be very vigilant in helping students connecting one life cycle phase to the next, summarizing what happened in previous lessons, and pointing out relevant details. A discovery approach toward teaching will not work here.

This was illustrated to me several years ago as I planned a second-grade unit of life cycles. I found from a pretest interview (an updated version is included in Chapter 9) that many of my students did not know that fruits are developed in flowers and that seeds can usually be found in fruit. I felt that these details were important pieces of the life cycle, so I planned an activity that at the time seemed foolproof: to learn about life cycles, students must see a life cycle.

And that’s what we did. I brought in a green-bean pod from my garden that had dried. We took out the seeds and planted them in a half-barrel in the playground, and soon sprouts emerged. Through early September, the sprouts grew into vigorous plants, which in turn flowered. Before the first freeze hit, we saw the flowers fade, and in their place, tiny beans grew. Students recorded the cycle in sketches in their observation journal. Each drew the seeds in the dried bean, the tiny sprout, the full-grown plant in flower, and the fading flower giving way to the bean. The cycle was complete—in my eyes, at least.

For the posttest assessment, I had each child draw the life cycle of the green bean, from seed to seed. To my surprise, only a fourth of the students who originally didn’t know on which part of the plant fruit and seeds originated knew now. Most of the students, the same ones who had accurately sketched the seeds in the pod just a month before, showed the seeds underground among the roots or encased in the branches. Almost no one drew the bean growing from the flower.

One likely reason for this is that I did not push the children to reflect on what they were seeing. As the children sketched I was running a reading group; I never had the opportunity to question them or to encourage
them to verbalize their observations to their peers. The class as a whole
never shared their sketches or was asked to use them in any way. We
never discussed the plant’s progress: how it had changes since last time,
if they had ever seen other plants flower like that, or even, Where did we
get those seeds from again? By not encouraging students to reflect on
their observations so that I could emphasize important elements, many
details never made it beyond the observation journal and into the stu-
dents’ understanding.

Raising animals or growing plants offers great opportunities for chil-
dren to learn about the environments of organisms and to engage in in-
quiries, in addition to learning about life cycles. I have found that many
students have questions that touch upon the environment of living
things, such as what they are fed and what their habitat is. Often the best
way to answer these questions is through hands-on inquiry. Studying an
organism’s environment at the same time the life cycle is being observed
allows students to stay involved in important hands-on science while the
life cycle slowly unfolds.

Plant Inquiry

One of these hands-on inquiries, involving pea plants, is described here.
I related a similar set of inquiries on the frog life cycle in Chapter 1.

This activity has three main goals, summarized from the objectives
listed in Chapter 4:

1. developing students’ knowledge of the inquiry process
2. teaching that a plant’s environment affects its health
3. increasing children’s knowledge of the plant life cycle through di-
rect observations

An Inquiry into Plants in Different Environments Will plants grow bet-
ter if they are given cola, water, or coffee? This was the inquiry question
being explored by a group of two multiage (first- and second-grade)
classes. This inquiry took place in the middle of our life cycles and envi-
ronment unit. Before the actual inquiry, during the exploration phase of
the inquiry framework, students each planted two pea seeds in paper
cups. I had them plant two so that at least one would sprout for children
to take home and so there would be enough second plants for us to use
in an experiment. Students observed and discussed their plants’ progress
as they wrote questions they had.

Many of the questions revolved around plants’ needs: Is my plant get-
ting enough sun? Will my plant grow without water? What if I gave my
plant milk? Even though no children asked specifically about the relative
benefits of cola, water, and coffee, this question was both practical and likely to lead to significant science and played off a vein of the children’s curiosity. Because the inquiry question was formed both by students and teacher, this inquiry would be a guided inquiry.

We began the inquiry phase of the inquiry framework when many of the plants grew to a height of about 6 inches. In the minilesson of this workshop, I reminded students our observations and discussions about their plants. I asked if plants really need water or if some other liquid would do. I suggested that coffee or diet cola might work just as well, because coffee makes some adults wake up and many kids love pop. Through a process of negotiation we devised a way to fairly test this question.

Black coffee and diet cola were the liquids of choice aside from water for two reasons. First, children are somewhat familiar with coffee and cola and they know that plants drink water. Second, I had let children pick their own liquid to test during the previous year. One of the unforeseen conclusions from this inquiry was that anything with sugar in it—juices, milk, non-diet pop—makes the soil incredibly smelly.

The activity period was short. I simply poured the three liquids into the soil of the specific plant and had children sketch the experiment set up (Figure 5–2). In the reflection period several children shared their predictions with the whole group. Finally, each child wrote down his or her prediction with an explanation. Over the next two weeks, we had five workshops in which we monitored and discussed the plants’ progress. Finally, as it became obvious which plant was doing better, we negotiated our results.

Solving Problems on the Plant Life Cycle  As the inquiry progressed, I presented several problems to the students that were designed to help them better understand the plant life cycle. These activities focused on the areas that the pretest interview showed needed attention: that seeds develop in fruit and that fruit forms from flowers.

In one of these workshops, I asked students where seeds could be found on plants. Many thought that fruits could hold seeds, but quite a few students felt that seeds would also be located in the roots, stems, flowers, and leaves of the plant. These misconceptions are common in children. Technically, all flowering plants form seeds in a plant’s fruit, which grows at the base of the pollinated flower. It is unfortunate that we also use the term fruit to describe sweet, edible plant parts such as apples and bananas. Because we do not think of green peppers or cucumbers as fruit, much less walnuts, wheat, or dried flower heads such as cotton, understanding that all seeds form in fruit is beyond the cognitive abilities of most young children. To address this issue, throughout the unit we used the term seed holder, a term that encompassed “fruits,” seeded vegetables,
nuts, dried flower heads—anything that holds seeds. With this adaptation, children were ready to solve problems designed to facilitate understanding of the plant life cycle. Several of these activities will be presented in the next two chapters.

**STUDENT-DIRECTED WORKSHOP**

**Background**

Student-directed workshops are based upon the work of Darrell and Dale Rubley Phillips (D. G. Phillips 1992; D. R. Phillips 1991; Phillips and Phillips 1994, 1996). As part of their effort to translate Piaget’s research into classroom applications, they proposed that students need to have
greater control of what they are learning and how they learn it. Phillips and Phillips felt that if children were allowed self-directed sessions where they could follow their own interests while working hands-on with their choice of objects, they would be drawn to activities that were appropriate to their cognitive development. Children who interacted with different math and science manipulatives, such as pattern blocks, seashells, colored water, and mirrors, would have excellent opportunities to learn mathematical and scientific concepts and processes for which they were developmentally ready. Another benefit of this object exploration is that children would be likely to develop the cognitive structures—including classification, ordering, and conservation—that are the foundation for understanding math and science.

Object Exploration and Classification

To see how this would look in my classroom and to test the effectiveness of object exploration on children’s classification development, I conducted another study involving three first-grade classes (Heuser 1996, 1997). Two classrooms formed the object-exploration group. The teachers of these classrooms conducted 20-minute periods, twice weekly, in which children worked with objects. This activity was usually in lieu of paper-and-pencil math exercises from the district-selected textbook. No formal instruction in classification was given.

The second group was the control. They did not schedule free exploration of objects but were taught math through the district math program, which consisted of workbook exercises and games. One lesson during this time was devoted to classifying attribute blocks according to different attributes.

Each child was given a one-on-one task interview (adopted from Phillips and Phillips (1996)) at the beginning of the study. Children were put in one of three categories of classification ability based on these pretest results:

Level A: Student could not group objects using a valid classification scheme (i.e. group by one defining attribute, such as size, shape, or color).

Level B: Student could group objects using only one valid classification scheme.

Level C: Student could group objects using two valid classification schemes.

After 4 months, students who tested at Level A in the pretest were given the same interview for the posttest. The results are shown in Figure 5–3.
Although most of the children in both groups could now classify by one classification scheme, the only children who could then go one step further and reclassify the objects based on a new set of criteria were those in the object-exploration group.

I drew two conclusions from this study as one of the object-exploration teachers. First, the data suggest that children given time to work hands-on, in ways that match their interests, are more likely to develop more sophisticated classification structures and thus be better prepared to understand math and science content. These results are not surprising given how children spend their free time. Video games, TV, and organized sports, although valuable in their own right, do not allow kids to work hands-on with collections of objects. It appears that giving children time in school to work hands-on gives them an advantage.

Second, the children I observed during these exploration periods were generally very focused, calm, and content. They had a sense of ownership in what they were doing. Children carefully examined their objects, looking at them from different angles, rubbed them against their cheeks, even smelled them. In addition to classifying, with no prompting from me, students naturally engaged in a range of behaviors. They made designs, stacked, counted, put objects into order, compared, weighed and measured, and talked about and made drawings of their projects. These sessions looked remarkably like . . . play!

Take these free exploration sessions and place them in the workshop format and you have a student-directed workshop (I use the term free workshops with the children). These are a part of my first-grade math and science program; student-directed workshops take place about once out of every five math and science classes. Kindergarten teachers tend to use these workshops more frequently. It has been my experience that many children start to lose interest in free exploration toward the middle of first grade. Children at that point of the year are often beginning to crave the more formalized instruction of teacher-directed workshops. On the other hand, some students enjoy and seem to benefit from student-directed workshops well into second grade. I offer this free exploration as one choice (the other choices being math games) during some workshops to meet the needs of these students.
Conducting Workshops

Student-directed workshops revolve around sets of objects. In my classroom, these sets are stored in clear plastic tubs for easy identification and access by the students. A list of some of the most useful objects is shown in Figure 5–4. There should be enough sets for every child to have one. For the most part, I have found that children engage in productive math and science behaviors more while working by themselves. More often than not, partners become involved in disruptive behaviors (such as playing “dinosaur war”) rather than counting, classifying, ordering, experimenting, or other important math and science processes.

These workshops begin with a minilesson. Student-directed minilessons are discussed in depth in the next chapter. Beginning with the first student-directed workshops, the workshop rules (see Figure 5–5) are emphasized and periodically reinforced. It is important to set high expectation for children in regard to taking care of materials, being respectful of others, and working hard. I always emphasize that, even though it may

1. Find your own space to work.
2. Work quietly so that you do not disturb others.
3. Be careful not to break or lose any pieces.
4. When you are done, put your collection away where you found it.
5. Work hard, challenge yourself, and enjoy your learning.

THREE WORKSHOP SEQUENCES

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<tr>
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FIGURE 5–4 Useful object and tools for student-directed workshops.

FIGURE 5–5 Workshop rules.
feel like they are playing, they have the responsibility to learn as much as possible. We never refer to these workshops as play. When I confer with the children (Chapter 7), I often ask, ”What are you working on?” or “What are you learning?”

In the activity period, students make their selection of object sets, find a workspace on the floor or desk, and begin to work. I keep a list of students so that each student gets to pick first at some time during the year. While they interact with their objects, I walk around and conference with students. During these conferences I question children, make suggestions, pose problems, or offer encouragement. Occasionally I do informal assessments—these are discussed in Chapter 9. Student-directed workshops end with a reflection period (Chapter 8) and students putting away their objects.
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