CHAPTER

6

Planning in the Problem-Based Classroom

Natural learning . . . doesn't happen on a time schedule and often requires more time than schools are organized to provide. Problem-solving experiences take time. It's essential that teachers provide the time that's needed for children to work through activities on their own and that teachers not slip into teaching-by-telling for the sake of efficiency.

Burns (1992, p. 30)

The three-part lesson format described in Chapter 4 provided a basic structure for problem-based lessons. That basic framework resulted from the need for students to be engaged in problems followed by time for discussion and reflection. However, many of the practical details of working with students in this environment are not clear from this general paradigm for a lesson.

This chapter begins with a step-by-step guide for planning problem-based lessons. Also explored here are some variations of the three-part structure, tips for dealing with diversity in the classroom, cooperative learning techniques, issues of drill and practice, homework, textbooks, and grading. In short, this chapter discusses the "nuts and bolts" of effective teaching.

Planning a Problem-Based Lesson

Regardless of your experience, it is crucial that you give adequate thought to the planning of your lessons. There is no such thing as a "teacher-proof" curriculum—where you can simply teach every lesson as it is planned and in the order it appears. Every class is different. Choices of tasks and how they are presented to students must be made daily to best fit the needs of your students and the objectives you are hired to teach. The outline in Figure 6.1 illustrates the suggested steps for planning a lesson. The first four steps are the most crucial. Decisions made here will define the content and the task that your students will work on. The next four steps are necessary to make sure that the lesson runs smoothly. Finally, you can write a concise lesson plan, knowing that you have thought it through thoroughly. Each step is discussed briefly next.

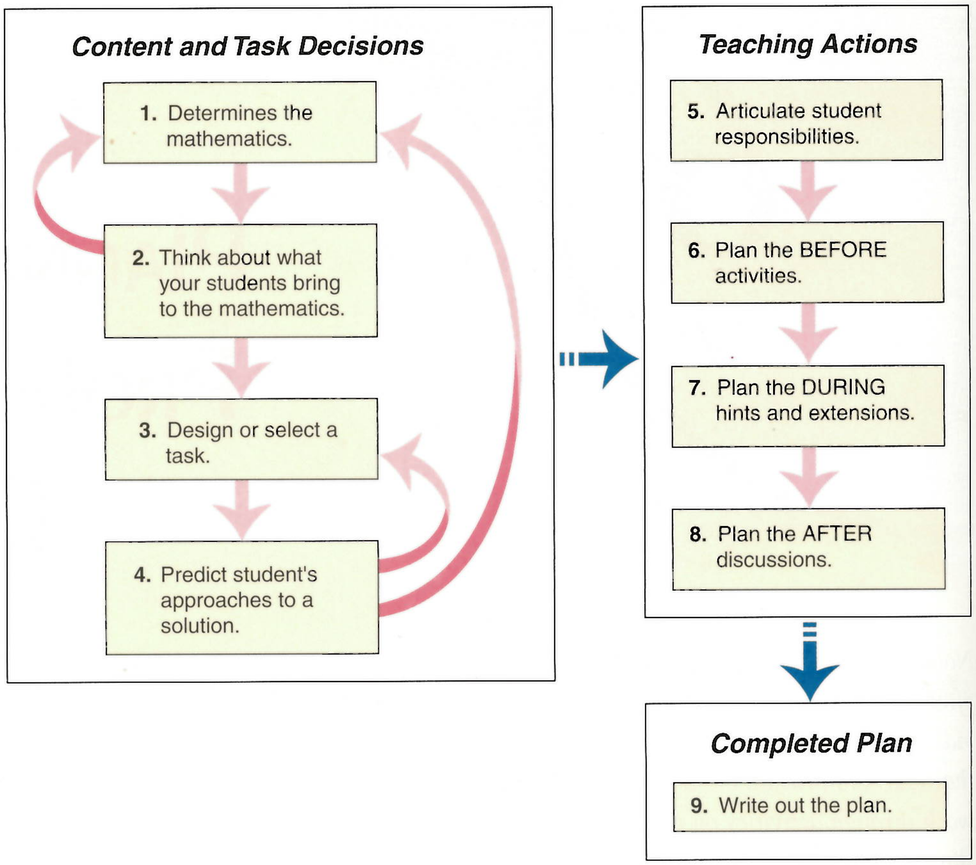
Step 1: Begin with the Math! Articulate clearly the *ideas* you want students to learn as a result of the lesson. Think in terms of mathematical concepts, not skills. Describe the mathematics, not the student behavior.

But what if a skill is the intended outcome? Perhaps you want students to master their subtraction facts or work on developing a method of multiplying two-digit numbers. For every skill there are underlying concepts and relationships. Identify these concepts at this step of your planning. The best tasks will get at skills through concepts.

Step 2: Consider Your Students. What do your students know or understand about this topic? Are they ready to tackle this bit of mathematics or are there some background ideas that they have not yet developed? Perhaps they already have some ideas that you have been working on and this lesson is aimed at expanding or refining these.

Be sure that the mathematics you identified in step 1 includes something new or at least slightly unfamiliar to your students. At the same time, be certain that your objectives are not out of reach. There is no sense in repeating old ideas. Nor is there any value in posing tasks that students cannot access without clear guidance from you. For real learning to take place, there must be some challenge, some new ideas—even if it is simply seeing an old idea in a new format or with a different model. Keep new ideas within the grasp of your students. If necessary, now is the time to revisit step 1 and make adjustments in your goals.

FIGURE 6.1 Planning steps for thinking through a problem-based lesson.



Step 3: Decide on a Task. Keep it simple! Good tasks need not be elaborate. Often a simple story problem is all that is necessary as long as the solution involves children in the intended mathematics.

Chapter 4 gave examples of tasks and suggestions for creating or selecting them. This book is full of tasks. The more experience you have with the content in step 1 and the longer you have had to build a repertoire of task ideas from journals, resource books, conferences, and in-service, the easier this important step in planning will become.

Step 4: Predict What Will Happen. You have made hypotheses about what your students know. Now use that information and think about *all* of the things your students are likely to do with this task. If you catch yourself saying, "Well, I hope that they will . . . ," then *stop*. Predict, don't hope!

Does every student in your class have a chance of engaging in this problem? Although students may each tackle the task differently, don't leave your struggling students to flounder. Perhaps you want to provide for modifications in the task for different students. (See the section on diversity later in this chapter.) This is also a good time to think about whether your students will work alone, in pairs, or in groups. Group work may be an assist to students in need of some extra help.

If your predictions are beginning to make you uneasy about your task, this is the time to revisit the task. Maybe it needs to be modified, or perhaps it is simply too easy or too difficult.

These first four decisions define the heart of your lesson. The next four decisions define how you will carry the plan out in your classroom.

Step 5: Articulate Student Responsibilities. You always want more than answers. For nearly every task, you want students to be able to tell you

- What they did to get the answer
- Why they did it that way
- Why they think the solution is correct

You need to plan how students will supply this information. If responding in writing, will students write individually or prepare a group presentation? Will they write in their journals, on paper to be turned in, on a worksheet, on chart paper to present to the class, or on acetate to use on the overhead?

Of course, there is the option of no writing. You may want to have students simply report or discuss their ideas without writing. Although this option is often adequate, if used repeatedly or before students are accustomed to discussing mathematics, some form of written work that goes beyond the answer is strongly recommended. Remember, writing is a form of rehearsal for discussions.

Step 6: Plan the *Before* Portion of the Lesson. Sometimes you can simply begin with the task and articulation of students' responsibilities. But, in many instances, you will want to prepare students by working quickly through an easier related task or some related warm-up exercise that orients students' thinking. After presenting the task, will you "let go" or do you want students to brainstorm solutions or estimate answers? (See Chapter 4 for discussion of the "before actions" in a lesson.)

Consider how you will present the task. Options include having it written on paper, taken from their texts, shown on the overhead, or written on the board or on chart paper. There are also times when it is adequate to simply present the problem orally. And don't forget to tell the students about their responsibilities (step 5).

Step 7: Think About the *During* Portion of the Lesson. Look back at your predictions. What hints or assists can you plan in advance for students who may be stuck? Are there particular groups or individual students you wish to specially observe or assess in this lesson? Make a note to do so. Think of extensions or challenges you can pose to students who finish quickly.

Estimate how much time you think students should be given for the task. It is useful to tell students in advance. Some teachers set a timer that all students can see. Plan to be somewhat flexible, but do not use up your discussion period.

Step 8: Think About the *After* Portion of the Lesson. How will you begin your discussion? One option is to simply list all of the different answers from groups or individuals, doing so without comment, and then returning to students or groups to explain their solutions and justify their answers. You may also begin with full explanations from each group or student before you get all the answers. If you accept oral reports, think about how you will record on the board what is being said.

Plan an adequate amount of time for your discussion. Five minutes is almost never sufficient. Aim for 20 minutes at least for rich problems. A good average is about 15 to 20 minutes.

Step 9: Write Your Lesson Plan. If you have thought through these steps, a plan is simply a listing of the critical decisions you have already made. The outline shown here is a possible format:

- The mathematics or goals
- The task and expectations
- The *before* activities
- The *during* hints and extensions for early finishers
- The *after*-lesson discussion format
- Assessment notes (whom you want to assess and how)

Variations of the Three-Part Lesson

The basic lesson structure we have been discussing assumes that a class will be given a task or problem, allowed to work on it, and end with a discussion. Certainly, not every lesson is developed around a task given to a full class. However, the basic concept of tasks and discussions can be adapted to most any problem-based lesson.

Minilessons

Many tasks do not require the full period. The three-part format can be compressed to as little as 10 minutes. You might plan two or three cycles in a single lesson. For example, consider these tasks:

Grades K–1:	Make up two questions that we can answer using the information in our graph.
Grade 2–3:	Suppose you did not know the answer to problem 14. How could you start to figure it out?
Grades 4–5:	On your geoboard, make a figure that has line symmetry but not rotational symmetry. Make a second figure that has rotational symmetry but not line symmetry.
Grades 6–7:	Margie has this drawing of the first floor of her house. (Pass out drawing.) She wants to reduce it on the photocopy machine so that it will have a scale of 1 cm to the foot. By what percentage should she reduce it?

These are worthwhile tasks but probably would not require a full period to do and discuss.

A profitable strategy for short tasks is *think-pair-share*. Students are first directed to spend a minute developing their own thoughts and ideas on how to approach the task or even what they think may be a good solution. Then they pair with a classmate and discuss each other's ideas. This provides an opportunity to test out ideas and to practice articulating them. The last step is to share the idea with the rest of the class. The pair may actually have two ideas or can be told to come to a single decision. The entire process, including some discussion, may take less than 15 minutes.

Workstations and Games

It is often useful for students to work at different tasks or games at various locations around the room. Stations are a good way to manage materials without the need to distribute and collect them. They also help when it is unreasonable or impossible for all students to have access to the required materials for an activity. Good computer tasks do exist, especially on the Web. Computer stations make sense for these activities. Stations also allow you to differentiate tasks when your students are at different stages in developing the current concept.

You may want students to work at stations in small groups or individually. Therefore, for a given topic you might prepare from four to eight different activities. Not every station has to be different. Materials required for the activity or game, including any special recording sheets, are placed in a tub or folder to be quickly positioned at different locations in the classroom.

A good idea for younger children or for games and computer activities is to explain or teach the activity to the full class ahead of time. In this way students should not waste time when they get to the station and you will not have to run around the room explaining what to do.

Many station activities can be profitably repeated several times. For example, students might be replacing missing numbers on a hundreds chart or playing a "game" where one student covers part of a known number of counters and the other student names the covered part. The game "Fraction Track" in the NCTM *e-Standards* (E-example 5.1) can be played profitably several times.

STOP Do these workstation activities or games fit the definition of a problem-based task as discussed in Chapter 4? Consider your answer before reading on.

A game or other repeatable activity may not look like a problem, but it can nonetheless be problem-based. The determining factor is this: Does the activity cause students to be reflective about new or developing mathematical relationships? Remember that it is reflective thought that causes growth. If the activity merely has students repeating a procedure without wrestling with an emerging idea, then it is not a problem-based experience. However, the few examples just mentioned and many others do have children thinking through ideas that they have not yet formulated well. In this sense, they fit the definition of a problem-based task.

The time during which students are working at stations is analogous to the *during* portion of a lesson. What kinds of things could you do for the *after* portion of the lesson? Discussions with students who have been working on a task are just as important for games and stations. However, these discussions will have to take place in small groups. You might sit down with students at a station and ask about what they have been doing, what strategies they have discovered, or how they have been going about the activity in general. Try to get at the reasoning behind what they are doing. Another possibility is to wait until all in the class have worked at the same game or station. Now you can have a full group discussion about the learning that came from that activity.

Just as with any task, some form of recording or writing should be included with stations whenever possible. Students solving a problem on a computer can write up what they did and explain what they learned. Students playing a game can keep records and then tell about how they played the game—what thinking or strategies they used.

Dealing with Diversity

Perhaps one of the most difficult challenges for teachers today is to reach all of the students in their increasingly diverse classrooms. Every teacher faces this dilemma because every classroom contains a range of student abilities and backgrounds.

Interestingly and perhaps surprisingly to some, the problem-based approach to teaching is the best way to teach mathematics and attend to the range of students. In the problem-based classroom, children are making sense of the mathematics in *their* way, bringing to the problems only the skills and ideas that they own. In contrast, in a traditional, highly directed lesson, it is assumed that all students will understand and use the same approach and the same ideas. Students not ready to understand the ideas presented by the teacher must focus their attention on following the teacher rules or directions in an instrumental manner. This, of course, leads to endless difficulties and leaves many students behind or in need of serious remediation.

In addition to using a problem-based approach, there are specific things you can do to help attend to the diversity of learners in your classroom.

- Be sure that problems have multiple entry points.
- Plan differentiated tasks.
- Use heterogeneous groupings.
- Listen carefully to students.

Plan for Multiple Entry Points

As suggested in the planning guidelines, when selecting a task it is important to think about how all of the students in the class are likely to approach it. Many tasks can be solved with a range of methods. This is especially true of computational tasks in classes where student-invented methods are encouraged and valued. (See Chapter 13.) For many tasks, the use or nonuse of manipulative models is all that is necessary to vary the entry point. Students should generally be permitted to use models with which they are familiar whenever they feel the need for them. Other students can be challenged to devise rules or to use methods that are less dependent on manipulatives or drawings.

Plan Differentiated Tasks

The idea here is to plan a task with multiple versions; some less difficult, others more so. There are several ways that you can make this happen.

For many problems involving computations, you can insert multiple sets of numbers. In the following problem students are permitted to select the first, second, or third number in each bracket.

Eduardo had {12, 60, 121} marbles. He gave Erica {5, 15, 46} marbles. How many marbles does Eduardo have now?

Students tend to select the numbers that provide them with the greatest challenge without being too difficult. In the discussions, all children benefit and feel as though they worked on the same task.

Another way to differentiate a task is to present a situation with related but different questions that can be asked. The situation might be data in a chart or graph, a measurement task, or a geometry task. Here is an example (adapted from Van de Walle, in press):

Students are given a collection of parallelograms including squares and rectangles as well as nonrectangular parallelograms. These questions can be posed:

- **Select a shape and draw at least three new shapes that are like it in some way. Tell how your new shapes are both similar to and different from the shape you selected.**
- **Draw diagonals in these shapes and measure them. See what relationships you can discover about the diagonals.**
- **Make a list of all of the properties that you can think of that every parallelogram in this set has.**

For this fifth- to eighth-grade task there is a challenge to engage nearly every student.

Still another method of differentiating the tasks in your classroom is by using workstations as described in the previous section. For example, if a fourth-grade class is working on equivalent fractions, a variety of equivalent fraction tasks can be designed all for the same concept. As you will experience in Chapter 15, not all such tasks are equally difficult. They are differentiated both by the kinds of materials that are used and the numbers involved. Stations can be assigned to students to best fit their needs and yet all will be working on the same concept.

Use Heterogeneous Groupings

Avoid ability grouping! Trying to split a class into ability groups is futile; every group will still have diversity. It is demeaning to those students not in the top groups. Students in the lower group will not experience the thinking and language of the top group, and top students will not hear the often unconventional but interesting approaches to tasks in the lower group. Furthermore, having two or more groups means that you must diminish the time you can spend with each group.

It is much more profitable to *capitalize* on the diversity in your room by using pairs or cooperative groups that are heterogeneous. Some teachers like to use random pairings or allow students to select the students they want to work with. These techniques may be fun occasionally, but it is advisable to think through carefully how you group your students. Try to pair students in need of help with capable students but also students who will be compatible and willing to assist. What all students will find is that everyone has ideas to contribute.

Listen Carefully to Students

Regardless of the classroom, it is always important to listen to your students. Try to find out how they are thinking, what ideas they have, how they are approaching problems causing difficulty, and in general develop as accurate an hypothesis about the ideas they have on the current topic as possible. Listening to children was mentioned as a strategy for effective teaching in Chapter 3 and as a means of assessing students in Chapter 5. This is not a new idea but an important one as you strive to help all children in your classroom. Every child is capable. By listening carefully you will be in a better position to put into practice the other suggestions in this section.

Drill or Practice?

Drill and practice, if not a hallmark of American instructional methods in mathematics, is a strategy used regularly in nearly every classroom. Most lessons in traditional textbooks end with a section consisting of exercises, usually of a similar nature and always completely in line with the ideas that were just taught in the beginning of the lesson. This repetitive procedural work is supposed to cement the ideas just learned. On the surface, this idea seems to make sense. In addition to this common textbook approach, drill-and-practice workbooks and computer drill programs abound.

A question worth asking is, "What has all of this drill gotten us?" It has been an ever-present component of mathematics classes for decades and yet the adult population is replete with those who almost proudly proclaim "I was never any good at mathematics" and who understand little more about the subject than arithmetic. This section offers a different perspective.

New Definitions of Drill and Practice

The phrase "drill and practice" slips off the tongue so rapidly that the two words "drill" and "practice" appear to be synonyms—and, for the most part, they have been. In the interest of developing a new or different perspective on drill and practice, consider definitions that differentiate between these terms as different types of activities rather than link them together.

Practice **refers to different problem-based tasks or experiences, spread over numerous class periods, each addressing the same basic ideas.**

Drill **refers to repetitive, *non*-problem-based exercises designed to improve skills or procedures already acquired.**

STOP How are these two definitions different? Which is more in keeping with the view of drill and practice (as a singular term) with which you are familiar? The drill definition requires that skills are already acquired before they are drilled. What do you think about that?

Using these definitions as a point of departure, it is now useful to examine what benefits we can get from each and when each is appropriate.

What Drill Provides

Drill can provide students with the following:

- An increased facility with a strategy but *only* with a strategy already learned
- A focus on a singular method and an exclusion of flexible alternatives
- A false appearance of understanding
- A rule-oriented view of what mathematics is about

The popular belief is that somehow students learn through drill. In reality, drill can only help students get faster at what they already know. Students who count on their fingers to answer basic fact questions only get very good at counting on their fingers. Drill is not a reflective activity. The nature of drill asks students to do what they already know how to do, even if they just learned it. The focus of drill is on procedures with little or no encouragement for reflective thought.

For most school-level mathematics, including computation, there are numerous ways of doing things. For example, how many different mental methods can you think of to add 48 + 35? To find 25 percent of $84 you can divide by 4 and subtract rather than multiply by 0.25. What approach would you use to find 17 percent of $84? Similar examples of the value of flexible thinking are easily found. Drill has a tendency to narrow one's thinking rather than promote flexibility.

When students successfully complete a page of routine exercises, teachers (and even students) often believe that this is an indication that they've "got it." In fact, what they most often have is a very temporary ability to reproduce a procedure recently shown to them. The short-term memory required of a student to complete the exercises at the end of the traditional lesson is no indication of understanding. Superficially learned procedures are easily and quickly forgotten and confused.

When drill is such a prevalent component of the mathematics classroom, it is no wonder that so many students and adults dislike mathematics. Real mathematics is about sense making and reasoning—it is a science of pattern and order. Students cannot possibly obtain this view of the discipline when constantly being asked to repeat procedural skills over and over.

Finally, drill leaves students, even those good at rule learning, with little to like or enjoy. For many students there is much to fear and avoid. The pressures of getting it right coupled with minimal understanding are pressures that many students handle poorly.

What is most important to understand is this: Drill will *not* provide any new conceptual understanding or ideas. Drill will *not* provide any new skills or strategies. Drill focuses only on what is already known.

What Practice Provides

In essence, practice is what this book is about—providing students with ample and varied opportunities to reflect on or create new ideas through problem-based tasks. The following list of outcomes of practice should not be surprising:

- An increased opportunity to develop conceptual ideas and more elaborate and useful connections
- An opportunity to develop alternative and flexible strategies
- A greater chance for all students to understand, not just a few
- A clear message that mathematics is about figuring things out and making sense

Each of the preceding benefits has been explored in this or previous chapters and should require no further discussion. However, it is important to point out that practice can and does develop skills. The fear that without extensive drill students will not master "basic skills" is not supported by recent research on reform curriculum or practices (see Chapter 1). These programs include lots of practice as defined here and most include very minimal amounts of drill. Students in these programs perform about as well as students in traditional programs on computational skills and much better on nearly every other measure.

When Is Drill Appropriate?

Yes, there is a place for drill in mathematics but it need not occur nearly as frequently as most seem to believe.

Criteria for Using Drill

Consider these two proposed criteria for the profitable use of drill:

- An efficient strategy for the skill to be drilled is already in place
- Automaticity with the skill or strategy is a desired outcome

Is it possible to have a skill and still need to perfect it or to drill it? Clearly this happens outside of mathematics all the time with sports and music as good examples. We learn how to dribble a soccer ball or play the chords shown on a sheet of music. At the outset of instruction, we are given the necessary bits of information to perform these skills. Initially, the skills are weak and unperfected. They must be repeated in order to hone them to a state of efficiency. However, if the skill is not there to begin with, no amount of drill will create it.

Automaticity means that the skill can be performed quickly and mindlessly. Most adults have automaticity with basic facts and simple computation. They perform long division without thinking about the meaning behind the steps.

STOP: Stop and make a mental list of the things in K–8 mathematics with which you think students should have automaticity.

Probably your list includes how to count, read, and write numbers. It should include mastery of basic facts (e.g., $3 + 9$ or 8×6). If you are like most people, you may have computation with whole numbers and even with fractions and decimals on your list. What may surprise you is that automaticity with computational skills is not nearly as important as it used to be. Certainly we want skills in computation but not necessarily with a singular or inflexible method. There are more items that are candidates for the list of desired automaticity but generally these will be small bits of mathematics, not big ideas. In fact, the list of things for which automaticity is truly required is actually quite short.

Automaticity with Flexible Strategies

Since flexible strategies have been mentioned as important, is it possible to develop automaticity with flexible strategies? At first blush this seems to be an oxymoron.

Flexibility is important in computation because the numbers and also the demands of the context suggest different approaches. Mental strategies vary widely for any operation depending on the numbers involved and the strategies that have been developed. Exact results are often not necessary and an estimation procedure can be employed. Even with something as simple as basic facts, we know that different students use different strategies. For example, to remember $9 + 5$, some people think of $10 + 5$ and take 1 off. Others take 1 from the 5 to make $10 + 4$. And there are different strategies for different facts. Neither of the two ideas just mentioned is useful for mastering $5 + 6$.

Developing flexible strategies requires adequate opportunity with varied numbers and contexts. Students need to learn how to sift through different methods of thinking. The development of different methods of thinking requires problem-based tasks. As more and more strategies are acquired, more opportunities to select from them and to get better at using them are required. There are elements of both practice (development of strategies) and drill (opportunities to select and use strategies) in becoming flexible with mathematical thinking. So perhaps this is a gray area between drill and practice. Or, perhaps as authors of most reform curricula seem to believe, flexible strategies are largely developed through practice in problem-based experiences. What is clear is that drill alone is not the answer.

Kids Who Don't Get It

As discussed earlier, the diversity in classrooms is a challenge for all teachers. For those students who don't pick up new ideas as quickly as most in the class, there is an overwhelming temptation to give in and "just drill 'em." Before committing to this solution, ask yourself these two questions: *Has it worked before? What is this telling the child?* The child who has difficulties has certainly been drilled in the past. It is naive to believe that the drill you provide will be more beneficial than the endless drills this child has undoubtedly endured in the past. Although drill may provide some very short-term success, an honest reflection will suggest that it probably will have little effect in the long run. What these children learn from more drill is simple: "I'm no good at math. I don't like math. Math is rules."

The earlier section of this chapter, Dealing with Diversity, suggests strongly that a conceptual approach is the best way to help students who struggle. Drill is simply not the answer.

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